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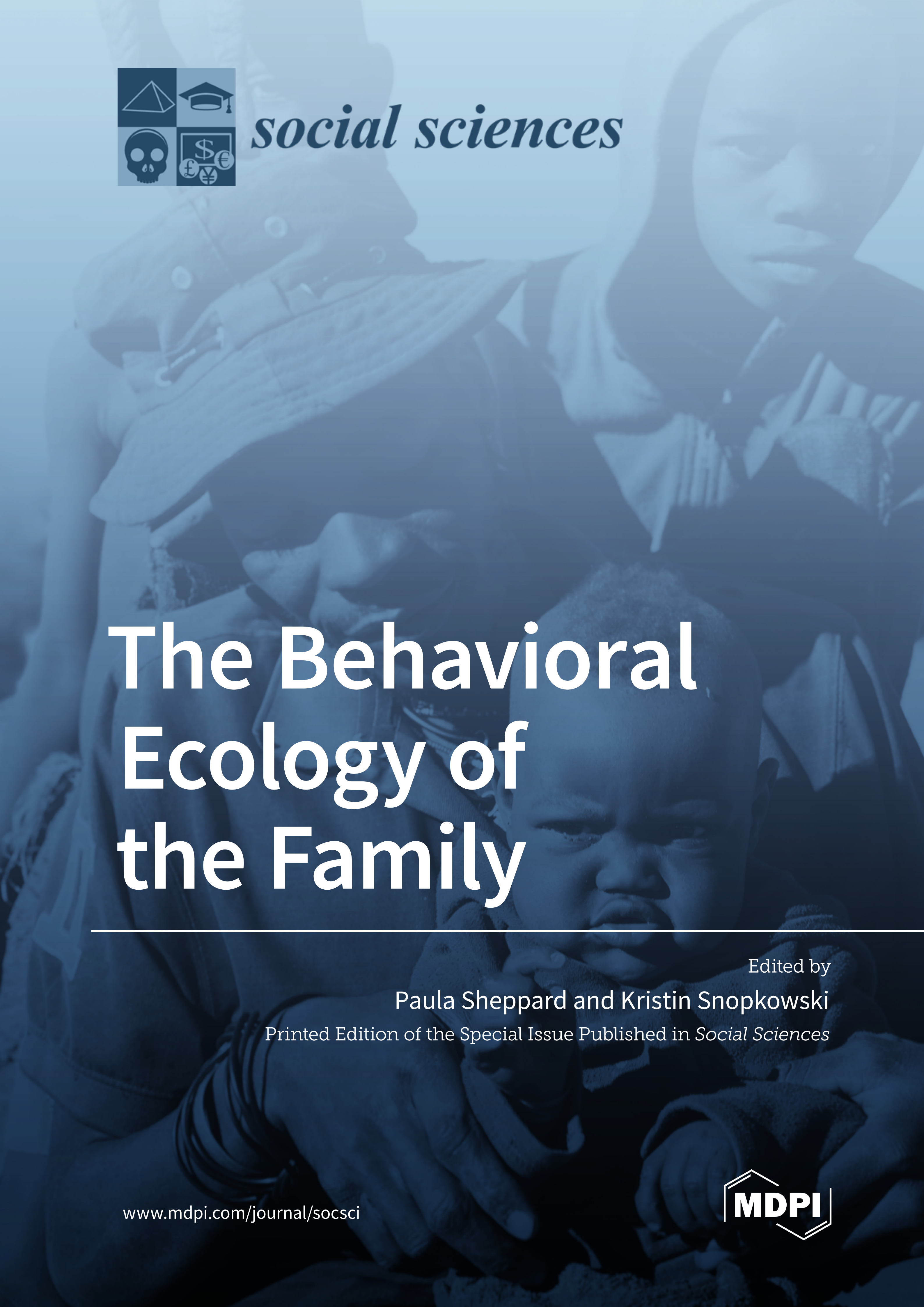

The Behavioral Ecology of the Family

Edited by

Paula Sheppard and Kristin Snopkowski

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About the Editors

Paula Sheppard

Paula Sheppard is an evolutionary anthropologist and human behavioral ecologist with a research focus on life history theory, reproductive decision making, and parental investment. Her research is often multidisciplinary and intersects family demography and evolutionary medicine.

Kristin Snopkowski

Kristin Snopkowski is an evolutionary anthropologist and human behavioral ecologist. Her research examines the ways that evolutionary and ecological forces have shaped modern human variation, with a particular focus on how kin cooperation and conflict influences reproduction, education, mental health, and menopause. She is also interested in the interplay of family dynamics and one’s hormonal profile.

Preface to "The Behavioral Ecology of the Family"

Humans stand out in their extensive and varied typologies of families. These include diverse marriage, mating, and descent systems, extended and blended family units, and an array of putative and blood-related "others" that help to raise children. The variety of environments that humans inhabit, both ecologically and socio-culturally, generate different conditions within which families are formed, creating the extensive diversity of human families seen across the world.

This Special Issue comprises a collection of papers that showcase how different ecologies—social, environmental, and cultural—produce variation in family types, formations, and kinship systems more generally. It has two commentary papers that complement the ten empirical studies conducted among diverse populations from all over the world. We have received contributions from researchers working across the board from small-scale societies to large industrialized populations.

Our aim here is to tell a story of the human family that illustrates how diverse ecologies create this rich variety of human families which we hope will appeal to a social science audience far beyond the behavioural ecology research community.

We'd like to thank all the contributors and reviewers who made this Special Issue come together. We also thank Brooke Scelza for our wonderful cover photograph. We are especially indebted to the generous field site participants who kindly gave us their time and allowed many of us to collect data over long periods. Without them, our understanding of cross-cultural differences in human social systems would be greatly impoverished.

Paula Sheppard, Kristin Snopkowski
Editors

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Perspective

Behavioral Ecology of the Family: Harnessing Theory to Better Understand Variation in Human Families

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Abstract: Researchers across the social sciences have long been interested in families. How people make decisions such as who to marry, when to have a baby, how big or small a family to have, or whether to stay with a partner or stray are questions that continue to interest economists, sociologists, demographers, and anthropologists. Human families vary across the globe; different cultures have different marriage practices, different ideas about who raises children, and even different notions of what a family is. Human behavioral ecology is a branch of anthropology that is particularly interested in cultural variation of family systems and how these differences impact upon the people that inhabit them; the children, parents, grandparents. It draws on evolutionary theory to direct research and generate testable hypotheses to uncover how different ecologies, including social contexts, can explain diversity in families. In this Special Issue on the behavioral ecology of the family, we have collated a selection of papers that showcase just how useful this framework is for understanding cultural variation in families, which we hope will convince other social scientists interested in family research to draw upon evolutionary and ecological insight in their own work.

Keywords: human behavioral ecology; kinship; marriage systems; cross-cultural variation; family formation; cooperation and conflict; cooperative breeding; kin networks

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1. Introduction

In this Special Issue, we showcase how using the evolutionary framework of human behavioral ecology (HBE) can provide deeper insight on human families. Human behavioral ecologists are interested in how human behavior can be understood from an adaptive standpoint. In the context of this Special Issue, we are interested in how families vary across time and space and how by understanding this variation we can shed light on human sociality more broadly. Moreover, this issue seeks to investigate contemporary policy-relevant problems (e.g., Lawson et al. 2015). Family is a cornerstone of social science research and a building block of human sociality, and here we argue that by utilizing the theoretical framework of HBE, we can develop new and empirically-testable predictions for human family research.

HBE recognizes human social behavior as the result of interactions between evolution and ecology. Originally developed in mainstream biology as a way to examine how an animal's behavior is adapted to the environment in which it lives (Simmons 2014), human behavioral ecology uses this ecological framework to investigate human behavioral diversity (Borgerhoff Mulder 1991; Cronk 1991; Winterhalder and Smith 2000). Behavioral ecology begins with the assumption that over time, behaviors that increase fitness become more common in the population. Fitness refers (in somewhat simplified terms) to the differential ability of alleles, strategies, or traits to replicate themselves (Coulson et al. 2006). Human behavioral ecology, therefore, is concerned with how different behaviors (and other traits) are associated with reproductive success. Over time, the characteristics that lead to more surviving offspring will become more frequent in the population. Human behavioral ecologists assume that individuals will generally act in an optimal way to maximize their fitness for a given ecology; an assumption that allows us to generate and test hypotheses to understand human behavior (Nettle et al. 2013).

What do we mean by 'ecology'? Along with the theoretical framework, HBE has also borrowed this terminology from mainstream biology, although human ecologies are more complex. An ecology traditionally includes environmental factors, such as rainfall, temperature, and altitude, but it also is comprised of social factors such as interactions with predators or conspecifics. This is the ecology that all organisms navigate and adapt to. Of course, any examination of humans is incomplete without incorporating culture as part of the environment. Culture has many definitions, but given our focus on studying humans, we may view it colloquially as 'the knowledge and behavior that characterizes a particular group of people' or 'information that is learned socially' (Heyes 2020). Cultural institutions, defined as socially created and culturally inherited rules on behavior that set expectations about social interactions (Currie et al. 2021), such as marriage systems, inheritance rules, educational institutions, and socioeconomic deprivation, all influence which behaviors or traits are successful (Gibson and Gurmu 2011; Henrich et al. 2012; Mattison et al. 2016; Moya et al. 2021). We can say that humans inhabit *socioecologies*. This approach leads to iterative questions regarding why particular cultural traditions or institutions developed, with human behavioral ecologists hypothesizing that ecological variables can provide insights into these cultural traditions too (Ember et al. 2007; Holden and Mace 2003; Mace 2014; Mattison et al. 2016; Nettle et al. 2013), although there are limitations to this approach as other factors, like subjugation may also play a role (Borgerhoff Mulder 1992). Originally, human behavioral ecologists studied cultural and behavioral variation using data from small-scale societies as these are the study sites of most anthropologists, however now the focus has been expanded to include data from large, industrialized societies to gain a more balanced understanding of human behavior.

While behavior is not genetically determined, we do assume that there are genetic bases for a range of behavioral responses and that individuals are able to respond flexibly given their current environment or situation. Furthermore, human genotypes are similar across human populations and as genes interact with the environment, humans exhibit immense phenotypic plasticity—the facultative ability of one genotype to be expressed differently depending on the environment (Cronk 1991). Humans are known for their ability to live in diverse environments, create eclectic cultures, and exhibit many varying behaviors, suggesting that human plasticity has been selected for over evolutionary time.

One of the main strengths of HBE is that researchers can focus their areas of inquiry on those that are predicted by theory, which may lead to unexpected insights and reduce data-driven trial-and-error. For instance, HBE predicts that people will produce children even though children are immensely costly (Mace 2014), that people are willing to engage in dangerous or risky behavior if it is needed to attract a mate (Wang 2002), and that mental health will suffer if parents are isolated without help to raise children during a global pandemic (Myers and Emmott 2021). All of these can be empirically tested.

Some have argued that the dramatic decline in family size that has been observed in most parts of the world provides evidence against an evolutionary understanding of human behavior (e.g., Vining 1986), but HBE sees this as an opportunity to better understand which environmental factors lead to this unique behavioral response. Indeed, many HBE researchers examine reproductive decision-making to understand the demographic transition (e.g., Borgerhoff Mulder 1998).

Another strength of adopting ecological theory is to think about behaviors as adaptive choices for a given ecology. For instance, in this issue, Schaffnit and Lawson (2021) examine "child" marriage. While global health campaigns have called for the eradication of child marriage, Schaffnit and Lawson use HBE to consider why this behavior is so widespread. An understanding of how this may be an optimal choice for a given environment can remove the stigma of behavior that may be viewed by outsiders as 'problematic'. We argue that by understanding *why* certain behaviors persist, instead of casting them as social ills, we can understand them as the result of costs and benefits, which in turn, depend on the environment. This approach has yielded success in thinking about other social issues such as obesity, crime, polygyny, and teenage pregnancy (Abbots et al. 2020; De Courson and Nettle 2021; Lawson et al. 2015; Nettle 2010; Nettle and Bateson 2019). This is not to say that where behaviors can be understood as adaptive under given conditions that as a society, we condone them. This is known as the naturalistic fallacy and thinking that what happens is 'natural' and thus must be morally right, is a misguided (and even damaging) use of evolutionary theory in understanding human behavior. In this special issue we hope to convince researchers across the social sciences that the HBE approach can bear rich fruit for those studying human social behavior, by showcasing here its value in family research.

2. Family Research in HBE

Family is a key area of focus in HBE, including family formation (or breakdown), investment in children, conflict/cooperation among family members, and how cultural institutions influence all parts of family life. Family is difficult to define (see this issue, Kramer 2021), but human behavioral ecologists typically follow the anthropological tradition of using the term 'kin' to refer to one's family. Across cultures, kin include people related biologically, through marriage, or via other processes (e.g., "fictive kin"; the family we choose). While human behavioral ecologists focus on genetic kin because genetic ties contribute to fitness and thus shared interests, a lot of work is also done on allegiances between classificatory kin and affinal kin (through marriage) as these are important relationships that build cooperation and reciprocity. Human behavioral ecologists who focus on family research generally examine variation in mating and partnering strategies, who, besides the mother, cares for children (alloparenting), and reproductive outcomes such as family size, birth spacing, and parental investment in children, all as a function of local socioecologies.

2.1. Mating, Marriage, and Divorce

A key feature of all human societies is the institution of marriage[1], although the specific rules are cross-culturally variable (for more details, see this issue: Kramer 2021). Some societies permit polygynous marriage (one man with multiple wives), others require that marriage only occurs between two individuals, and a few cultures have polyandrous marriage (one wife with multiple husbands). An HBE framework provides insights into how ecological factors, such as pathogen stress or levels of paternal investment, may be associated with marriage systems, where a greater load of pathogen stress and lower male contribution to children's welfare tend to be associated with higher levels of polygyny (Low 1990; Marlowe 2003). A cross-cultural examination of marriage demonstrates that the belief that marriages should be based on love between spouses is far from universal (for an example see this issue: Winking and Koster 2021). In many societies across the world, families exert at least some control over the selection of a person's spouse (Apostolou 2007; van den Berg et al. 2013). Recognizing the role of families in marital decision-making combined with a methodological framework that emphasizes optimal choices given socioecological constraints, Schaffnit and Lawson (2021, this issue) identify four hypotheses for why women may marry young, despite a worldwide campaign to eradicate child marriage. The authors argue that early marriage may be a product of economic deprivation, which overrides the potentially poor health consequences to early marriage (Schaffnit and Lawson 2021).

Beyond marriage, men and women sometimes engage in extra-pair partnerships[2]. In some societies, particularly those with patrilineal descent systems, female sexual behavior is highly controlled, resulting in cultural institutions that restrict women's autonomy, such as veils, foot binding, and domestic violence (King 2008; Mackie 1996; Pazhoohi et al. 2017; Smuts 1995). What are the conditions that lead to different cultural rules regarding female autonomy and extra-pair partnerships? In this issue, Scelza and colleagues (2021) describe how the distribution of key resources influences the temporary residence locations of men and women, and among the Namibian Himba, where pastoralism (animal herding) often leads to spouses spending long periods apart. This coupled with unusual social norms such as double descent, where individuals maintain clan membership with both the matrilineal and patrilineal lineages, with a likely history of matriliny, promotes loosening restrictions on female sexuality, resulting in many women having long-term partnerships in addition to their marriage partner. In this context, extra-pair partnerships may be a strategy for women to gain additional resources (Scelza et al. 2021). This case study provides insight into the particular socioecological costs and benefits that influence the likelihood of women seeking sex beyond the marital union.

Researchers are also interested in factors associated with divorce, as negative child outcomes have been associated with parental divorce in many post-industrial societies (Amato 2000). An historical and cross-cultural perspective provides evidence that divorce rates vary across time and space (Apostolou 2007; Heaton et al. 2001) and a variety of factors may be associated with divorce rates, such as adult sex ratio (Schacht and Mulder 2015; Schacht and Kramer 2016), the availability of alloparents (Quinlan and Quinlan 2007), or women's financial autonomy (Snopkowski 2016). In this issue, Winking and Koster (2021) examine the causes of divorce among a Mayangna/Miskito community in Nicaragua to identify the costs and benefits of marriage and divorce, and determine whether divorce trends mirror those in post-industrial societies. The authors find that women are more likely to initiate divorce even though divorced life is harder for them than their male partners and that early marriage itself does not constitute a risk factor for divorce in this context.

Using a HBE perspective, with an emphasis on identifying costs and benefits of alternative behaviors, and examining mating behaviors cross-culturally, provides a fuller picture of human partnering behavior than simply drawing on insights from a single (often WEIRD[3]) context.

2.2. *Reproductive Outcomes: Timing of Births, Family Size, and Parental Investment in Children*

Another key area of HBE research focuses on reproductive outcomes and the associated investment in children. Given the global decline in fertility over the past centuries, researchers from a variety of disciplines seek to understand human reproductive decision-making. As mentioned above, HBE assumes that people want to maximize fitness by having children, despite their cost, in contrast to some others which assume the goal is to maximize some other utility, such as wealth or education. To understand human fertility, HBE examines fertility outcomes cross-culturally to understand how the role of physiology (Kaplan 1996) and psychology (McAllister et al. 2016) along with active decision-making and random chance (Hruschka and Burger 2016), combine to influence fertility outcomes including age at first birth, length of birth intervals, age at last birth, and childlessness (Sear et al. 2016). The field of reproductive ecology examines how women's reproductive physiology is regulated through a system of hormonal mechanisms that respond to socioecological factors, such as the energetic status of women (Ellison 2003; Panter-Brick 2000), although the physiological determinants of fertility are likely more relevant in energetically stressed populations. Recent work has attempted to integrate the role of economic costs and benefits with the insights of cultural evolution[4] (Bentley et al. 2016; Colleran 2016).

HBE uses a theoretical framework known as *life history theory* (more details can be found in Kramer 2021, this issue) to explain how organisms allocate energy, where any investment made for one purpose cannot be used for another (Hill 1993; Stearns 1992). When considering reproductive decisions, parents face a tradeoff between investing in current offspring or shifting investment towards future children. As parents choose to invest more in their current offspring's education, status, or wealth, they may opt to reduce the number of future offspring they have (Sear et al. 2016). Researchers have long recognized the role of women's education in predicting fertility outcomes, but HBE seeks to understand *why* education matters and whether the mediating pathways vary across time or place (Colleran and Snopkowski 2018; Snopkowski et al. 2016). HBE has also examined the role of childhood experiences on reproductive outcomes, using a framework which predicts that stressful childhoods (including parental absence) may result in earlier age at pubertal maturity and age at first birth (Coall et al. 2016; Sear et al. 2019; Sheppard et al. 2014), at least in high-income contexts. The theoretical premise is that poor conditions indicate higher mortality and so the optimal fitness-enhancing response is to reproduce sooner rather than later, when it might be too late (Chisholm 1993).

A prominent topic of research in HBE is how father absence is associated with children's, especially daughters', own reproductive trajectories. While there is fairly consistent evidence for earlier timing of puberty and family formation in WEIRD contexts (Belsky et al. 1991; Boothroyd et al. 2013; Ellis 2004; Quinlan 2003) a cross-cultural approach reveals much more variation indicating that father absence means different things depending on local ecologies (Sear et al. 2019). In this issue, Moya et al. (2021) use a longitudinal and intergenerational dataset from Sweden to examine how parental absence associates with timing of first birth, whether this is mediated by educational achievement, and if these relationships hold across two adjacent generations. Results show that all outcomes vary by parent sex, child sex, and generation. Overall, parental absence tends to expedite first births and these associations are partially mediated by university attendance, where parental absence reduces the likelihood that their child pursues higher education. One key takeaway of this article is the amount of variability that exists in these relationships, suggesting a complex web of interacting factors.

Socioecological factors likely influence not only when children are born, but which sex is produced. Prior research has found that environmental harshness is associated with sex ratio at birth (Schacht et al. 2019) as males may experience elevated frailty in utero when conditions are difficult, although evidence from industrialized societies is mixed. In this issue, Schacht et al. (2021) examine how rapid industrialization in Utah may influence this relationship, hypothesizing that the role of environmental harshness may be dampened once a population undergoes industrialization. Utilizing a natural experiment brought about by the completion of a railroad in 1869, the authors find that in years of arid conditions (likely associated with drought and increased mortality), the proportion of males born decreases, as hypothesized. This research demonstrates the important role urbanization can play in the relationship between ecology and reproductive outcomes.

As countries transition to low infant mortality rates and reduced family size, social networks change. The labor market economy means that people spend much more time with co-workers rather than family members, and children spend time at school. In contexts where people migrate long distances for work, they may no longer live near their kin. People may have fewer offspring because they have less help available (Turke 1989) or because of the information they receive (Newson et al. 2007). If kin networks are weakened along with these mortality and fertility transitions, then there is likely to be less opportunity for kin to support or help one another. Indeed, this is what Hackman and Kramer (2021, this issue) find in Mexico where some of the indigenous Mayan villages are shifting their mode of production from a subsistence agricultural economy to wage-labor earnings. Those who have moved to a market economy tend to have less kin support than those who continue to rely on subsistence agriculture. Observing what contemporary transitioning societies such as the Maya do provides clues to the processes that may have led to the demographic transition in other parts of the world.

Another avenue to explore these changing networks and their implications is to examine reports of kin and non-kin communications. In this issue, Stulp and Barrett (2021) found that Dutch women were more able to discuss their reproductive decisions with their friends than their parents, even though close family exerted more pressure to have babies. Dutch women also feel they can call upon both blood relatives and affinal (through marriage) relatives for help with childcare, but less so their friends and other members of their social networks. Like many social scientists, Stulp and Barrett are curious to understand why in higher income countries such as the Netherlands, women have fewer children than they can afford.

Using a HBE perspective lends many insights into reproductive decision-making, including how socioecologies influence the tradeoff of offspring quality and quantity.

In this issue, we explore the role of parental absence and environmental harshness on reproductive outcomes and investigate how changing socioecologies alter social networks which, in turn, influence how people make reproductive decisions.

2.3. Alloparenting

Using a comparative approach to examine differences between humans and other great ape species, anthropologists have identified unique attributes of the human family life. Human young are born much more helpless than those of other species, and have an extended period of dependence (childhood and adolescence), typically not having their first births until late teens or later (Bogin and Smith 1996). But even though human offspring have a long period of dependence, the rate at which human females can reproduce is faster than other great apes (Blurton Jones 1986; Galdikas and Wood 1990). This combination of long child dependence and short birth intervals means that human mothers typically have multiple dependent offspring of varying ages. This is in contrast to other primate species where mothers typically care for one offspring until they are independent food producers and then mothers can progress to their next pregnancy, shifting investment from one offspring to the next. It is through this comparative perspective that anthropologists recognized that a human mother cannot possibly care for her multiple dependent offspring, and herself, without help. This has led some to refer to humans as "cooperative breeders", where individuals other than mothers help raise offspring (Hrdy 2009; Kramer 2010). This phenomenon is common among birds but rare among mammals although it has evolved in several primate species, including marmosets and tamarins (Hrdy 2007).

The recognition that mothers need help to raise offspring has become the focus of a lot of HBE research that investigates alloparents and how they influence reproductive outcomes. If mothers need help from others, then who helps? Research from HBE and the broader social sciences, has documented that while fathers provide care in many societies, their investment varies across and within societies (Geary 2000; Gray and Anderson 2010; Hewlett 2017; Hewlett and Macfarlan 2010), and men are not the only helpers of mothers. Cross-cultural evidence has found that grandparents (especially grandmothers) may be particularly important for improving child survivorship (Sear and Mace 2008) and that older siblings frequently act as 'helpers at the nest' (Kramer 2010).

Cross-cultural and historical research also demonstrates that the nuclear family—two parents and their children (particularly where men engage in the labor market and women care for children) is a relatively recent cultural invention (Creighton 1996; Raybould and Sear 2020; Sear 2021). For most of human history, people were integrated into larger social networks of kin. This may have been based on a descent group, where people lived near others from either their patriline (father's kin) or matriline (mothers' kin). And while men and women may have engaged in somewhat different productive tasks, both men and women were critical to the acquisition of resources (Sear 2021). Nevertheless, differing ecological conditions can lead to interesting flexibilities in these cultural customs. For instance, men and women's social networks are expected to differ depending on the kinship system they live in. In this issue, Mattison et al. (2021) test this hypothesis using data from the Southwestern Chinese Mosuo, a population that has both matrilineal and patrilineal groups inhabiting neighboring regions making it ideal to test competing hypotheses for how lineages affect social ties. Overall, they found evidence for flexibility in gender roles within marriage and question the prevailing ideology that Western gender norms have been adopted globally.

Alloparenting is more than simply providing help to mothers; it can also involve the replacement of support if a parent dies or is absent due to divorce. In this issue, Perry (2021) demonstrates that among patrilineal families in rural Bangladesh, maternal kin frequently provide support to children who are left without a parent, even if that parent is the mother. However, alloparents are only partly able to mitigate the cost of losing a mother in this context; maternal orphans moved between numerous kin-carers and were more likely to have never attended school. Similarly, in rural Timor-Leste, Spencer and Judge (2021, this issue) found that children living with grandparents, or those fostered into other homes, had higher body mass indices (denoting better nutrition) than those who lived with only biological parents. This might be because many of these grandparents had access to more household resources through veteran pensions.

Alloparenting is not only found in societies where extended families are available, as there is plenty of evidence of mothers relying on help from others in contemporary, WEIRD societies where nuclear families are the norm. In this issue, Spake et al. (2021) show that British women rely heavily on their partners for help with childcare but if they are unpartnered then they rely on their mothers and a select few other maternal kin. Compared with partnered women, single mothers also rely more heavily on paid childcare. This was also seen in the US, although single American women can rely on their previous partner (i.e., the father of the child) for help too, much more so than British women can. This difference may partly be explained by the more generous state social support in the UK compared to the US (Brown 2016).

Studies of alloparenting are tightly linked to other research areas in HBE. Knowing that alloparents are willing to help raise children may affect a person's decisions regarding reproduction, but also mating and even divorce. Because people integrate decisions about mates, social networks, production, sharing, conflict, and reproduction, all of which depend on one's socioecology, it is impossible to research these topics independently. Utilizing HBE, which provides a unified theoretical framework of optimizing fitness using costs and benefits, may provide insights into the integrated set of features that is the human family.

3. Conclusions

In this Special Issue, we illustrate the benefits of applying a theoretical framework to create directed research that can complement data-driven methods so commonly used in other social sciences such as demography and quantitative sociology. Human Behavioral Ecology recognizes that the currency that people are trying to maximize is fitness[5], not wealth or status, or even health, even though those things are often quite strongly associated with fitness. This insight is the grounding of all HBE hypothesis-testing and can be harnessed to explain the immense variation in human social behavior. It can also explain how apparently illogical behavior, such as life-threatening risk-taking, or not pursuing a high-education pathway, may be a logical choice for some people given their current circumstances.

Human behavioral ecology is not only useful for understanding why people do the things they do but it has policy-relevant applications too. For instance, if we recognize that teenage pregnancy is often the product of limited choices and an unknown future that young women have in high-mortality neighborhoods (Geronimus et al. 1999) policymakers can focus attention on providing ways to improve young women's health. Similarly, policy focused on reducing poverty, such as Universal Basic Income (Nettle 2018) can remove the insecurity of the future enabling people to prioritize long-term goals over short-term risks.

Here we have gathered an array of articles that demonstrate how the rich ecologies we inhabit as a diverse species can explain the myriad different family structures, reproductive outcomes, and social networks that we see across the world. We have also demonstrated the value of conducting cross-cultural research, not only because those cultures are intrinsically interesting but also because a global perspective can provide insights about societies and behavior in the global North.

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Conflicts of Interest: The authors declare no conflict of interest.

Notes

[1] More accurately described as 'long-term pair bonding' since marriage is cross-culturally variable.

[2] Intimate relationships with people other than their marriage partner.

[3] Western Educated Industrialized Rich and Democratic (Henrich et al. 2010)

[4] Cultural evolutionists emphasize the role of group social norms, culturally transmitted traits (in contrast to genetically transmitted traits), and social influences at multiple interacting levels such as social networks, families, and social class to understand the evolution of human behavior. There are many similarities between the fields of HBE and cultural evolution with many researchers integrating these fields.

[5] Fitness maximizing is not a conscious aim. Many decisions around mating, reproducing, and parenting are responses and reactions, and not necessarily done consciously.

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social sciences

Review

The Human Family—Its Evolutionary Context and Diversity

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Abstract: The family defines many aspects of our daily lives, and expresses a wide array of forms across individuals, cultures, ecologies and time. While the nuclear family is the norm today in developed economies, it is the exception in most other historic and cultural contexts. Yet, many aspects of how humans form the economic and reproductive groups that we recognize as families are distinct to our species. This review pursues three goals: to overview the evolutionary context in which the human family developed, to expand the conventional view of the nuclear family as the 'traditional family', and to provide an alternative to patrifocal explanations for family formation. To do so, first those traits that distinguish the human family are reviewed with an emphasis on the key contributions that behavioral ecology has made toward understanding dynamics within and between families, including life history, kin selection, reciprocity and conflict theoretical frameworks. An overview is then given of several seminal debates about how the family took shape, with an eye toward a more nuanced view of male parental care as the basis for family formation, and what cooperative breeding has to offer as an alternative perspective.

Keywords: behavioral ecology; family studies; cooperative breeding; patrilineal

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1. Introduction

Family formation shapes many aspects of our daily lives—who we work, eat and sleep with, who we share with, whether we live in large extended or conjugal families, and the time males and females, adults and children, spend in the company of each other. The ways families are structured also affect where we live after marriage, who we inherit our name and property from, who is included in our kin group and who is excluded, whether we marry one or multiple partners, how disagreements and authority are brokered, whether both females and males can instigate divorce and the extent to which gender equality prevails. The family expresses a wide array of forms across cultures and ecologies, and within any one society. While the nuclear family is the norm today in developed economies, it is the exception historically and in many other cultural contexts. Indeed, if there is any way to characterize the human family, it would be its diversity and flexibility.

This article reviews several avenues of research in behavioral ecology that have addressed the evolution of the family. First, I provide an orientation to characteristics that distinguish group and family formation in the human lineage from other closely related species. This is followed by an overview of the theoretical contributions that behavioral ecology has made toward understanding dynamics within and between families; these include life history, kin selection, reciprocity, the division of labor and other cooperation and conflict frameworks. Some of the important debates that have emerged from research on the evolution of the family are then discussed. This review has three aims: to discuss what is known and is speculative about the ancestral context in which the human family evolved; to recast conventional views of the nuclear family to reflect the empirical, cross-cultural record; and offer alternative perspectives to the patrifocal tradition of describing the human family.

Throughout, I draw on examples from contemporary, small-scale societies (also called traditional societies) for several reasons. In behavioral ecology, the topic of this Special Issue on the family, small-scale societies, particularly hunter-gatherers, have been central to study because their demographic and subsistence conditions, and hence social lives, encompass more diverse forms of the family than are often evident in industrialized societies.[1] Family life has substantially changed in recent centuries with urbanization and industrialization and is novel in many regards. In industrialized societies, conjugal families (spouse(s) and their dependent children; also called the nuclear family) are the norm. The reduction in fertility in most of the developed world means that children live in small families with few siblings. Families are not only smaller because of the multigenerational effects of the demographic transition and longer generational times, they are also composed of fewer collateral kin (aunts, uncles and cousins). Because of high rates of divorce, remarriage, and geographic dispersion, nuclear families are often isolated from grandparents and other relatives. On an evolutionary time scale, this trend toward atomization into small conjugal groups is quite recent; for most of human history, society was seldom organized as such (Van den Berghe 1990). It is important to clarify that small-scale societies are not thought of as relics of the past, but exemplify a more representative, diversified and inclusive view of human family life. That said, many of the tenets presented here are directly applicable to family formation in industrialized societies, and understanding the novel constraints and opportunities that nuclear family organization has presented.

Where necessary, specialized language is italicized and briefly defined. As a review of behavioral ecology approaches to family formation, the charge here is to hopefully communicate the usefulness of this approach to family studies in the social sciences generally.

1.1. Characterizing Social Structure in the Human Lineage

Nonhuman primates offer a comparative lens to appreciate those social and family traits that are part of a common primate heritage, and those traits that are particular to our species and derived in the human lineage. Chimpanzees, the great ape genetically most closely related to humans, have long been used as the behavioral model assumed to best resemble the mating and childrearing structure of the deep past. More recently, however, this has given way to debate about whether our ancestors lived in multimale-multifemale polygynandrous (both sexes mating with multiple partners) groups such as chimpanzees (Gavrilets 2012; Hrdy 2009; Van Schaik and Burkart 2010), or were instead organized in polygynous, gorilla-like harems (Dixson 2009; Grueter et al. 2012), or had a hamadryas baboon-like structure with multiple single-male groups living together within a larger population. In fact, certain family and social characteristics may have more in common with some species of birds (Van den Berghe and Barash 1977), social carnivores and even social insects (Moffett 2019), than chimpanzees with whom we share much of our genetic makeup. Despite debate over the social organization from which the hominin line developed, most researchers agree that group living and multilevel societies are ancient features of human sociality.

Humans can be broadly described as living in multilevel societies organized in nested interacting levels (Grueter et al. 2012; Hamilton et al. 2007; Chapais 2008, 2011; Kelly 2013; Marlowe 2005a; Flinn et al. 2007), including conjugal families, extended families, multi-family residential clusters, bands, tribes, with layers added as political, demographic and hierarchical complexity increase. In principle, the number of nested levels is unlimited (Chapais 2013), including church, state, national and global institutions in contemporary industrialized societies. In contrast, small-scale societies are usually characterized as having local autonomy and authority, and truncated interactions with centralized or top-down institutions (see Note 1). Marriage, dispersal, provisioning and childrearing patterns, as discussed in the following sections, shape family formation, and are the source of its variation and relationship to more inclusive social entities. It is important to point out, however, that any generalized formulation of human social structure, or characterizations of family living in traditional and industrialized populations have numerous exceptions.

1.2. Human and Nonhuman Primate Multilevel Systems

Human societies are comprised of what can be described as multimale-multifemale groups with multiple breeding females. This combination is rare in animal societies—the explanation usually given that rivalries between males competing for females prohibit social cohesion. Although societies composed of multiple breeding males and females are found among a few other primates, including chimpanzees and some baboons, several features distinguish the structure of human communities.

First, humans reside in multifamily residential clusters formed around long-term pairbonds (Chapais 2013). In all human societies, pairbonds are socially recognized through marriage unions, which have a range of monogamous (one male/one female), polygynous (one male/multiple females) and polyandrous configurations (one female/multiple males) that vary both within and across societies (Apostolou 2007; Beckerman and Valentine 2002; Flinn and Low 1986; Marlowe 2000; Walker et al. 2011). Pairbonds are certainly not the only form that intimate relationships take, and in no society are sex and parenthood likely restricted to marriage. The point here is that pairbonds exist in all human societies. They may have been favored for a variety of reasons, but are generally thought to be derived in the hominine line (Quinlan 2008).

Second, across human societies, men and women, adults and children do different tasks, target different resources and share the fruits of their labor. While this takes many forms and details vary widely cross culturally, the age and sexual division of labor is foundational to human subsistence (Alvard and Nolin 2002; Codding et al. 2011; Gurven 2004a; Gurven and Hill 2009; Kaplan et al. 1990; Kuhn and Stiner 2006) and childrearing (Hrdy 2009; Kramer 2011), two pillars of family formation. While the age and sexual division of labor is not unique to humans, the combination of pursuing different subsistence activities, cooperating in joint activities, sharing childcare, food, and other resources is unmatched among other primates.

Third, adults maintain often life-long relationships with their natal families and move easily between residential groups. This fluidity is an unusual primate trait, and serves to establish social networks across residential groups (Chapais 2008; Grueter et al. 2012; Rodseth et al. 1991). This has been extensively studied in hunter-gatherers, who form bands ranging in size from 35–80 adults and children, comprised of families of various descriptions, within which members cooperate in daily subsistence and childrearing activities (Gurven 2004a, 2004b; Hamilton et al. 2007; Marlowe 2005a, 2005b). Bands form more inclusive social entities who share the same dialect, communal access to resources, and gather occasionally for purposes of ritual, politics, trade, exchange information, gifts, mates, sports or warfare (Kelly 2013). This is unlike anything other great apes do.

Among chimpanzees, for example, males are the philopatric (staying in one's natal group after sexual maturity) sex and are highly antagonistic, sometimes lethally, toward males from other troops (Boesch and Boesch-Achermann 2000; Goodall 1986; Nishida et al. 1985; Watts and Mitani 2001; Wrangham 1999). Chimpanzee females, usually the dispersing sex, likewise often encounter acrimony when they join a new troop, tend not to form close female bonds (Gilby and Wrangham 2008; but see Lehmann and Boesch 2009), and are unlikely to see their mother or siblings after they leave their natal troop at maturity. Explanations for why humans are so varied in their dispersal and residence patterns and cultivate social bonds across multiple groups have centered on building networks to exchange food, raw materials, labor (Gurven 2004b; Gurven and Hill 2009; Hamilton et al. 2007; Hill and Hurtado 2009; Hill et al. 2011; Kaplan and Hill 1985; Kaplan et al. 2000; Kramer and Greaves 2011; Kaplan et al. 2000), information (Binford 2001) and marriage partners (Kramer et al. 2017).

Ties across multiple groups are possible because humans recognize both maternal and paternal relatives and maintain relationships with their natal kin after dispersing. This interacting social structure where individuals can move between groups rests on the vast relationships that humans keep track of, a dexterity feasible only with spoken language. The complex kin terminologies, which are foundational in traditional societies, allow people to monitor relations across both generations and over large geographic areas (Meggitt 1962; Berndt and Berndt 1964; Schefler 1978).

1.3. Characterizing the Human Family

What then of the family? Defining the family is elusive in a "you know it when you see it", but a difficult to delimit way. Common considerations from sociology, anthropology and psychology are the family as a lineage, or line of descent; a grouping of a consanguineal (blood relatives) and affinal kin (in-laws), the basal economic unit or unit of production and consumption, and the group of people that live together in the same structure or property. Many researchers place marriage and kinship at the organizational core of the family, with marriage assembling not only partners who cooperate, but networks of kin and their associated alliances, obligations and responsibilities.

Ethnographic studies give an insider's view of how people assort in small-scale societies. Even so, circumscribing the family is not without its challenges. Ethnographers can ask and readily get answers to questions such as who are your parents, grandparents, children and siblings, and from this information construct kinship and relatedness trees. One can also ask and observe who shares with whom, who works with whom, who cares for children, who occupies a residential structure or compound, and a range of more qualitative questions. But how to identify a family as a unit with discrete membership is less straightforward. For example, in the Pumé language (hunter-gatherers living on the llanos of Venezuela), there is no equivalent term for family (Box 1). When away from camp and a Pumé encounters another, he or she is greeted first with a general kinterm, roughly translated as 'my female relative' or 'my male relative', which signifies their identity as Pumé, and then specifically through kin ties, by association through parentage, siblings or children. The Pumé do not use individual names to address each other and kin terminology is sufficiently complex to reference the 500 or so band members that they might encounter over their lifetimes. But no moniker exists for 'my family'.

As a root grouping, the conjugal family is identifiable through biological parentage, and the ethnographer can record the composition of residential units and sharing groups (often called households). But membership becomes blurry at the edges because the nuclear family in most societies outside of the industrialized world is seated in a gradient of relationships—extended families or joint families, which are nested in larger entities that interact to different degrees, depending in part on geography and propinquity.

While definitions are seldom satisfactory, and it is difficult to observe the family in isolation from other social entities, how the family is circumscribed does become important in analytic and modeling decisions. People assort in a range of groupings depending on whether the aim is parenting, meeting subsistence needs, or joint large-scale collaborative projects. The units of analyses might then be expected to differ with the research question.

Box 1. Savanna Pumé marriage and family.

The Savanna Pumé are a group of mobile hunter-gatherers, who live on the llanos of west-central Venezuela (Kramer and Greaves 2017; Kramer et al. 2017), and are typical of other tropical foragers in many aspects of their social and family lives (Marlowe 2005a, 2005b). They live in small, multifamily groups of ~60 adults and children. While polygyny occurs, most marriages are monogamous (13% of men and 9% of women have been polygynously married at some point during their lives). Individual marriages vary, with some couples having life-long monogamous marriages (64% of marriages), while others may marry polygnously for some years, divorce and remarry several times. Both males and females have autonomy when and whom to marry, divorce and remarriage decisions. Couples are considered married if they are sexually engaged, and many adults (40%) reenter the marriage market after their first marriage dissolves due to either spousal death or divorce. Girls have their first children on average in their mid to late teens, and have 5 to 6 children over the course of their reproductive years. Child mortality is quite high, with many children not surviving the hardship of their first wet season (Kramer and Greaves 2007). Household composition ebbs and flows in annual cycles. Multiple families aggregate during the wet season into long-houses and disaggregate into separate brush shades during the dry season. Sharing relationships and work parties likewise are structured differently at different times of the year, and for different resources (Figure 1). An individual's relationship to the larger group of Savanna Pumé is accorded through kinship, which include terms for closer and more distant relatives, consanguineal and affinal distinctions, older and younger siblings, ascendant and descent kin. Many Pumé maintain a life-long affiliation with a particular band, and frequently visit relatives who live in other bands.

Figure 1. Three Savanna Pumé group views: (**a**) a conjugal family, (**b**) a female foraging party group composed of kin and nonkin from several families and (**c**) an extended family.

1.4. Ancestry of the Family

As a broad historic trend, the family has diminished in size, shape and function as many of its economic, educational and religious roles are replaced by church and state. The family as a conjugal unit is quite recent and prevalent only in some parts of the world (Sear 2016). For example, prior to the 18th century, European languages did not include a term for the nuclear or biological family. The Roman word *familia*, equivalent to house, referred to the residential group, but no specific term was given to the parent–child unit (Gies and Gies 1987). But what is known of the family in the distant past?

Most animals are solitary except for forays to mate or raise offspring until they fledge or wean. Getting together to mate or parent may be transient or enduring, depending on species. Although the family leaves no unambiguous fossil or archaeological record, living great ape social organization gives clues about the evolutionary hurdles that were overcome for multifamily groups to emerge and live together in relative amicability.

If the ancestral hominin society was chimpanzee-like with a multimale-multifemale group composition, the challenge would have been to establish stable mating bonds within a polygynandrous breeding system. For both males and females to 'agree' to pair-bond, ensure paternity and biparentally invest in offspring is no small feat, which is why as a family system it is so rare in mammals (Clutton-Brock 1991; Lukas and Clutton-Brock 2012). If the ancestral system was gorilla-like instead (Geary and Flinn 2001), the transition would have involved coalescing single- or multi-male harems into multifamily communities, which would require an equally tough shift in dampening male competition, constraining polygyny and developing mutual regard for each other's pairbonds. Either scenario likely occurred over millions of years and in multiple stages (Chapais 2013).

Less often considered is the possibility that family systems emerged from matrifocal groups. Elephants, whales, lions and some social carnivores are examples where mothers benefit from raising young in nursery or crèches groups (Lukas and Clutton-Brock 2012). In these communal breeding species, it is advantageous for nursing mothers to stick together because young are more protected from predators in larger groups, rather than to share care or feeding per se. In humans, cooperative interactions between mothers and offspring extend well beyond weaning, and the formation of groups of mothers and her juvenile children or of multigenerational mothers may be a critical but understudied step in the evolution of the human family (Kramer 2011, 2014; Kramer and Otárola-Castillo 2015).

2. Behavioral Ecology Approaches to the Family

Behavioral ecology developed within the field of evolutionary biology in recognition that behavior, as well as biology, is shaped by natural selection. Its application to humans provides a theoretical and empirical basis to evaluate those aspects of social and family structure common across societies due to a common evolutionary past. The emphasis on the interaction between ecology and behavior, and consequently on phenotypic plasticity (West-Eberhard 2003) also gives a framework to generate predications about family variation across environment, history and culture.

2.1. Life History Theory

The diversity of marriage, family and kin arrangements can be seen as varied responses circumscribed by a shared biology and life history. Life history theory, an integral component of behavioral ecology, views species diversity as the outcome of different ways to allocate time, resources and energy across the life course to maximize fitness. Having a hybrid of both a slow and a fast life history shaped the central problem human mothers face, to which the family, at its simplest a small cooperative group, is a solution.

Because humans grow slowly, mature late and live long lives, they are often characterized as having a slow life history (Charnov and Berrigan 1993; Gurven and Walker 2006; Walker et al. 2006; Bogin 2006). As a species-specific pattern, human children take two decades before they start their own reproductive lives, which is long for a primate. In addition to growing slowly, human children are more likely to survive. In hunter-gatherer societies, a child is almost 40% more likely to survive to reproductive age than a chimpanzee juvenile (Gurven and Kaplan 2007; Hill et al. 2001; but see Wood et al. 2017). But with some interesting nuance. Whereas little difference is evident between hunter-gatherer and chimpanzee infant survivorship (both are ~80%), gains in juvenile survival (from weaning to reproductive age) differ markedly. Although variation exists among studies, a human forager is almost twice as likely to survive to age 15 than a chimpanzee. Most explanations for the higher human probability of survivorship point to the effects of caring for juveniles. Among other great apes, after weaning, food sharing is minimal between adults and offspring, and juveniles provision their own calories. Along the hominin line, a different life history strategy was favored; infants were weaned early and young juveniles were fed.

Once mature, natural fertility (where women do not use parity-specific birth control) mothers make up for late maturity and a slow start by reproducing quickly (what would be called a fast life history). Nonhuman great ape mothers nurse their young on average for 4–6 years (Robson et al. 2006; Thomson et al. 1970). Comparatively, in a society without bottle feeding, mothers fully wean babies between the ages of 2 and 3 (Kennedy 2005). The relatively young age at weaning is closely associated with short birth intervals. In natural fertility societies, children are spaced on average ~3.1 years apart, a birth interval two to three times shorter than that of other great apes (Kaplan et al. 2000; Lancaster et al. 2000; Thompson et al. 2007). Combined, a hybrid life history of a slow maturation and a *fast-reproductive* pace commit mothers to raise multiple dependents of different ages—something a nonhuman great ape mother rarely does (Lancaster 1997). This evolving life history, which took millions of years, at some point in the past would have posed a time allocation and economic problem for mothers (Kramer and Otárola-Castillo 2015); how to find the time and resources to care for multiple dependents of different ages? How this was solved in many ways is what sets the human family apart from other primates.

2.2. Kin Selection and Dynamics within Family

The primacy of kin relations to family formation has a long history of study in anthropology and the social sciences. Kin selection theory, developed in evolutionary biology in the 1960s (Hamilton 1964; Smith 1964), added a genetic logic to the centrality of kin relations in social structure. Kin systems can be seen to serve two main functions: identity and cooperation.

Family formation at its most fundamental rests on being able to recognize one's parents, siblings, and other relatives (Box 2). In addition to those closest to us, humans are amazingly astute in their capacity to identify kin and have boundless ways to codify familial membership. For example, griots of Malian West Africa preform genealogical recitations, which may reach back many generations, as a way to legitimatize relatedness (Irvine 1978). For most mobile hunter-gatherers, kin identity carries important information when meeting strangers, allowing them to communicate their connection, in a sense as a letter of introduction, to gain access to resources or territory outside one's home range.

Kin identification, enabled through language and elaborate kin terminology, concretizes in and out groups to establish rules for marriage and incest avoidance. In this regard, the diversity of marriage and residence norms is neither capricious nor arbitrary cultural variation, but based in biological logic and mediated by socioecology. For example, the use of mother to refer to one's mother as well as aunts is common in many hunter-gatherers (Schefler 1978). People who use this terminology are not biologically naïve; they know the difference between their birth mother and their social mothers. These terminologies recognize the close genetic relationship children have to both their mothers and aunts, and reify equivalent support relationships that can be counted on, in high mortality or marginal environments (likewise, where paternity is relatively certain, father may be used to refer to one's father and uncles).

Box 2. Kin recognition.

Some abilities to recognize kin are quite ancient and shared across primates, while others arose more recently in the hominin line. At its most basic, giving birth at different times and in different locations is requisite to recognize one's mother, and hence one's siblings. Breeding and dispersal patterns have further effects on being able to recognize kin. Multi-generational maternal kin are identifiable if females are philopatric. However, recognition of paternal kin depends on some form of pairbonding or means to identify fathers and grandfathers. Human life history further extended the ability to recognize kin. Because the time to maturity is long and birth intervals are short, mothers often raise an infant, weanlings and juveniles simultaneously, which enables strong bonds to form between mothers and offspring, and between siblings (Chapais 2008). Complex kin systems, which are highly developed in traditional human societies, greatly expand the ability to distinguish a range of maternal and paternal relationships (social, step, biological and classificatory kin). Sophisticated means to recognize kin today includes genetic testing.

Kin selection is often invoked as the theoretical principle explaining cooperation and sharing within families. Hamilton (1964) elegantly simple formula offered an explanation for the widely documented empirical observation across species that individuals favor assisting kin, and close kin over distant kin. In its application to humans, kin-bias is particularly evident for childcare, which tends to be a family affair (Crittenden and Marlowe 2008; Henry et al. 2005; Kramer 2009; Leoneiti and Nath 2005; Scelza 2009; Weisner and Gallimore 1977). Likewise, a number of studies show that food is preferentially shared with relatives (Betzig and Turke 1986; Gurven et al. 2001; Koster 2011; Wood and Marlowe 2013; Ziker and Schnegg 2005).

While kin selection helps to understand why family members cooperate with each other, it does not explain why families emerge in the human line but not in other closely related species. Insight into why related individuals dependent on each other in ways not seen in other species can be drawn from the human life history of mothers raising multiple dependent young (see above), and the complexity of the human subsistence niche.

The complexity of human livelihoods means that only under rare circumstances does a person alone do everything needed to survive—a constraint that creates both opportunities and benefits for the division of labor (Kramer 2018). Simply said, there are insufficient hours in the day for any one individual to find food, procure and process it, make tools, construct clothing and shelter, care for children, and maintain social and information networks. Although many exceptions exist, a division of labor is an efficient means to solve the time allocation problem of not being able to do everything to survive, even if there are modest inequities, e.g., some individuals put more into the pot than they get out. Within families, divisions of labor occur across age, sex and skill. For example, from a young age, children are shared to with the expectation that they give back. Children may perform easier and less skilled tasks, but they produce other resources that both contribute directly to their own calorie requirements and are shared to others (Kramer 2005a, 2005b, 2011, 2014). Common children's activities include foraging for fruit and berries, digging small tubers, hunting for small game, fishing, collecting shellfish, harvesting grain, fetching water and collecting firewood, and also are the primary care-takers of their younger siblings (Kramer and Veile 2018; Kramer 2021). Within families, a sexual division of labor complements an age division of labor (discussed in Section 3.2).

Kin selection also predicts conflicts of interest within families. While close ties within families theoretically link economic interests among its members, families are also composed of players whose agendas are not necessarily or always aligned. Within the family, conflicts of interest arise between males and females, parents and children and between siblings (Sulloway 2008; Boone 1988; Hagen et al. 2001; Lawson et al. 2012; Lawson and Mace 2008; Penn and Smith 2007; Strassmann and Gillespie 2002). Theory would predict that, although interests may be more aligned among those closely related than outsiders, within kin groups, an individual will ty to optimize his or her own survival, well-being or reproduction, even if it may be detrimental to other kin.

2.3. Reciprocity and Mutualism Foregrounding Multifamily Cohesion

For much of human history, we lived in small residential clusters of interacting families (Chapais 2008; Chapais 2011; Kelly 2013; Marlowe 2005a, 2005b). What tips humans from interacting with those outside the family as potential competitors to collaborators? Here, theories of reciprocity (Trivers 1971; Gintis 2000; Nowak and Sigmund 1998) and mutualism (Clutton-Brock 2002) developed in behavioral ecology help explain resource and labor pooling among nonkin and across families (Chapais 2001, 2006).

Although childcare, food sharing and coordinated labor activities are staples within families, ethnographers also often note that food commonly comes from outside the family (Gurven 2004a, 2004b; Gurven and Hill 2009; Hamilton et al. 2007; Hawkes et al. 2001; Hill et al. 2011; Kaplan and Hill 1985; Kramer and Ellison 2010; Murdock 1967; Wiessner 1982, 2002; Allen-Arave et al. 2008). As examples, among the Ache (foragers living in the forests of Paraguay), the majority of the meat one consumes is given from a nonfamily members (Gurven 2004a, 2004b). When a Savanna Pumé forager returns to camp with food, a portion is distributed to as many hearths as is practical (e.g., how many is in part determined by resource size; a caiman, for example can be shared out to many more families than a small basket of roots). The most common explanation for resource transfers among nonkin is that it mitigates risk and smooths day-to-day and individual variance in food supply (Gurven and Hill 2009; Kaplan et al. 2000; Gurven 2004a, 2004b).

In addition to food production, pairing skills across families figures in collaborations among nonfamily members (Chapais 2006). Partiality toward kin, yet preferences for competence plays out among the Savanna Pumé foragers. Hunting parties are often composed of relatives, but good hunters (e.g., those with high return rates) also seek out other proficient hunters as friends and hunting partners, a preference noted among other groups of hunter-gatherers (Wiessner 2002). Friendships also tie reciprocal relationships across unrelated families. Among the Yucatec Maya, for example, while households that help each other are usually are closely related, a portion of supportive helping relationships also are between households with no kin or affinal affiliation (Hackman and Kramer 2021, this volume).

Other undertakings that are part of normal subsistence or produce collective goods—building a house, constructing an irrigation ditch, hunting large or migratory prey, tanning hides, excavating a well—require coordination, if not cooperation across the group. These types of large-scale projects simply cannot be performed alone (Alvard and Nolin 2002 for the example of whale hunting). With increased technological complexity, examples become abundant.

Cheating, self-interest and other collective action problems destabilize reciprocity from taking hold in many animals. The capacity for reciprocity not to break down, and for humans to live in interdependent multifamily groups, also derives in part from the complexity of human subsistence, long human lives and intergenerational reputations. Many reasons have been forwarded why reciprocity might exist (Gurven 2004a, 2004b). However, collective action problems may themselves be muted because many different kinds of resources and labor are exchanged. How does one equivocate the five fish received from one household, for the ten tubers they gave back? Or the value of the firewood received, for the fruit given in exchange? How do people value the time spent foraging for food for the time someone else spent processing it? Or that someone who is called upon to heal the sick, receives more meat than he contributed. In the modern setting, similar types of exchanges occur all the time. The point made here, is that the exchanges across many different currencies may stabilize reciprocity more than collective action models might predict. Generosity is highly valued among many hunter-gatherers (Marlowe 2010); if exchanges are grossly unequal sanctions are leveraged against cheaters. Because humans have life-long relationships and language to tell the story, reputations are inherited (Boehm 2012; Wiessner 2020), and cheaters do eventually pay.

3. Key Debates about Family Formation

What distinguishes the human family rests on species-specific patterns of mating and reproducing. These two domains, however, have generated substantial debate about the universality of certain traits and the ancestral conditions which gave rise to the modern family. Several of these debates are discussed below, with a focus on those that challenge conventional assumptions and have generated discussion on alternative approaches on the evolution of the human family.

3.1. Are Humans Patrifocal by Nature?

Debates about the origins of the family have surrounded which sex disperses at maturity, and whether families and multifamily groups are centered around maternal or paternal kin. The conventional male-centric view of both dispersal and residence has given way to more nuanced perspectives on family formation.

In many primate species, at sexual maturity, one sex stays, and the other emigrates and in time joins a new group—presumably in avoidance of incestuous breeding. Early human sociality is often described as male philopatric (meaning females dispersed at maturity) based on what chimpanzee do and what was presumed to be a universal hunter-gatherer dispersal pattern. This characterization persists in the nonanthropological literature, although it has long been disputed (Ember 1975; Lee 1979; Lee and DeVore 1968; Meggitt 1965; Murdock 1949; Turnbull 1965). In small human populations, dispersal varies considerably both individually and societally, with males migrating in some cases, females in others, both leaving home or neither leaving home in still others, and many groups expressing multiple patterns simultaneously (Alvarez 2000; Beckerman and Valentine 2002; Blurton Jones 2016; Kramer and Greaves 2011; Marlowe 2003b; Walker et al. 2011; Kramer et al. 2017). In other words, human dispersal is highly flexible.

Expectations about male philopatry led to further assumptions about patrilocality (a post-marital residence pattern, where women move to live with their husband's family) and patrilineality (descent and inheritance reckoned through the father and the male line) being the basis of human society (Radcliffe-Brown 1930; Service 1962; Steward 1955). Ethnographic reality, however, deviates from this expectation. A number of recent case studies point out that residence patterns among hunter-gatherers are flexible, facultative, and may change frequently across the life course (Marlowe 2010). Spouses often move between local groups, shifting residence between maternal and paternal kin throughout a marriage union (Alvarez 2000; Kramer et al. 2017; Marlowe 2004). For example, among the Hadza (Sub-Saharan hunter-gatherers), women prefer to live with their kin in the first years of marriage when they have young children to care for. As families mature, men prefer to live with their kin (Marlowe 2010, pp. 40–41; Wood and Marlowe 2011). Records of camp membership document that family composition varies with children's age and, moreover, may reassort daily, weekly and seasonally to include either maternal and paternal kin, a residence pattern referred to as bilocality or multilocality. Cross-cultural studies that synthesize much of the comparative hunter-gatherer data likewise show a preponderance of bilocal residence (Kelly 2013; Marlowe 2004; Kramer and Greaves 2011), disputing earlier expectations that the ancestral family is characterized by patrilocality and patrilineality.

Unless otherwise constrained, bilocality makes sense as the preferred residence pattern since it recognizes affiliations on both the mother's and father's side, maximizing the potential safety net options and alliances. Bilaterality is common in hunting and gathering economies where subsistence activities change throughout the year and bilateral networks permit greater geographic flexibility in residential mobility. In contrast, unilateral residential and descent kinship is more common among pastoralists and agriculturalists, who tradeoff excluding half their kin with building strong alliances with the other half (Van den Berghe 1990; Walker and Bailey 2014). At its simplest, at some demographic scale, coordinating with, sharing food, exchanging labor obligations and responsibilities with an ever-expanding group of people becomes impractical. While unilineality limits commensal group size and obligations, at the same time it creates large lineage affiliations for territorial defense, warfare (Chagnon 1979), water management and other large-scale collaborative projects.

3.2. Is Male Parental Investment the Driving Force in the Origin of the Family?

In few mammalian species do females and males parent together. The limitations usually cited are paternity confidence, e.g., males need to know that they are the father to invest in offspring, and that their help needs to make a difference to offspring quality. Consequently, habitual male care is typically associated with monogamy (social monogamy, if not biological monogamy), a combination that occurs in ~5% of mammalian species (Clutton-Brock 1991; Lukas and Clutton-Brock 2012). Although more common in the primate order (Lukas and Clutton-Brock 2013; Opie et al. 2013), male parental care is not observed in chimpanzees and bonobos, species to whom humans are most closely related.

Arguments about the evolution of paternal care in the hominine line are closely aligned with assumptions about the sexual division of labor. Here, the causal arrow is debated. The need for male help was traditionally argued to be the predominant pressure driving monogamy (Clutton-Brock and Harvey 1977; Kleiman 1977), while recent research makes a strong case that paternal investment is a consequence of monogamy (Boomsma 2009; Lukas and Clutton-Brock 2013; Opie et al. 2013). No doubt a division of labor is an efficient means to manage a household and raise young (Becker 1981; but see Sear 2021). Although fathers generally help little with childcare, they are important economic contributors in many contemporary contexts (Gurven and Hill 2009; Kaplan et al. 2000; Marlowe 2007), both in traditional and industrialized societies, and their help is linked to improved survivorship and well-being (Gurven and Hill 2009; Hill and Hurtado 2009; Kaplan and Lancaster 2000; Lancaster et al. 2000; Marlowe 2003a, 2003b; Meehan et al. 2013; Quinlan and Quinlan 2008). However, as an evolutionary argument, the focus on male investment may oversimplify reasons why families formed in the first place. The division of labor literature overwhelmingly has centered on male specialization and hunting. However, this narrowly focuses on a food that is too ecologically variable as a dietary constituent to be broadly explanatory, and ignores the many other ways that the division of labor figures into daily lives. For example, for Savanna Pumé foragers, terrestrial game constitutes approximately 5% of the diet, and rather than being about meat, the division of labor is driven by women's foods (fruit and roots), food processing and domestic tasks. Focus on the sexual division of labor as the impetus for family formation also overshadows the importance of the age division of labor, which is critical in incorporating older and younger generations into family groups (Kramer 2011).

3.3. Cooperative Breeding as an Alternative Evolutionary Basis for Family Formation

Mothers, or mothers and fathers, are often challenged to alone raise the multiple dependents that are characteristic of our life history. For example, where resource flows have been observed in Maya families, fathers contribute as much time as mothers to economic activities that support children (Kramer 2009). Nonetheless, when parents have more than four children, which they often do under natural fertility conditions, the work effort of mothers and fathers is insufficient to meet family consumption. In the Maya case, their children's help filsl this gap (Kramer 2005a, 2005b; Lee and Kramer 2002). Recognition that others help parents (often their own children, older generations or collateral kin) led to an important recent shift in thinking about family systems. Rather than a focus on the pairbonded parent–child unit, cooperative breeding recognizes that many caregivers help mothers in addition to fathers (Hrdy 1999; Ivey 2000; Kramer 2005a, 2005b; Kramer 2010; Mace and Sear 2005).

Cooperative breeding is an unusual reproductive system in which group members other than parents help to raise offspring who are not their own. Although expressed in diverse taxa, cooperative breeding is rare, occurring in an estimated 9% of bird (Cockburn 2006) and 3% of mammalian species (Russell 2004). Allocare situationally occurs across a range of primates, however, cooperative breeding is not a shared great ape trait (Hrdy 2005; Hrdy 2016; Lancaster and Lancaster 1983). Hence, its emergence in the human lineage marks a significant departure in parenting strategies and may signify an alternative pathway to family formation.

Cooperative breeding unites many traits that characterize human modernity: life history, pooled energy budgets, family and group structure (Kramer 2010; Kramer and Ellison 2010). Distinct theoretical arguments have been made for the evolutionary importance of juvenile helpers (Kramer 2011, 2014; Kramer and Otárola-Castillo 2015) and grandmothers (Alvarez 2000; Hawkes 2003; Hawkes et al. 1989; Hawkes et al. 1998; O'Connell et al. 1999). The help mothers receive benefits them by alleviating time constraints, which arise from supporting multiple dependents of different ages—infants, young children and old children, who require different kinds of resources and time investments. For example, Maya mothers who raise large families only provide approximately 40% of her family's consumption, and approximately 50% of infant care, the balance of which is met by the help of her children and husband (Kramer 2005a, 2005b; Kramer and Veile 2018). In managing the competing demands of multiple dependents, mothers in many societies find the extra time to devote to young children, particularly nursing children, by downwardly adjusting their investment in economic activities—foraging for food, time spent in agricultural work, domestic activities or wage employment, depending on their livelihood (Hawkes et al. 1997; Hames 1988; Hurtado et al. 1985; Hurtado et al. 1992; Kramer 2009; Marlowe 2005a, 2005b). The help mothers receive also has a demonstrated positive effect on their children's health, growth, and well-being (Kramer 2010, Table 2), as well as increasing maternal fitness primarily through enabling mothers to give birth at shorter intervals and improving child survivorship (Kramer 2009; Lahdenpera et al. 2004; Lee and Kramer 2002; Sear and Mace 2008).

In addition to her own children and mother, aunts (usually mother's sister), grandfathers, other relatives and nonrelatives may also help to provide childcare, food, shelter and other assistance. Human children are well adapted to having nonparental helpers, so much so that they have positive effects on children's development. Exposure to multiple caretakers expands a child's social sphere and is associated with cognitive and psychological benefits (Pope et al. 1993; McKenna 1987; Wilson 1986; Weisner and Gallimore 1977; Isler and Schaik 2012), such as emotional regulation and shared intentionality, which is the basis for theory of mind and other uniquely human prosocial abilities (Burkart et al. 2009).

4. Conclusions

In sum, the evolutionary arc of family formation illuminates how unusual the human family is as a social form and the diversity its shape takes. Because individuals commonly maintain life-long relationships with their natal families, despite marriage, emigration and establishing families of their own, it sets the stage for expanding spheres of social interaction. While the nuclear family norm of parent(s) and dependent children prevails in industrialized societies today, it was likely rare in the past. A behavioral ecology approach to family studies is a useful framework to appreciate family diversity past and present and reconsider patrifocal views of how families form.

Human life history and the central dilemma of mothers—how to find enough hours in the day to support dependent offspring—is foundational to understand why cooperative relationships between mothers and children, spouses and others emerged in the human line, and no doubt resonates with mothers today. In post-industrial societies, mothers face new challenges to the same allocation problem of providing competent childcare while finding time for economic and domestic activities—a tradeoff as relevant today as it was in the past. As a theoretic starting point, kin selection, reciprocity and mutualism allow us to square preferences within families, and why family members are often more willing to cooperate with each other than outsiders. It also allows us to understand why there may be conflicts, and why the family is often not enough and we live in communities of multifamily groups. Human-specific features of family life such as the age and sexual division of labor, pairbonds, sharing, reciprocity and cooperative breeding can be comprehended in the context of the complexity of human livelihoods in both traditional and industrial societies. The cross-cultural empirical record supports that the family is a highly flexible social organization that is transiently, culturally and ecologically adaptable, adynamic less transparent from traditional positions on patrilocality, patrilineality and male parental care. This is not to say that these features of family formation are not evident and important in the human record, but other perspectives such as cooperative breeding may further a more inclusive perspective.

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Notes

[1] For simplicity *industrialized* is used throughout to refer to contemporary industrialized nation-state societies, in contrast to *small-scale* or *traditional societies*. Small-scale society here refers to small rural communities, often indigenous, or culturally, ethnically homogeneous, that while existing today within nation states have autonomy in terms of economy and governance and rely largely on local production for subsistence. Defining small-scale societies has been approached from several perspectives: (1) demographically, they are small communities; (2) they have minimal connection to market forms of energy and national supply chains; (3) their social and informational networks are predominantly local and noninstitutional. *Nonindustrial* is sometimes used as the preferred term, however it suggests a historical trajectory and takes the perspective of "us compared with them," rather than the other way around, which is more evolutionarily appropriate. Unfortunately, no term describes either society fully, in its variation or without bias.

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social sciences

Article

The Role of Spousal Separation on Norms Related to Gender and Sexuality among Himba Pastoralists

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Abstract: The gender-specific labor demands of arid pastoralism often lead to spousal separation. Men typically respond in one of two ways: engage in mate guarding tactics, or loosen restrictions on female sexuality. Among Himba pastoralists in northwest Namibia, the latter strategy is dominant. Rooted in a history of matriliny, Himba have strong norms promoting female sexual autonomy. We propose that these conditions, combined with a stochastic resource base, have led to women utilizing a combination of formal and informal partnerships to meet their needs and the needs of their children. Aspects of Himba socioecology also increase the costs of mate guarding for men and lower the costs of extra-pair paternity, further bolstering a concurrency strategy. Using a mix of quantitative and qualitative data, we show how spousal separation, female autonomy, and concurrency are linked, and suggest that in this harsh environment having a mix of formal and informal romantic partners may be less costly and more beneficial than a system of monogamous marriage.

Keywords: spousal separation; female autonomy; multiple mating

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1. Introduction

The sexual division of labor has long been viewed as a core element of human social organization (Durkheim 1933; Becker 1985; Murdock and Provost 1973). Husbands and wives form complementary partnerships, taking on different tasks linked to production and reproduction, driven by the common goal of efficiently raising joint offspring (Gurven et al. 2009). At times, this kind of labor specialization requires that spouses spend significant periods of time apart, for example on multi-day foraging trips, while moving livestock between camps, or when engaging with long-distance trade networks. When this happens, it raises a conundrum for men: the very duties of fatherhood that drive him to leave are those that put his future paternity at risk. In order to balance these competing demands for production and reproduction, social norms are often put in place that restrict women's autonomy and monitor their behavior. These restrictions are widely viewed as efforts to prevent paternity loss while spouses are apart. However, the relationship between spousal separation and female autonomy is not always so clear. There are instances where instead of restricting women's autonomy, sexual freedom is tolerated, or even encouraged. This alleviates the costs of mate guarding for men and their families, but increases the chance that they will invest in children who are not biologically their own. This second situation is less common, but may be adaptive in some circumstances. To explore this possibility, we provide a case study of one population of Himba pastoralists living in northwest Namibia. In this community spousal separation is common, extra-pair paternity is frequent, and the majority of men and women have concurrent marital and nonmarital partnerships. By looking at concurrency within its larger social context, we gain a greater understanding of why these less conventional marital norms may arise and thrive in certain settings.

1.1. Spousal Separation in Socioecological Context

A common response to the dilemma of spousal separation is the enactment of various social norms that inhibit women's autonomy. Placing restrictions on women's behavior and movements constrains their ability to engage in extramarital relationships and reduces the risk of paternity loss. The manifestations of these restrictions vary across cultures, from monitoring women's movements (Dickemann 1979) and their menstrual cycles (Strassmann 1992); to claustration and veiling (Pazhoohi et al. 2016); to extreme physical disfigurement such as foot-binding, infibulation, and other forms of genital mutilation (Mackie 1996); to intimate partner violence (Stieglitz et al. 2018). But evolutionary scholars have long contended that the underlying motivation for all of these practices is the same: to prevent women from engaging in nonmarital sex, and thus prevent a misallocation of paternal investment (Wilson and Daly 1995; Smuts 1995; Buss 2002).

Nomadic pastoralists are prime examples of this relationship, as they are particularly prone to frequent spousal separation and often enact limits on women's autonomy (Randall 1995). Pastoralism typically occurs in marginal environments, with marked seasonality and limited periods of adequate rainfall. In these cases, herders must move their animals to fodder, rather than bringing fodder to the animals. Migration allows herders to maximize access to pastureland, either by shifting the entire herd seasonally, or by splitting the herd across camps when forage is limited (Dyson-Hudson and Dyson-Hudson 1980). Although mobility strategies vary across groups, typically men are more mobile than women, both in undertaking major shifts in locale, as well as in their daily movements. They are also more likely to spend nighttime hours outside of camp, protecting the herd. In a cross-cultural study, Becker (2019) sought to examine the relationship between pastoralism and female sexual autonomy, predicting that individuals from pastoralist groups will be more likely to practice social norms that inhibit female mobility and sexuality than those with more sedentary modes of production. Using a multinational dataset, she found that women from traditionally pastoralist ethnic groups were more likely to have undergone infibulation and have more restricted mobility, were more tolerant of intimate partner violence, and adhered to more restrictive norms about their sexual behavior. The paper goes on to show that it is male absenteeism in particular, rather than patriarchal structures, that led to the high frequency of these behaviors.

Despite this overall trend, not all nomadic pastoralists fit the pattern that Becker illuminates. Data from the Standard Cross-Cultural Sample show that almost half of pastoralist cultures are reported to have moderate to high levels of female infidelity (Scelza 2013). Most famously, Nuer pastoralists traditionally maintained several forms of marriage, recognizing the distinction between *pater* and *genitor*, and allowing for women, both formally and informally, to have multiple partners (Evans-Pritchard 1951; Gough 1971). Even in cultures that fit the correlation Becker finds, the picture is complex. Among Maasai, who practice female circumcision and have strong patriarchal norms, extramarital partnerships are common. As one ethnographer writes, " … lover relationships are an all- pervasive part of *IlOitai* society. I knew of no Maasai woman in the Ilkerin area who had not had at least one lover during her married life which shows that the practice is basic to *IlOitai* social existence" (Knowles 1993, pp. 198–99). Spousal separation is key to the enactment of these relationships, "Because husbands can be away for weeks at a time, and everybody knows who is where, there is little chance of the lovers being caught" (Knowles 1993, p. 199).

1.2. The Costs and Benefits of Concurrency

There is no clear consensus about why spousal separation leads to strict norms for sexual behavior in some places and more relaxed norms in others. A behavioral ecology perspective would suggest that we might find clues by comparing the costs and benefits of different strategies for both men and women. For men, there are two main types of costs: the costs involved in keeping one's current partner faithful (mate guarding), and the costs of lost paternity, when children born to their wives are fathered by someone else. The costs to women reflect similar trade-offs. If she attempts a non-marital partnership, there is a risk of harm to her or her children. If she remains faithful, she might miss out on important resources or opportunities that could better her situation. These costs must then be compared with the benefits of staying versus straying for men and women, and those benefits can be material, social, or genetic (Scelza 2013; Walker et al. 2010).

First, let us consider weighing the costs of mate guarding with the costs of lost paternity. One way this has been clearly exemplified is through studies of inheritance systems. Where inheritance is patrilineal, the costs of (mis)investment in non-biological kin are greater. When men can acquire transferable wealth, they are incentivized to pass it to their close kin, sons being the most frequent recipients. However, this only makes sense when those sons are likely to be his. In this case, expending energy on restricting female sexuality in order to ensure paternity may be well worth the cost compared to the potential loss of passing one's wealth on to a non-biological relative. It is likely for this reason that we find frequent associations between patriliny and restricted female autonomy (Barry 2007; Hendrix and Pearson 1995). This is also believed to be one reason why matriliny and pastoralism rarely co-occur. As groups in sub-Saharan Africa shifted their mode of production from horticulture to pastoralism (i.e., heritable wealth increased), they also typically shifted from matrilineal to patrilineal social structures (Holden and Mace 2003). The increased fitness returns associated with male biased inheritance are implicated in the shift to pastoralism, likely driving mate guarding behaviors and other practices to avoid lost paternity.

Patrilineal inheritance often co-occurs with virilocal residence, where married couples co-reside with the husband's kin. This can lower the costs of mate guarding at the same time that costs of lost paternity rise, because having kin available allows men to offset the time and energy involved in tracking their partners' whereabouts onto other interested parties. On the contrary, where matrilineal inheritance and uxorilocal residence coincide, women remain with their own kin after marriage, which makes mate guarding more difficult for men. The additional freedom (sexual and otherwise) that women have in these cases is less problematic given that paternity is irrelevant to the inheritance of property in this system.

Other sociodemographic factors can also affect the relative costs of mate guarding and lost paternity. For example, in some ecologies, child labor is a critical component of household production. Where children play important roles in labor or childcare, they are subsidizing part of their investment, which can mitigate the cost of lost paternity. Another contributing factor is the adult sex ratio (ASR), which affects the likelihood of finding partners (Schacht et al. 2017). Where women are in the majority, men can more easily absorb the costs of lost paternity because they are more able to find new or additional partners. Female-biased ASRs are generally associated with greater instability in partnerships and lower paternal investment (Guttentag and Secord 1983; Schacht and Mulder 2015). Conversely, when males are in the majority, mate guarding becomes more cost effective, because the chances of recuperating paternity loss, or finding another partner, are lower.

For women, concurrency is associated with other costs, which must also be considered. Engaging in non-marital partnerships can bring on physical, emotional, or economic harm. Betzig (1989) finds that infidelity, and specifically female infidelity, is a leading cause of divorce cross-culturally. In cultures where women's access to resources is intimately tied to their marital status, this can mean severe economic loss, in addition to social and reputational harm. Intimate partner violence (IPV) is also commonly linked to infidelity (Goetz et al. 2008; Daly et al. 1982). The risks of IPV and the potential losses associated with divorce vary by social system, just as they do for men. Women living in matrilineal, matrilocal societies tend to have a greater ability to divorce, and face fewer costs when they do (Takyi and Gyimah 2007). Maintaining matrilineal kin ties can also reduce the risk of spousal violence (Sedziafa and Tenkorang 2016). The risks of IPV and divorce, at whatever level, must be weighed against other risks associated with monogamy. For example, in ecologies where resources are stochastic, relying on a single man as your domestic partner may be more risky than having several men to draw resources from. Similarly, being monogamously married means that if her husband dies, a woman and her children could face a period of scarcity. The risks are compounded if there is a female-biased ASR, as the chances of remarriage are lower.

In addition to weighing different types of costs, we must also consider any benefits that can accrue from concurrent partnerships. For men, their own concurrency is likely to have a direct, linear effect on their fitness—more partners typically leads to more children. Among both the Ache and the Tsimane, higher-status men have more extramarital partnerships (Hill and Hurtado 1996; Von Rueden et al. 2011). Men can also benefit from women's concurrency, through social exchange, kin selection, or intrasexual competition. For women, the relationship between number of partners and number of children is less straightforward. Concurrency can bring social or material benefits that can positively impact her fitness (Scelza 2013; Hrdy 2000; Starkweather and Hames 2012). For example, Ache women with multiple spouses have more surviving children than those with only one spouse, likely due to the importance of men's resource provisioning (Hill and Hurtado 1996). However, the literature on direct correlations between number of partners and number of children is mixed (Borgerhoff Mulder and Ross 2019; Jokela et al. 2010).

Several ethnographic accounts exemplify how concurrency can benefit both men and women. Among Massai, it is allowed, and in fact encouraged, for men of the same age-set to share sexual partners, including their wives. The practice is believed to help cement the bond between men. Talle writes, "The intimacy between males in the Maasai society is forcefully expressed through the sharing of girlfriends when they are morans, and wives when they are married elders ... In some cases a husband may urge his wife to be impregnated by a certain age-mate of his, whom he admires either for his oratory skills, bravery, or certain physical qualities. The child strengthens the relationship between the two men ... " (Talle 1994, p. 283). The importance of these male alliances is believed to be critical to resilience in the marginal environment Maasai live in (Mwangi and Ostrom 2009). Women are also reported to benefit from these relationships. Knowles (Knowles 1993, p. 201) writes of women's lovers, "They can provide an informal network of people who may be called upon to help in a crisis." This can be particularly critical for women who are more resource insecure: " ... women whose husbands are poor in cattle may have to rely upon links with lovers in order to be able to feed their children .... A good lover is therefore not only a sexual partner but also someone who looks after their lovers' needs," (Knowles 1993, p. 200). Furthermore, similar to men, Maasai women forged relationships with their husband's lovers, becoming friends and relying on each other to exchange small items (Knowles 1993; Llewellyn-Davies 1978).

Among previous generations of Inuit, partner sharing was common, and as with the Maasai, the relationship of concurrency with social alliances and resources has been identified as causal. In this case, the links were between couples, who could rely on each other in times of crisis, and in the exchange of goods and services when needed. Wife exchange due to spousal separation was believed to be as much about having a subsistence partner as a sexual one (Guemple 1986). The relationship therefore was not just about sharing of spouses as sexual partners, but as domestic and productive partners.

Material benefits and social support have been linked to the practice of partible paternity, common to lowland south Amerindian populations. Under this practice, intercourse with multiple men is necessary to "build" the offspring, and as a result children can have primary, secondary, and even tertiary fathers. Numerous hypotheses regarding the benefits of this practice for men and women have been explored (Walker et al. 2010). Women may benefit by adding additional sources of support during pregnancy and after birth. In the Bari, a forager-horticulturalist population of Venezuela, women benefit by receiving additional resources from multiple investors, resulting in an increased likelihood of carrying pregnancies to term, and higher infant survival (Beckerman and Valentine 2002). Conversely, men may benefit through increased reproductive opportunities, particularly high-status men, or by solidifying alliances with friends and kin, similar to the Maasai practice described above.

1.3. Study Overview

In almost all of these examples, we see that reproductive decisions reflect local historical and ecological pressures. Human behavioral ecologists frame this in terms of conditional strategies (Cronk 1991). This approach can help us to understand why a particular pressure can lead to different outcomes in different settings. In this paper we examine how one particular pressure, spousal separation, can lead to relaxed norms about female sexuality, in stark contrast to the typically described pattern where spousal separation is associated with intensive mate guarding and restrictions on women's behavior prevails. To do this, we focus on the costs and benefits of three interrelated behaviors: mate guarding, female autonomy, and concurrent partnerships in a case study of Himba pastoralists, living in rural, northwest Namibia. We take a multimodal approach, relying on a combination of qualitative and quantitative data collected during a 10-year study of formal and informal relationships in one Himba community. We begin with a detailed ethnographic explanation of our three key factors. Following this, we present quantitative data from a series of experimental and naturalistic data. Finally, we bring these results together with historical and other qualitative data to make the case that high female autonomy, sexual freedom and concurrent partnerships are likely an adaptive response to spousal separation in this context.

2. Study Setting

The Himba are semi-nomadic pastoralists living in the northwest Kunene region of Namibia. Currently there are about 50,000 Ovahimba living in Namibia and Angola, though exact numbers are difficult to detect due to their high mobility. Our research has concentrated on a single community located about halfway between the regional capital of Opuwo and the border town of Epupa, where we have been working since 2010. At any given point the community has about 40 active households and about 1000 residents. General information about Himba culture, norms, and practices has been published elsewhere (Bollig 2006; Malan 1995).

2.1. Himba Demography and Family Life

Himba households consist of men, their wives, children, and additional extended kin, ranging from 8–25 members. Polygyny is common, and first marriages are arranged, ideally to first cousins. First marriages for women often occur in early childhood, but a change of residence does not occur until sometime after puberty, and many of these marriages are never consummated. Men marry for the first time in their late 20s, creating a large age gap between a man and his first wife. Subsequent wives tend to be closer in age, and are more likely to be "love matches." Divorce is frequent, and subsequent marital partners are often self-selected. There is a clear sexual division of labor present, with men engaging in livestock-related tasks, including taking cows to sources of water and out to pasture. Women primarily engage in domestic labor, including gathering firewood, cooking, and collecting water from distant waterpoints, as well as growing, harvesting, and processing corn and other domesticates from household gardens.

From an early age, children assist in various gender-specific domestic tasks, and child labor is vital to the household economy. Girls as young as five assist in childcare and cooking, and when older, assist with water and firewood collection, and help their female kin in the household gardens. Boys' primary responsibility is to herd goats, although girls may participate in this activity as well. As a result, girls are generally viewed as more valuable and useful in the domestic pursuits of the household. Fosterage is common, with 38% of women fostering out at least one child (Scelza and Silk 2014).

Girls' high labor value may partially explain the low adult sex ratio (ASR) found in this population, estimated as 0.71 (approximately 71 men for every 100 women) in one sample (Scelza et al. 2020c). Despite differences in household labor between boys and girls, Himba do not report any overt cultural norms that suggest a gender bias in parental care or investment. The drivers of this sex bias have not been systematically studied, but Himba anecdotally report higher child and infant mortality in boys, which may contribute to a low ASR. In sub-Saharan Africa, the high domestic value of girls, combined with potential economic value delivered through bride price, is thought to explain sex differences in childhood nutrition and mortality (Wamani et al. 2007; Svedberg 1990).

2.2. Spousal Separation

As is true in many pastoralist societies, there is a constant fluidity in Himba people's movements. Seasonal shifts are common, with most households keeping a main residence (*ozonganda*), as well as additional livestock posts (*ozohambo*). Elder male heads of household, unmarried men and women, and some children are most likely to shift to cattle posts. Polygynously married men might take one of their wives with them to the cattle post and leave the other behind; wives might also head to one of the small stock posts with their children, while their husbands stay with the larger stock. These movements affect the likelihood that both formal and informal partners will be in close proximity at different points in the year.

In addition to spousal separation that results from the duties of pastoral production, short- and long-term visits to kin also impact the likelihood that husbands and wives will be co-resident at any given time. In particular, because post-marital residence is patrilocal, women often return to their natal compounds, and most of the time they do this alone or with young children, but without their husbands. Previously, we found that 50% of married women in this area were co-residing with natal kin at the time of our census (Scelza 2011b). These visits often center on reproductive events. Women typically return to their mother's compound (or another close maternal relative) during the last trimester of pregnancy, and stay through the birth and for several months afterward. The length of their postpartum stay varies depending on whether they have a co-wife at home (allowing for a longer absence), the birth order of the child, and whether they had a difficult birth or recovery. However, in addition to these factors, lengthy peripartum visits can also indicate troubles in the marriage. We have heard multiple stories of women going home for a birth, and then choosing to stay, or their husbands never coming back to "pick them up," resulting in eventual divorce.

Shorter-term trips for ceremonies, funerals, and political meetings also occur frequently for both men and women. Women often travel without their husbands, either to visit kin in neighboring compounds, or for particular ceremonies or trips to town (Scelza 2011b). Previously, we showed that for a sample of 40 nights where men reported where they slept, on 24 (60%) they were sleeping away from home (Prall et al. 2018). These trips can be taken with or without one's spouse, but we have heard repeatedly from interlocutors that ceremonies and funerals open up opportunities to meet with informal partners.

Finally, there are everyday separations that should be considered. As is common in subsistence-based societies, the division of labor typically means that men and women take on different tasks, spending large parts of the day apart. For men, who are herding, this can extend into the night, as they look for rogue cattle, or travel at night or early in the morning to avoid the heat of the day. Although these separations are short, they do open up opportunities for visiting informal partners. One interlocutor reported to us that there is an informal rule that a man should not return home after dark if he is kept away late, as arriving at night could cause him to find his wife with her lover.

2.3. Female Autonomy

Himba are one of the few populations in the world that practice double descent, where individuals maintain membership in both a matriclan and a patriclan. In their specific case, the majority of wealth is passed matrilaterally between brothers and from mother's brother to sister's son, but there is patrilineal inheritance of residential property, as well as rights related to ritual practices (Gibson 1956).

Matriliny often co-occurs with greater autonomy and sexual freedom for women, but it is much more common in horticultural societies than among pastoralists and agriculturalists (Barry 2007; Hendrix and Pearson 1995). The combination of matrilateral inheritance and pastoralism among Himba is very unusual. Historically, shifts from horticulture to pastoralism are thought to accompany shifts from matriliny to patriliny (Holden and Mace 2003). It is possible that Himba are in a state of disequilibrium, and will eventually also transition to a patrilineal inheritance system, but this has yet to occur. For now, the link between high female autonomy and matrilateral inheritance remains, although there is some evidence that men are shifting their preferences toward patrilineal inheritance (Scelza et al. 2019).

Currently, women have significant freedoms associated with reproductive decision-making. Although arranged marriages are common for first marriages, love matches, where the couple choose each other and then go to their families to formalize the arrangement, constitute the majority of second marriages. Women are also able to divorce with ease, and do so frequently. Births outside of marriage are not generally stigmatized and there are norms in place to name a “social father” for that child. An extensive fosterage system also provides a degree of support for women, as they often leave children born out of wedlock or from a previous union with their mothers when they remarry (Scelza and Silk 2014).

2.4. Concurrent Partnerships

In addition to the freedoms that Himba women have to divorce easily and (at least for second marriages) choose their spouses, it is also common and normative for both men and women to have non-marital partners (Scelza and Prall 2018; Hazel 2012). The widespread acceptance of this practice has led to the highest rate of extra-pair paternity ever recorded, with 48% of children fathered by someone other than the husband (Scelza et al. 2020b). A combination of genetic evidence and paternity assertions acquired through interviews also showed that both men and women are attuned to paternity, and both very accurately detect nonpaternity. However, this high rate of extra-pair paternity does not always lead to the titration of investment that evolutionary scholars would predict. Both experimental and observational evidence has shown that Himba men place great value on their role as social fathers, even when they suspect they are not the biological father (Prall and Scelza 2020b; Scelza et al. 2020a). There is some evidence that spreading paternity across multiple partners positively impacts women's reproductive success, as women who have more children with lovers have overall greater fertility (Scelza 2011a).

There is also circumstantial evidence that informal partners are an important source of support for women when strategizing to provide for their children. In a study of partner preferences, women reported valuing resource-related traits in both formal and informal partners (Scelza and Prall 2018). In a study of partner preferences, we previously showed that women who had high resource needs were open to a greater number of potential partners (Prall and Scelza 2020a). This, combined with ethnographic evidence where women speak about the gifts that their lovers bring them, indicates that we should be paying more attention to the role of informal partners within broader networks of support.

3. Methods

3.1. Ethical Approval

This work was approved by the UCLA Institutional Review Board (#10-000238). Community support was granted by the Chief of Omuhonga, Basekama Ngombe. All participants provided oral consent.

3.2. Ethnographic Data

Informal, unstructured interviews and participant observation have been ongoing since 2010 when the project began. The reproductive history interviews described below often included follow-up conversations in response to structured survey questions, in order to gain context about people's reproductive decisions. Focus groups have also been held on topics including partner preferences, marriage decisions, polygyny, matriliny and inheritance, parental care and biases in investment, and nonmarital partnerships. All the quoted statements included in this paper occurred during either the reproductive history or female autonomy interviews described below, or during formal focus groups.

3.3. Structured Interviews

Semi-overlapping sets of interview questions were used with men and women in order to include data on the three main aspects of this study: spousal separation, female autonomy, and concurrency. These data were collected as part of a broader project on marital and family dynamics among Himba, and so were not constructed specifically for the purposes of this study. Each set of questions is described below, along with information on associated samples (see Table S1 for more details).

1. Spousal Separation: A set of 44 women were asked about the locations of each of their romantic partners over the previous 12 months. Their responses were given seasonally in four blocks: early dry (July–Aug), dry (Sep–Dec), early wet (Jan–Mar), and wet (Apr–Jun).

2. Female Autonomy: Three sets of questions on female autonomy were asked of both men and women. The first set asked about women's freedom of movement (N = 76). Four binary questions asked whether it was permitted for a woman to travel alone to the following places: her natal compound, a funeral, the clinic, and the regional capital of Opuwo. Next, an open-ended question asked how long a wife could visit her natal compound without her husband getting upset (N = 84). Finally, a group of men and women (N = 67) were asked about whether IPV was acceptable under different conditions, including having a non-marital partner. Additional details on these surveys are shown in the Supplementary Materials.

3. Tolerance of Infidelity: Himba men (N = 51) were presented with a vignette on female sexual autonomy. The vignette stated that a married Himba woman had a boyfriend who she sees regularly and has sex with. They were first asked a binary question of whether or not this was acceptable (i.e., socially normative). They were then asked what would happen if a woman did this. These responses were coded into categories (e.g., physical harm, reputational harm, multiple responses per man allowed) while maintaining the full text of responses for further context. Finally, the men were asked if they had ever seen or heard about this happening, and to describe what happened in an open-ended response.

4. Relationship Histories: Men (N = 42) and women (N = 81) were asked a set of questions about each of their current partners, including the length of the relationship and the last time they had sex (for information on a total of 303 relationships). Another set of men (N = 42) and women (N = 108), some overlapping with the previous sample, were asked about the most recent gift they had either received from (women) or given to (men) each of their current romantic partners. This resulted in data on 338 partnerships. When possible, we recorded details about the transfer such as the amount of cash, type of livestock, and type of food item.

5. Food Insecurity: Food insecurity was measured among women (N = 118) using a modified form of the cross-culturally validated household hunger scale (Deitchler et al. 2010). The survey asks five questions with a three-point response scale. Total scores can range from 0 to 10, with higher scores denoting greater food insecurity. Next, we measured diet breadth using a seven-day recall where women were asked if they had access to the following common foods over the last week: maize, sour milk, meat, melon, sugar, and other store-bought foods.

3.4. Analysis

Descriptive statistics are presented on the various aspects of female autonomy. For the binary questions on female mobility, responses were added together to form a summary score. Descriptive statistics were also presented on the female concurrency vignette and the relationship history and resource transfer data.

To analyze the resource transfer data, days since last gift (N = 319) was estimated using a Gaussian regression model of log +1 transformed days, with varying intercept by participant (N = 144), and age and partner type as predictors. Gift type was estimated using a categorical model, with age and partner type as predictors. Because some women reported multiple partners, varying intercepts by individual participants were also included.

To predict the effects of boyfriend age and marital status on time since last sex (log transformed +1, N = 150) with informal partners, a Gaussian regression was used, with age and marital status also employed to predict the variance on the outcome. Varying intercepts by individual participants were included to correct for multiple relationships by individual respondents.

To estimate the effects of concurrency on food insecurity a truncated Poisson regression was used to predict food insecurity score by age and relationship category. Because so few women were unmarried without a boyfriend, we constructed a categorical variable relationship category, dividing women between married with a boyfriend (N = 52), married without a boyfriend (N = 10), and unmarried with a boyfriend (N = 56). Women who provided both food security and concurrency data in multiple years were included for each year they were interviewed. In total, 158 responses were recorded. To correct for multiple responses per participant, a varying intercepts parameter was included.

All models were fit to *RStan* (Stan Development Team 2019) using the *brms* (Bürkner 2017) package in R, using three chains of 5000 iterations each, and convergence assessed using $\hat{r}$ scores. All models used regularizing priors. For some analyses, age was missing for several participants, so age was imputed using the *mi*() function. Posterior mean and 95% credible intervals (CI) of coefficients are reported below, and additional model results shown in the Supplementary Materials.

4. Results

4.1. Spousal Separation

Husbands and wives were found to be co-resident for 65% of the year, and women were in the same general location as their boyfriends for 78% of the year (Figure 1). Propinquity with boyfriends was more steady across the seasons, whereas spousal separation was most prominent in the start of the dry season, with co-residence during that period occurring less than half the time. Another way to measure spousal separation is by looking at the time since last sexual contact, as reported by both men and women. Himba men report that when they are in the same location as their wives, they have sex regularly (daily, or every couple of days if they have multiple wives) and our data seem to support that. The modal response in our dataset was sex within the last 24 hours (N = 70). However, we see a non-linear pattern after that (Figure 2 and Figure S1). The second most commonly reported answer was that the couple had sex “last month.” In total, 26% of individuals reported it had been at least 30 days since having sex with their spouse. This does not include another 14% who reported that they (or their wife) were pregnant or had recently given birth and so were practicing a period of peripartum abstinence, which in some cases lasted more than a year.

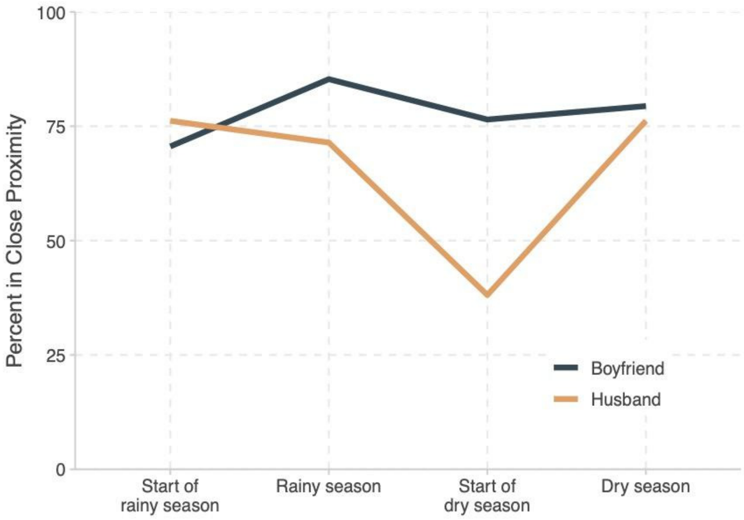

Figure 1. Co-residence by season. Women (N = 42) reported whether they were residing near husbands and boyfriends at four points over the previous year.

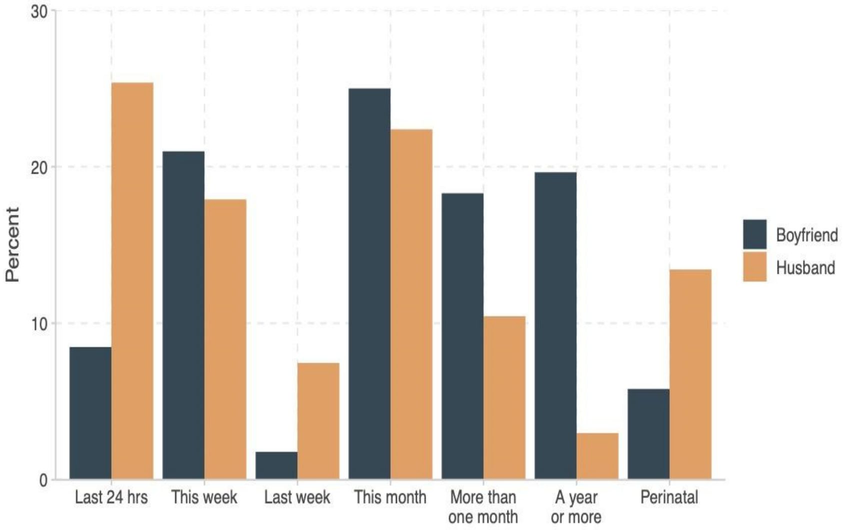

Figure 2. Time since last sexual contact with husband and boyfriend.

4.2. Female Mobility and Reproductive Freedom

When asked about their preferences, Himba had variable opinions about whether husbands should accompany wives when they travel (Figure 3A). Although the majority of both men and women reported it was acceptable for a married woman to take trips for functional purposes on her own (e.g., to the clinic or to town), they were more split on whether she should be accompanied for more social visits. Although 62.5% of women thought it was acceptable for a woman to go to a funeral or ceremony on her own, almost the same percentage of men thought it was not acceptable. Their opinions about visits to a woman's natal compound were also strikingly different, with 87.5% of women saying it was acceptable for her to visit her kin on her own, compared to only 50% of men. When asked about the appropriate length of a wife's visit to her natal compound, the median length of time was 30 days. Women and men differed in the length of time, where women reported a median time of 30 days, whereas men reported it was only appropriate to visit for a median of 14 days (Figure 3B).

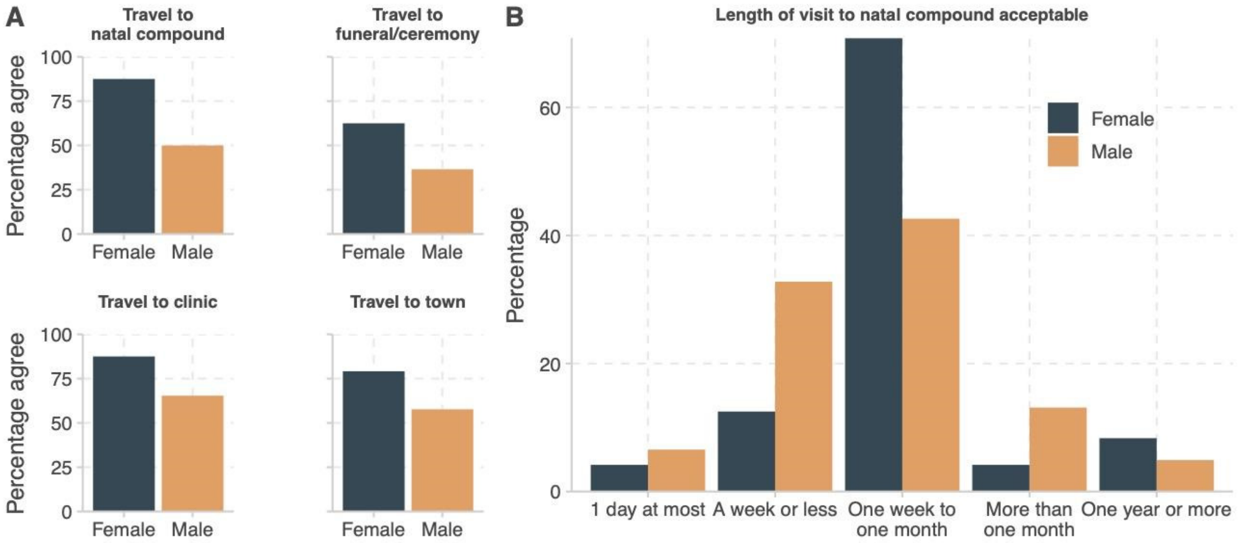

Figure 3. Views on freedom of movement. (**A**) Men's and women's responses to a binary question of whether it is acceptable to travel alone to a variety of places. (**B**) The acceptable length of time men and women feel a wife can visit her natal compound for a routine (non-pregnancy related) visit.

Men and women were also asked about the circumstances under which they deemed intimate partner violence to be acceptable. Across circumstances, women were more likely than men to report that a husband hitting his wife was acceptable (Figure 4). The only case where a majority of men said it was acceptable to hit a woman was if she neglected their children, and even here it was a slim majority (52%). Older respondents tended to find intimate partner violence in response to the queries less acceptable, although the effects of age tended to be highly uncertain, with credible intervals overlapping zero (Table S2). One exception was to the question on refusal of sex, where older participants rated IPV in response to wives' refusal to have sex as appropriate (standardized age: $\beta = 0.73$, CI = 0.13–1.39).

In our vignette study, Himba men were split on whether it was acceptable for a woman to have a boyfriend with whom she has regular contact (Figure 5). Older men were more likely to find this acceptable than younger men (standardized age: $\beta = 0.69$, CI = 0.10–1.31, Table S3), but overall a majority felt this was unacceptable. Despite this, an overwhelming majority (98%) reported that they were aware of this practice. When asked what would happen if such a relationship occurred, views were split across several types of punishment (Figure 5C), including physical harm (to either the wife or her boyfriend) and harm to the marital relationship, with 23.2% reporting that there would be no punishment at all.

4.3. Concurrency and Resource Transfers

Combining both women's and men's reporting of informal romantic partners highlights some important demographic patterns. Of 227 instances where a boyfriend's age and marital status are known, married boyfriends are 48.2 years old on average (sd = 14.7) compared to unmarried boyfriends at 31.6 years on average (sd = 11.7). Modeling of sexual recall data indicates that younger men are more likely to have had recent sex with girlfriends (standardized age $\beta = 0.90$, CI = 0.21–1.59), but marital status alone has no impact on time since last sex (married $\beta = -0.31$, CI = -1.16–0.51). However, interactions between boyfriend marital status and boyfriend age indicates that younger unmarried men are more likely to have had sex more recently, but that older married men show a shorter duration since last sex with girlfriends than do older unmarried boyfriends ($\beta = -1.15$, CI = -2.00–-0.31, Table S4). These results should be interpreted with caution, given the age differences between married and unmarried boyfriend means there are few instances of unmarried older men present in the data (Figure S2).

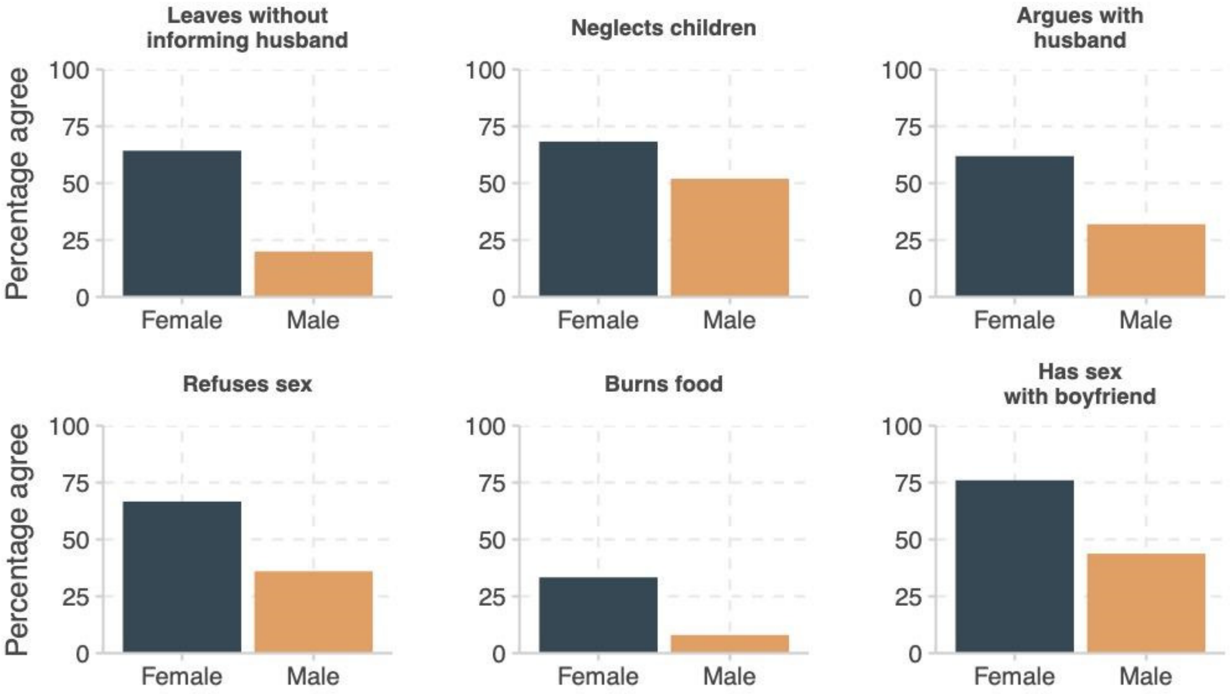

Figure 4. Views on reasons for intimate partner violence. Men and women were asked whether it was acceptable for a husband to hit his wife for any of the following reasons.

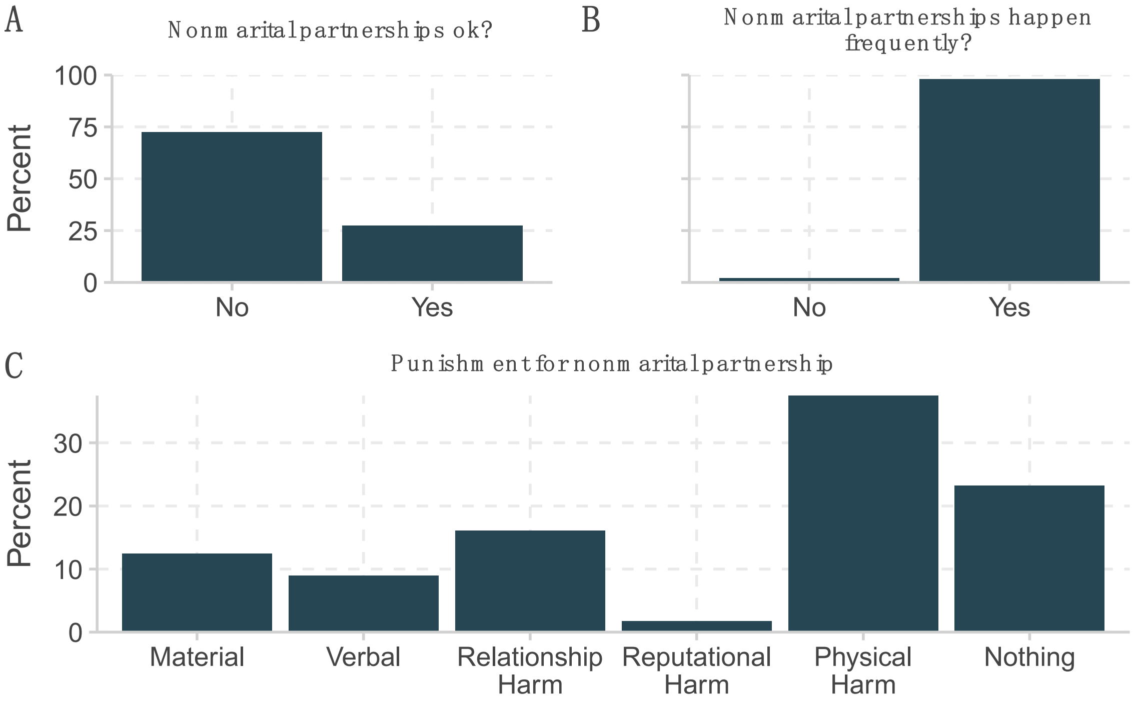

Figure 5. Views on concurrency. Men were asked (**A**) whether it was OK for a married woman to have a regular sexual relationship with a boyfriend, (**B**) whether they had heard of this happening, and (**C**) to list the potential repercussions for this act.

Women reported the date and type of their most recent gift from each romantic partner. On average, women received gifts from their husbands more recently than from their boyfriends (Figure 6), and this difference was supported by model results (effect of husband on log days: $\beta = -1.47$, CI = -1.87–-1.06, Table S5). Cash was the most common type of gift from both husbands and boyfriends, though it accounted for a greater proportion of gifts from boyfriends. Husbands were more likely to provide food and livestock whereas boyfriends were more likely than husbands to gift token items such as bracelets and beads (Figure 7, effect of husband on log-odds of gift: bracelets/beads $\beta = -1.92$, CI = 3.25–−0.69; food $\beta = 0.73$, CI = 0.40–−0.05; livestock $\beta = 1.63$, CI = 0.37–2.85, Table S6).

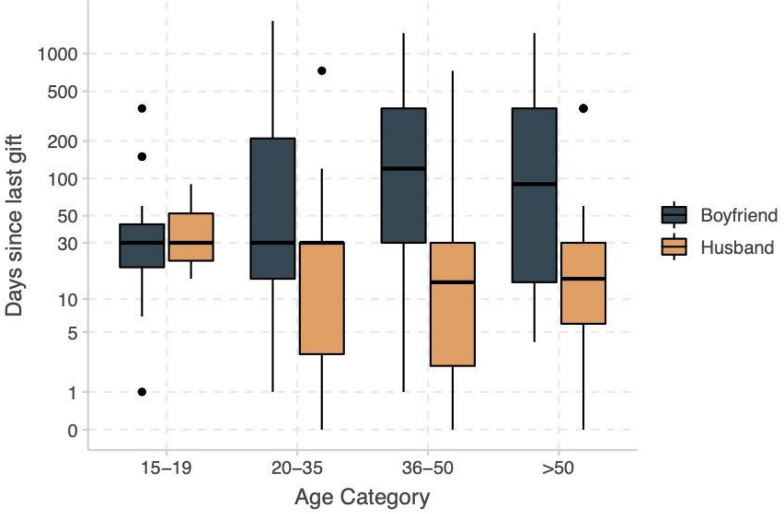

Figure 6. Resource transfer frequency from husbands and boyfriends.

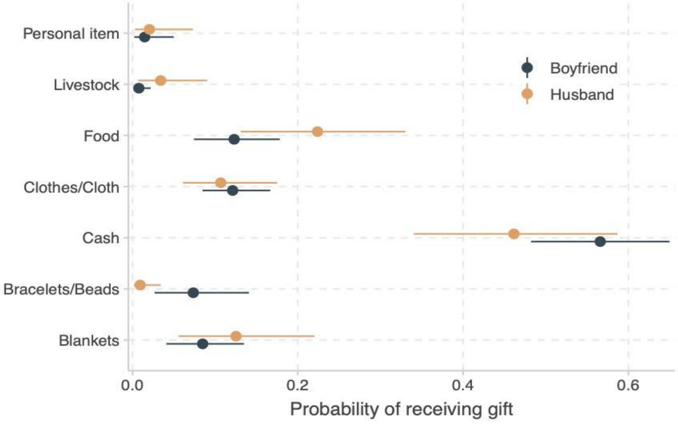

Figure 7. Model predictions in gift type. Model estimates of mean probabilities and 95% credible intervals shown by horizontal bars.

To better understand the effects of resource transfers on well-being, we evaluated food insecurity and diet breadth as a function of women's partner status (Figure 8). Women were divided into three groups: married with a boyfriend, married without a boyfriend, and unmarried with a boyfriend. Model predictions of mean food insecurity and diet breadth scores indicate that married women with a boyfriend tend to have lower food insecurity than the other two groups, but prediction intervals of all three categories overlap, and the estimate for married women without a boyfriend is highly variable due to a small sample in that category (Table S7). Little difference was found between the three groups for diet breadth (Table S8).

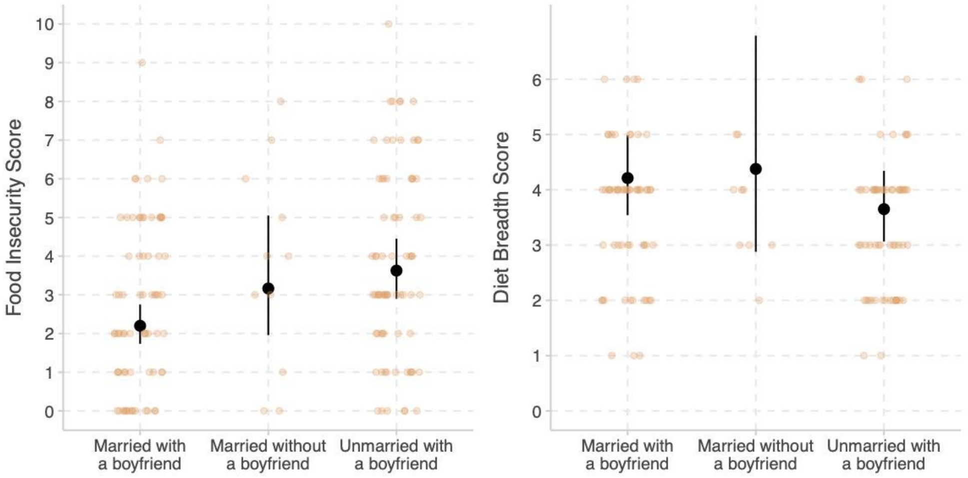

Figure 8. Food insecurity and diet breadth by partner category. Model estimates of category means and 95% credible intervals shown by vertical bars, plotted alongside raw data.

5. Discussion

Here we bring together data on various aspects of Himba lives and livelihoods in order to understand how the particular socioecological context of contemporary Himba life affects their marital and reproductive decision-making. In particular, we are interested in understanding why a normative system of concurrent partnerships and sexual autonomy for women exists in this pastoral system, instead of the more typical pattern of strong mate guarding and restrictions on women's autonomy.

Like many pastoralists, Himba must contend with a stochastic resource base, moving livestock in response to seasonal rainfall patterns and with them, various members of the household. As Bollig describes, these ecological constraints greatly affect household composition:

> *Himba pastoralism depends on independent movements of livestock camps (ozohambo) and households (ozonganda). After a few weeks of heavy rain (usually January to March) the entire household herd gathers at the main homestead . . . . In an average year they stay together for three to four months while the major gardening work is done . . . . However, a cattle camp . . . will be established long before grazing resources become depleted . . . . Later, in July or August, male goats and sheep are separated from the household and either a separate small stock camp is established or the small stock herd joins the cattle camp . . . . At the height of the dry season, between September and December, a number of households shift all their remaining cattle to their cattle camp . . .* (Bollig 2006, pp. 46–47)

Depending on how many camps are established, and how many able-bodied adults are available for herding, various members of the household might be separated. Our data reflect the general pattern Bollig describes in that husbands and wives are most likely to be separated during the early dry season when the herd is split between the main household and the cattle camp.

Our data also point to a pathway from spousal separation to extra-pair paternity. We show both that spousal separation can lead to long periods of abstinence between spouses, and that sex with boyfriends is common enough to lead to extra-pair paternity. Although more than a quarter of respondents noted that it had been at least a month since they had had sex with their husband, sex with a nonmarital partner was reported to have occurred within the last month in 37% of cases. Several interlocutors mentioned spousal separation explicitly as the cause of their abstinence, noting that their partner was at the cattle post. Although these separations can be long, they do not necessarily indicate marital strife. As one woman who had been apart from her husband for many months explained, "You know you are divorced if you are in the same place and he doesn't come to you. But if you are just in different places, then you are still together."

Similarly, interlocutors also remarked that spousal separation is instrumental to maintaining relationships with non-marital partners. Although it is widely seen as normative to have lovers, there is a set of rules that all parties are expected to follow in conducting those relationships. Boyfriends arrive after dark and leave just before dawn, and they often try to determine ahead of time whether their partner is alone. With cell phones becoming increasingly common, this can often be accomplished directly between partners, but as one Himba man explains, others are often enlisted in the process: "I see her when her husband is not around. I can ask around, even kids you can ask, to see if the husband is around. In the evening I would go to a house of someone I know nearby and tell someone to let her know I'm there. Then I go there late at night to see her. We wake up early, before the roosters, and I leave to go back home." For their part, husbands are expected to sleep away from home if they are out after dark (e.g., chasing a rogue cow after sunset). This reduces the chance that a husband and lover will mistakenly encounter each other.

Our aim in this paper was not just to illustrate the correlation between spousal separation and a normalized system of concurrent partnerships, but also to understand why they co-occur. We believe there are three distinct, but interrelated, reasons why spousal separation is associated with sexual autonomy and concurrent partnerships among Himba: (1) Phylogenetic inertia sets the stage for norms promoting female autonomy, while also increasing the costs of mate guarding; (2) demographic and economic factors reduce the costs of lost paternity for men; and (3) the stochastic resource base makes concurrency a viable way for men and women to improve their fitness.

5.1. *Phylogenetic Inertia*

Himba arrived in Namibia via the Bantu expansion, and only became ethnically distinct from their close relatives, the Herero, in the last 100 years (Bollig 2006). Holden and Mace (2003) analyzed shifts in the inheritance structures and modes of production of Bantu groups as they moved across the continent, and depict a general pattern where the adoption of pastoral production led to a shift from matrilineal to patrilineal inheritance. Himba/Herero are unique in that they transfer livestock matrilaterally, and links to one's matriclan are culturally and functionally important (Malan 1995; Gibson 1956). The Bantu language tree that Holden and Mace used to conduct their analysis shows that of the five groups Herero are most closely related to, one practices double descent similar to Herero, and the other four have matrilineal inheritance (Figure S3). Further back, Holden and Mace show that Herero are in the half of the phylogenetic tree with the majority of matrilineal Bantu populations.

Their deep history of matriliny helps to explain why norms promoting female autonomy are likely prominent among Himba. Early ethnographies of Herero describe many of the same sexual practices that exist today, including frequent divorce, high rates of nonmarital sex, acceptance of children born outside of marriage, and senior wives being included in the process of choosing a co-wife (Gibson 1959). Our data compliment these findings, showing that Himba women have relatively high freedom of movement, including lengthy visits unaccompanied by their husbands (Figure 3). These visits serve a dual purpose, keeping up relationships with natal kin, and allowing women opportunities to maintain concurrent relationships. Relatives can also serve as conduits for resource transfers. As one man described, "You cannot give it straight to the woman if she is married. You give 'behind.' You can send it [the gift] to her father or sister, then when she goes there she gets it and she can say it was given to her by her family."

However, the picture of Himba autonomy is complex. Although they have more freedoms than women in many pastoral societies, the limits placed on them indicate that some mate guarding is occurring For example, husbands are most reticent about their wives traveling alone to a funeral or ceremony, which is commonly described by both men and women as being a place where lovers frequently meet. Intimate partner violence is not uncommon, and violence in response to extra-marital sex was second only to child neglect in its acceptability among men and had the highest acceptability rating among women.

Women and men both linked sexual jealousy to IPV, and several of the women in our interviews mentioned being hit by their partners. One woman explained, “My husband is very jealous. He beats me because he loves me. He doesn’t tell me to leave. He just beats me.”

There are also complicated notions about non-marital partnerships at play, as evidenced by our vignette study. The majority of men stated that a married woman having a boyfriend is unacceptable, and almost every respondent reported that they knew about this happening. We see similar variation in the types of punishments men reported, ranging from nothing, to mild verbal warnings, to severe physical harm. Several of our respondents described a situation where a husband who found out about his wife’s boyfriend snuck into his compound at night (when he knew they would be together) and attacked and killed the boyfriend. We do not know that our interlocutors were all describing the same event or different ones as we did not ask people to give names when they told these stories, but regardless, this exemplifies how dangerous concurrency can be, even in this population where the practice is largely normalized. However, other men described much more measured responses. One reported, “The husband asked the boyfriend not to sleep with his wife. The boyfriend continued anyway. One day the husband met an agemate who told him the man was still sleeping with his wife. That night he didn’t come home. Later, he caught the boyfriend again. He called the community and they met and fined the boyfriend 10 cows.”

It appears that Himba hold a dual notion of concurrency. On the one hand, they stated that informal partnerships are an integral part of their culture, socially acceptable, and very common. On the other hand, both men and women reported sexual jealousy and there are efforts to constrain spouses’ relationships with lovers, especially if they become too frequent and become a threat to the marital union. As one man summed it up, “You don’t want other people to sleep with your wife, but it’s the tradition.” There are several explanations for this tension. Although it may be socially advantageous for men not to buck the current system, individually they may be motivated to maintain as much paternity certainty as possible. Alternatively, as with many double descent systems, Himba may be in a state of disequilibrium, in the process of shifting their social structures from matriliny to patriliny (Scelza et al. 2019). We show here that older men are more likely to be accepting of women’s concurrency. Age also had a negative but non-significant effect on men’s beliefs about IPV, with older men less likely to believe IPV is acceptable under varying circumstances. These results could represent a generational shift, with more patrilineal, patriarchal norms becoming more prominent. Another possibility is that older men are less incentivized to mate guard because they are further along in their reproductive careers (Pazhoohi et al. 2016).

In addition to the direct impact of matriliny on female autonomy, the particular form of double descent that Himba practice, which involves largely matrilateral inheritance of cattle, impacts the costs and benefits of paternity certainty for men. When wealth can be aggregated and distributed, it can be used to generate fitness-related benefits such as bride-price payments and multiple wives via polygyny. This tends to benefit sons’ reproductive success more than daughters’, and has been used to explain the correlation between patriliny and pastoral production (Holden and Mace 2003). However, parents must balance the gains that their sons can accrue from inherited wealth with any costs of misallocated investment due to paternity uncertainty.

When cows are inherited matrilaterally, a different calculation becomes relevant. Paternity certainty pertains mainly to relatedness between siblings (as a man is giving to his sister’s son). Classic interpretations of the “paternity threshold model” of matrilineal inheritance require levels of paternity uncertainty that are highly unlikely, even in populations such as Himba where extra-pair paternity rates are the highest ever recorded (Greene 1978; but see Rogers 2013 for further discussion). However, when the paternity threshold is considered alongside other socioeconomic factors, stable strategies for this type of matrilineal inheritance can emerge. Fortunato (2012) shows that both polygyny and polyandry can make diagonal transfers (from uncle to nephew) beneficial to men's fitness. With their combination of formal polygyny and informal polyandry, and a system of diagonal transfers of wealth, Himba may be a prime example of how high rates of extra-pair paternity, via women's concurrency, can be fitness beneficial to men. If this combined system of polygyny and polyandry alongside matrilateral inheritance is beneficial to men, they may be more tolerant of spousal separation and less incentivized to spend time and energy on mate guarding.

5.2. Demography and Economics

There are several aspects of Himba sociodemography that affect the costs and benefits of spousal separation and potentially lost paternity. The first is the adult sex ratio. We previously reported that Himba have an ASR of 0.71 (i.e., 71 men for every 100 women, see Scelza et al. 2020c). This was the lowest ASR in that sample of 11 populations, as well as another cross-cultural study of ASR (Schacht et al. 2014). Although the reasons underlying the imbalance in this population are not well understood, a female-biased sex ratio appears to be a long-term trend. Reports from the early 20th century also show a surplus of adult women among Herero, with a sex ratio of 0.75, based on a sample of 16,201 individuals (Malcolm 1924). Gibson reported similar numbers in the 1959 (Gibson 1959), as did Harpending and Pennington in the 1990s (Harpending and Pennington 1991). The ratio of males to females affects the stability of partnerships. When there are more women than men in a population, men face lower costs to deserting their current partner because there are more alternatives in the population to choose from. In other populations this has led to female-biased sex ratios being associated with less monogamous behavior (Schacht and Mulder 2015; Schacht and Kramer 2016).

Another factor that must be considered is the value of child labor. When children contribute to household production, they offset some of their own costs, mitigating potential losses to men if they care for children who are not their biological offspring. Although we do not present data on child labor here, our previous findings lend support to this idea. Himba men have been shown to bias their investments in biological versus non-biological children, in what appears to be a functional response to their productive value (Prall and Scelza 2020b). Girls, who Himba resoundingly praise as being valuable laborers, have poorer anthropometric outcomes when they are believed to be *omoka* (non-biological offspring). Our data support the idea that this may be because girls have to work harder to "earn their keep" in this situation. One Himba woman said to us, "Sometimes when the child starts to grow up, the child will be working very hard and the husband might start to like that child, even more than his own child." On the other hand, Himba boys, whose labor is generally considered to be less valuable, are more likely to be fostered out when they are believed to be *omoka*. One woman explained, "When the husband talks about that child, he hates him. When he sees him he tells you to take that child to your parents." In this case, it seems that men may be lowering their own investment costs when paternity certainty is low and the net cost of the child is greater.

5.3. Benefits of Concurrency

Our data show that women can benefit directly from having multiple partners. Women with both husbands and boyfriends have greater food security than those who have partners of only a single type. Although it is difficult to identify a causal pathway from concurrency to greater food security, the mix of data we present serves to illuminate how husbands and lovers support women in different ways. Husbands tend to be more reliable partners, giving gifts more often and in greater quantities than boyfriends. Boyfriends are less likely to provide food or livestock than husbands, but more likely to give cash. Women have noted that this is useful because cash can be given discreetly, and can be used for a wide variety of purposes, including for food, medical care, or transportation. These data show that the bond between spouses is strong—women rely on their husbands as their primary sources of support, and husbands largely fulfill that role. Boyfriends, on the other hand, are less socially obligated to give, and so there is more variability in the frequency of their giving, and in fact, whether he gives her anything of note at all.

Our qualitative data reveal an important aspect of resource transfer patterns that did not show up in our quantitative data. Multiple women reported that boyfriends are called upon in critical times, either when there is an inordinately large expense, or when their husband is not available to help. One woman explained, "They [her friends] could tell him [her boyfriend] that I needed something, so he would know . . . . If he saw I was having a problem he would give something to me to help, because we have been together so long . . . . My child was sick and my friend went to tell [the boyfriend] and he came to me and gave me N$1000." These rare events are unlikely to show up in the recall data described above, which is better suited for describing general transfer patterns. In addition, the safety net of knowing that you could ask if you needed something is also an important aspect of resource security, and one that would not be picked up in our quantitative data. As one woman stated, "He's never given me anything but I love him. I know if I asked he would give me something."

Boyfriends, therefore, help in ways that can be either complementary or supplementary. This may be particularly critical when spousal separation is common because there are long periods of time (particularly historically when cars and cell phones were less common) when husbands may be unable to help. If a child is sick, or an unexpected food shortage arises, boyfriends can step in. One woman stated, "If you are tired of asking the husband, you can ask the boyfriend. It's good to have both to ask," while another said, "You need to eat two times. From the husband and the boyfriend."

It should be noted that where this trickles down to affect the well-being of a couple's children, both the husband's and the wife's fitness can be positively affected by concurrency. This creates a system of generalized reciprocity for men. Husbands invest in their wives' children, only some of which are his biological offspring—which comes at a cost. However, help comes in toward those children from his wives' informal partners. In addition, a man may be providing some investment toward children he has with his lovers, but the majority of investment in those children comes from their social father. Formal modeling and more specific empirical data would be needed to know whether this results in a net benefit for most men, but our data point toward this being a stable response in a system with a stochastic resource base and high mate guarding costs. Men can accrue the kinds of standard gains to fitness that are predicted through sexual selection theory, and any paternity loss that occurs in their marriage is buffered by support from other men.

6. Conclusions

Spousal separation is a recurrent cultural phenomenon in marriages around the world, often driven by ecological constraints that require men and women to carry on their productive activities separately. In many situations, this leads men to place a myriad of constraints on women's freedoms in order to ensure paternity certainty during his absence. However, restricting women's movements and behavior is costly, so costly in some instances that it may not be worthwhile. To date, we lack a clear understanding about why one outcome or the other emerges. Here, in this case study of Himba pastoralists, we propose that rather than there being a single explanatory variable, a confluence of historical, demographic, social, and economic circumstances must be studied together in order to understand why one strategy becomes dominant over the other in a particular setting.

Among Himba, a long history of matriliny opened the door to retaining (at least for the time being) social norms that promote female autonomy and sexual freedom for both men and women, even after the introduction of pastoralism. The drought-prone ecology of northwest Namibia, combined with a need to break up livestock across multiple camps, makes mate guarding particularly difficult, which may have further disincentivized shifting from matrilineal to patrilineal inheritance. Instead, a reciprocal system of caretaking, through both formal and informal partnerships, gives both women and men greater ability to cope in this environment. The system is further bolstered by a productive system that is highly reliant on child labor and a female-biased ASR, which allows men to make up for marital paternity loss through their own extra-marital partnerships more easily.

One of the values of a mixed-method study such as this is that it pieces together various population-specific elements into an explanatory framework. However, in being so specific, one might question how broadly applicable the Himba case is to other populations that practice spousal separation. We find that this particularist view, in conjunction with the theoretical grounding of human behavioral ecology, illuminates a set of strategies that are relevant well beyond the confines of northwest Namibia. We show how key components of reproductive decision-making (e.g., the cost of mate guarding, the ameliorating effect of child labor, the ASR) combine to form a stable strategy. Each of these components has been described before as being influential on human mating and marriage behavior. However, in trying to understand the "messiness of the human phenome" (Gurven 2020), we need to spend more time looking at their intersections.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/socsci10050174/s1, Figure S1: Inheritance structure and mode of production for Himba and related groups, Table S1: Intimate partner violence model results, Table S2: Boyfriend vignette model results, Table S3: Days since last gift model results, Table S4: Gift type model results, Table S5: Food insecurity model results, Table S6: Diet breadth model results.

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Relationships of Resource Strategies, Family Composition, and Child Growth in Two Rural Timor-Leste Communities

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Abstract: Subsistence and economic activities undertaken by households in the context of transition from subsistence farming to cash economies are sometimes seen as substitutable with only minimal reference to the households themselves. We use data from in-depth interviews of 190 householders in Ossu (mountains) and Natarbora (coastal plains), Timor-Leste, to query relationships of family composition, resource strategies, and their relationships to children's growth. Principal component analyses of six household composition variables reveal "grandparent and fostered-in children", "two generational households with numerous adults and children", and "smaller households with few adults and fostered-out children", explaining 72% of the variance. A similar procedure with 11 resource variables produced four components explaining 56% of resource variance. Households with grandparents have a pension income and engage in large animal husbandry, and are associated with better standardized BMI for resident children. Households with numerous members (but not grandparents) are more invested in subsistence gardening and are negatively associated with child stature. Salaried income is not associated with household composition, but children in these households are taller than their peers. Consistent differences between the two communities are partially a result of differences in socioecology, but there remain unexplained differences that may relate to cultural practices.

Keywords: anthropometrics; socioecology; subsistence farming; economic development; principal component analysis

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1. Introduction

Human subsistence requires that time and energy be allocated among a suite of competing activities and opportunities. Traditional subsistence farming practice can be guided by culturally transmitted rules for the appropriate timing of and attention to various tasks. Over time, rules guiding successful practices persist and can be "adaptive" in the sense of decreasing risk and increasing energy acquisition. Environmental changes such as social disruption, economic development, or climate change disrupt historical experience, constrain some traditional options, and introduce others (Thu and Judge 2017). Long-standing rules are less likely guides to successful strategies. In rural Timor-Leste, it has proven difficult to find reliable independent predictors of children's growth (Judge et al. 2012; Spencer et al. 2017). Spencer et al. (2018b) associated correlated subsistence behaviors using Principal Component Analysis (PCA) and related household scores on the resulting independent components to child growth. There was modest success with this approach, but "community" was consistently a significant independent factor. Spencer et al. (2018b) considered sources of cash income and farming as two separate categories of resources and analyzed them separately. Here, we recognize the inherent trade-offs in time spent acquiring cash via daily work and farm production and look collectively at all resource strategies to determine those that are more or less integrated with each other. We then ask whether communities differ in their strategic sets and explore the relationships between family composition and resource strategies and whether/how these impact children's growth.

Timor-Leste is one of the newest and least developed Asian countries. The country includes communities characterized by 16 Austronesian and Papuan language groups and varying systems of family affiliation. Independent since 2002, Timor-Leste has developed from a post-occupation, scorched earth position to a country dedicated to improving the conditions and potential for its 1.3 million population, approximately 70% of whom are rural. Eighty percent of the economically active population is engaged in subsistence agriculture (Macrotrends 2020). Within a large subsistence economy, households access cash income through participation in the nation's developing commercial economy (day labor, local marketing, and trading) or via state-sourced income, which includes pensions and jobs such as teaching and administration. Small pensions are available to the elderly and to impoverished mothers (the *Bolsa da Mãe*), and substantial pensions for veterans of Portuguese service and/or the fight for independence. The veteran's pension is highly valuable and provides higher income (but at longer intervals) than a government salary.

Timor-Leste's Human Development Index ranks 141 of 189 countries (United Nations Development Programme 2020). Although the life expectancy at birth has increased since 2002 to 69 years of age as infant mortality has declined, anthropometric indicators of child malnutrition have barely changed in spite of many health and nutrition initiatives by the Timor-Leste government and NGOs. The percentage of children under five years who are categorized as stunted hovers around the 50% mark (Spencer et al. 2018b).

To better understand the local predictors of better or worse child growth, almost a decade of work in two rural communities has resulted in a longitudinal data set rich in anthropometrics and family ecology characteristics (Judge et al. 2012; Thu and Judge 2017; Spencer et al. 2018a). Ossu de Cima, a mountainous community of 4300 inhabitants in the central east, ranges from about 600 m ASL to 1000 m ASL and faces south from the country's central mountain range. The majority speak Makassae or Kairui as a first language (languages of Papuan origin). Natarbora/Barique is on the southern coastal plains with an altitude of 5–50 m ASL and a population of 5438 Tetun-terik speakers (Austronesian origin), 3000 of whom reside in the communities of our research. While most communities in Timor-Leste are patrilineal in family affiliation, somewhat less than 12.5% of the population are matrilineal (Narciso et al. 2012). In Ossu, family affiliation is through the male line, and generally, sons inherit the land—although land rights are often ambiguous or contentious in Timor-Leste as a result of dislocations during the occupation. Traditional marriage practice includes bride price (*barlake*) that until recently was counted primarily in water buffalo or cows (Bettencourt et al. 2013); more recently, other goods—including cash—have come into barlake negotiations. Children ostensibly belong to the father's lineage at the completion of payment of bride price. In contrast, Natarboran family affiliation is more matrilineal with strong bilineal practices. A ritual assignment of each child to either the mother's lineage or to the father's lineage is symbolic and, beyond the universal report that the first child is assigned to the mother's lineage, practices were described variously among Natarboran respondents. These assignments do not result in any change of location for the child but rather delineates their role in various ceremonies hosted by either the maternal or the paternal lineage.

Families are often characterized as groups of individuals with shared accommodation, resource streams, and relatedness through birth or marriage (Goody 1976). Family health and well-being are a product of the environment (e.g., resource availability, social stability, mortality risks), household decisions (Crooks et al. 2007), and social supports achievable during times of hardship or crisis (Hadley 2004). Child survival and growth are functions of the environment the family inhabits as well as the ways that resources and labor are allocated within the family (Chen et al. 1981; Harrison and Schmitt 1989). Our research has focused on child survival and growth as a function of conditions of the family within a local environment. Stem families (grandparent(s), parents, and children) are most common in Ossu, and while stem families predominate in Natarbora, joint families (two siblings and their spouses and children) are also common. In both communities, fostering of children is a common aspect of household composition. Households foster in children, usually those of relatives, or send children to live elsewhere (foster out). Fostering transfers vary in permanence; some children are essentially adopted into a new household, while others come and go between their biological household and their foster household or among fostering households. In neither community do foster children pay a growth penalty for not living with biological parents (Judge et al. 2012; Spencer et al. 2017).

The two rural communities in Timor-Leste vary in the agroecological zone and in traditional family affiliation but are both largely agricultural with basic similarities in agricultural participation and in child fostering practices. Children in Natarbora consistently show better growth than those in Ossu (Spencer et al. 2017). Natarbora children are also more physically active (Spencer et al. 2019). The question is whether the demonstrated differences in growth can be explained by the agroecological differences or whether there remains variation in growth that might be explained relative to community-level cultural variation, such as matrilineal and patrilineal affiliation systems.

In this paper, we look at how the communities differ in the organization of household economies and to what extent these differences explain differences in child growth. A previous investigation into households in these communities found household characteristics as independent variables explained only some variation in child growth (Spencer et al. 2017). We, therefore, examined the socioecological differences in the two communities using PCA—one PCA clustering household composition variables and another combining resource variables (agricultural-related variables and income access)—and relate these to the growth outcomes of children. Using a natural experimental design, we ask what (if any) characteristics of households' subsistence resources and household composition differ across communities and if and how this is related to child growth.

2. Methods

Spencer et al. (2018b) collected data from interviews in the post-rainy season of 2016 with householders in two rural communities, Ossu (n = 96 households) and Natarbora (n = 94 households), Timor-Leste. Interviews ascertained household demographics and resource availability (for details, see Reghupathy et al. 2012). The resources cataloged included forms of income (e.g., salaries, pensions, social support, and day-wages) and agricultural practices of the household (number of crops, and the number and type of animals). Dietary diversity and food variety scores (FVS) were calculated from 24-h food recalls (Ruel 2003; Styne et al. 2006), and FVS and frequency of egg consumption were included in this analysis. The numbers of resident grandparents/other adults, children (fostered and biological), and their relationships to the head woman of the household (or her husband) were recorded.

Anthropometric measures (height, weight, and middle-upper arm circumference) were recorded for all children to age 19 years and for mothers of those children when present. Height, weight, and body mass index (BMI) were standardized using the WHO protocol (de Onis et al. 2004). A total of 737 children aged from 1 month to 19 years were initially included in this analysis (mean = 9.6 years of age, SD = 5.15). Children with any missing value were excluded from the linear mixed modeling of growth parameters.

Correlated characteristics of agricultural practice and income sources and household membership were aggregated using data from 192 households in two separate PCAs to reveal independent sets of correlated practices for each of the two themed sets of data. Food variety (FVS) was included in the agricultural practices PCA as dietary diversity scores showed insufficient variation among households. For each PCA, components were retained based on the percentage of variance explained and scree plot inspection and were subject to varimax rotation. We considered loadings of 0.35 and above in interpreting the component.

Relationships between the household composition conditions and the resource configurations were assessed by looking at the bivariate correlations of factor scores in households over the two sets of variables.

To compare the principal components across the two communities, the factor scores obtained from each component of each PCA for households were compared across communities using an independent T-test for comparison of means. Those principal components were subsequently compared for effects on the growth of children in each community.

This research received ethics clearance and permission from the Ministry of Health, Timor-Leste (MS-INS/GDE/DP-EA/V/2016), and The University of Western Australia Human Research Ethics Committee (RA/4/1/2401).

3. Results

3.1. Descriptives

The descriptive characteristics of the two communities are detailed in Table 1. Ossu households tend to have more children per adult in the household, and are somewhat more are engaged in garden production. The vast majority of households in both communities raise livestock, but the species raised differ substantially; fifty percent more of the households in Natarbora raise cattle or water buffalo than Ossu households do. Natarbora also has many more households receiving veterans' pensions, which exceed in value all the other pensions.

Table 1. Number or percentage of households in Natarbora and Ossu engaged in agricultural activities and off-farm cash income in 2016.

Variable Categories	Natarbora	Ossu
Households surveyed	94	96
Mean number of adults per household	3.1	2.8
Mean number of children per household	3.9	4.1
% Making garden	66.0	78.1
% Raising animals	95.7	96.9
% Raising cattle and/or buffalo	65.2	42.1
% Raising pigs	83.0	85.4
% Raising chickens	85.1	91.7
% With salary income	27.7	30.2
% With pension income	77.7	43.8
% With agricultural income	18.1	21.9

3.2. Family Composition and Resource Clusters

The household composition PCA returned three independent components that, together, explain 72% of the variance in the co-resident household members. The first component loads most heavily on resident grandparents (both grandmothers and grandfathers) and has the only positive loading on fostered-in children (Table 2); this principal component itself explains 32.8% of the variance. The second component loads most heavily on numbers of adults (who are not grandparents) and numbers of children—indicating large two-generation households. The third component loads most heavily on children fostered out and on negative children fostered in—indicating smaller households that include only biological children (Table 2).

Table 2. Variable loading for household composition (HC) principal component analysis (from Spencer et al. 2018b). Bolded indicates strong loadings (≥0.35).

Variable	HC 1 "Foster-in + Grandparents"	HC 2 "Large 2 Generation Households"	HC 3 "Foster-out, No Grandparents, Few Adults"
grandfather present	**0.92**	0.02	0.01
grandmother present	**0.91**	−0.07	−0.07
# adults (excluding grandparents)	−0.02	**0.80**	−0.19
# biological children	−0.02	**0.76**	0.33
# children fostered out	0.08	−0.08	**0.84**
# children fostered in	**0.35**	−0.33	**−0.57**
% Variance explained	32.76	22.28	17.00

The resources PCA yields four principal components that, together, explain 55.62% of the variance (Table 3). The first component we label "diverse subsistence" as it captures the production of small animals, crops, and a lack of cash income. The first component explains 17.6% of the variance and is closely followed by the second component that explains 16.4% of the variance. The second component indicates a reliance on salaried work and a lack of household food production. Disposable wealth is also indicated by the larger number of appliances in households with this subsistence strategy. The third component is dominated by high-value pensions and a larger number of pensions (11.9% of variance); pensions indicate income that does not require labor and thus lower trade-offs with other subsistence strategies. The last component ("large animal husbandry") is dominated by the raising of cows and pigs and income from agricultural sources (9.7% of variance).

Table 3. Variable loading for resources (Res) principal component analysis. Bolded indicates strong loadings (≥0.35).

Variable	Res 1 "Diverse Subsistence"	Res 2 "Salaries + Appliances"	Res 3 "High Value Pensions"	Res 4 "Large Animal Husbandry"
#cows	0.15	−0.04	0.17	**0.68**
#pigs	0.16	0.11	0.34	**0.61**
#chickens	**0.68**	0.09	0.07	0.06
frequency eat eggs	**0.68**	0.07	−0.01	−0.03
Food Variety Score	**0.66**	0.04	−0.01	0.11
# crops grown	**0.37**	**−0.66**	−0.01	0.16
Salary income	0.23	**0.61**	−0.17	−0.08
High $$ pensions	−0.14	0.10	**0.82**	0.17
Total # pensions	0.02	−0.32	**0.74**	0.02
Agricultural income	−0.10	−0.12	−0.29	**0.71**
# appliances	0.27	**0.76**	0.03	0.14
% Variance explained	17.61	16.41	11.90	9.70

3.3. Relationships of Family Composition and Resource Strategies

To determine if there is a relationship between family composition and resource strategy, we performed a simple bivariate correlation of family composition and resource components (Table 4). Household composition best characterized as "grandparents and fostered-in children" was positively correlated with the PCA component "high-value pensions" (as might be expected given that veteran's pensions were more common for older men and some older women) and on resource strategies that focus on large animal husbandry and income from farm products. Households characterized by higher numbers of adult members other than grandparents and larger numbers of biological children were positively correlated with subsistence farming with little animal production, and there was a trend for association with large animal husbandry. Lastly, small families who had fostered children out of the household were negatively associated with all resource strategies—and the negative association with subsistence farming was significant.

Table 4. Correlational matrix of components of the resource PCA and the family composition PCA. Pearson's r, and *p*-value. *n* = 185 households.

	HC 1 "Foster-in + Grandparents"	**HC 2 "Large 2 Generation Households"**	**HC 3 "Foster-out, No Grandparents, Few Adults"**
Res 1 "Diverse subsistence"	0.060 $p = 0.408$	**0.156** **$p = 0.034$**	**−0.184** **$p = 0.012$**
Res 2 "Salaries + appliances"	0.099 $p = 0.181$	0.068 $p = 0.360$	−0.048 $p = 0.513$
Res 3 "High value pensions"	**0.368** **$p < 0.001$**	−0.111 $p = 0.134$	−0.055 $p = 0.461$
Res 4 "Large animal husbandry"	**0.246** **$p = 0.001$**	0.137 $p = 0.063$	−0.067 $p = 0.367$

3.4. Comparing Household Composition and Resource Strategies in Ossu and Natarbora

For the most part, the communities evidenced similar resource and family composition. However, one family composition component and two resource components differed significantly between the two communities (Table 5). Natarbora households had higher scores on high-value pensions (age and veteran's pensions) than Ossu households. Natarbora households also had higher factor scores on the large animal husbandry (pigs and cows) component than Ossu households. Lastly, Natarbora households had higher scores on the component of family structure that included multiple generations (presence of grandparents) as well as fostered-in children than Ossu households.

Table 5. Independent samples *t*-tests comparing household factor scores by subdistrict. Significantly different factors are bolded.

Component	**Subdistrict**	***n***	**Mean**	**SD**	**t**	**df**	***p***
Foster-in + grandparents	Ossu Natarbora	96 94	−0.16529 0.16880	0.90359 1.06828	−2.325	181.664	**0.021**
Large 2 generation households	Ossu Natarbora	96 94	0.01598 −0.01632	1.18670 0.77017	0.223	163.42	0.824
Foster-out, no grandparents, few adults	Ossu Natarbora	96 94	−0.08825 0.09013	0.99131 1.00607	−1.231	188	0.220
Diverse subsistence	Ossu Natarbora	94 91	0.04299 −0.04440	0.99093 1.01284	0.593	183	0.554
Salaries + appliances	Ossu Natarbora	94 91	−0.10599 0.10945	0.92381 1.06711	−1.470	183	0.143
High value pensions	Ossu Natarbora	94 91	−0.36296 0.37492	0.91110 0.95234	−5.386	183	**<0.001**
Large animal husbandry	Ossu Natarbora	94 91	−0.15957 0.16483	0.86528 1.10304	−2.230	183	**0.027**

3.5. Relationships of Community, Household Composition and Resource Strategies to Achieved Child Growth

To explore whether differences in practices between communities explain differences in child growth between communities, we ran linear mixed models for standardized height and for standardized BMI incorporating subdistrict, factor scores of three household composition components, and for the four resource strategy components. The inclusion of subdistrict in models despite known differences in resources between the two communities allows the capture of latent variables not captured elsewhere, for example, familial affiliation. Resources may mediate the relationship between household composition and growth, or vice versa; however, the directionality of such relationships is unknown, and households maintain flexibility of both composition and resources. Household composition and resource variables were therefore included in the same rather than separate models to facilitate interpretation of results. A full model was reduced stepwise by removing the variable with the lowest significance (greatest *p*-value) and examining the Akaike AIC for efficiency of the model until reaching a minimum AIC and including all significant independent variables. Mother's height and child's sex were included due to known associations with child growth in this population.

Children's standardized height was predicted by the sex of the child and the mother's height, as was reported consistently for this population. While some of the resource strategies and household compositions were not related to child z-height (Table 6), the subdistrict was significant even when all resource strategies and household compositions were included. The community remained significant in the final model (Table 7). Thus, there are some differences between the communities in child height that are not captured by resource strategy or by household structure. Community is not merely a proxy for variations in socioecological practices.

Table 6. Initial LMM of z-height (n = 570; AIC = 1556.036); reference category is in brackets. Significant predictors are bolded.

Parameter		Estimate	Std. Error	t	Sig.
Intercept		−10.423359	1.456631	−7.156	<0.001
Subdistrict	Ossu	−0.421111	0.111504	−3.777	**<0.001**
	(Natarbora)	0	0		
Sex of child	Female	0.217472	0.075936	2.864	**0.004**
	(Male)	0	0		
Mother's height in cm		0.057361	0.009552	6.005	**<0.001**
Diverse subsistence		−0.040200	0.049921	−0.805	0.422
Salary + appliances		0.115425	0.047928	2.408	**0.017**
High-value pensions		0.074295	0.054813	1.355	0.177
Large animal husbandry		−0.002299	0.053968	−0.043	0.966
Foster in + grandparents		−0.057679	0.056527	−1.020	0.309
Large 2 generation households		−0.190549	0.061204	−3.113	**0.002**
Foster out, no grandparents, few adults		−0.054851	0.053257	−1.030	0.305

Table 7. Final LMM of z-height (n = 564; original AIC = 1582.549, final AIC = 1570.147).

Parameter		Estimate	EMM (SE)	*p*
Intercept		−9.903 (1.208)		<0.001
Subdistrict	Ossu	0.479 (0.083)	−2.205 (0.056)	**<0.001**
	(Natarbora)		−1.726 (0.059)	
Sex of child	Female	0.218 (0.079)	−1.857 (0.056)	**0.006**
	(Male)		−2.074 (0.055)	
Mother's height (cm)		0.054 (0.008)		**<0.001**
Salaries + appliances		0.100 (0.039)		**0.010**
Large 2 generation households		−0.181 (0.048)		**<0.001**

The relationship of z-BMI to socioecology and community was less straightforward. The starting model included all of the variables included in the height model noted above (Table 8). However, in the early steps of the refining process, the subdistrict was not a significant predictor of child z-BMI. In fact, only after all four resource components and one of the household composition variables were removed, a significance of less than 0.1 for community appeared (Table 9). Thus, there are community differences in these resource and household composition variables, but they are small in terms of their relationship to standardized BMI. The enduring socioecological variable that independently predicted z-BMI was the "grandparents and fostered-in children" household structure. Across communities, this is an independent predictor of better child z-BMI. "Grandparents and fostered-in children" households did not show better stature measures, so the positive association with z-BMI is more likely due to differences in weight for age.

Table 8. Initial LMM of z-BMI (n = 566; AIC = 1701.415); reference category is in brackets. Significant predictors are bolded.

Parameter		**Estimate**	**Std. Error**	**t**	**Sig.**
Intercept		0.797914	1.367643	0.583	0.560
Subdistrict	Ossu	0.143176	0.103004	1.390	0.165
	(Natarbora)	0	0		
Sex of the child	Female	0.243922	0.087900	2.775	**0.006**
	(Male)	0	0		
Mother's height in cm		−0.013764	0.008962	−1.536	0.125
More and higher value pensions		−0.028407	0.050041	−0.568	0.570
Salaries and appliances		−0.014081	0.043770	−0.322	0.748
More adults and morebiological children		0.089140	0.055626	1.602	0.110
Subsistence farming		0.008732	0.046232	0.189	0.850
Large animal husbandry		0.009824	0.050609	0.194	0.846
Foster in + grandparents		0.144478	0.052057	2.775	**0.006**
No fostering out; smallerfamilies		−0.011883	0.049888	−0.238	0.812

Table 9. Final LMM of z-BMI (n = 566; original AIC = 1701.415, final AIC = 1673.785).

Parameter		**Estimate**	**EMM (SE)**	***p***
Intercept		−1.296 (0.078)		<0.001
Subdistrict	Ossu	0.228 (0.089)	−0.945 (0.061)	**<0.011**
	(Natarbora)		−1.173 (0.064)	
Sex of child	Female	0.261 (0.087)	−0.929 (0.062)	**0.003**
	(Male)		−1.190 (0.061)	
"Foster in + grandparents"		0.1397 (0.045)		**0.002**

4. Discussion

4.1. Relationships of Family Composition and Resource Strategy

The family composition in the two communities related to both resident numbers and generational relationships. In both communities, stem families (grandparent(s), parents, and children) were common. In both communities, the presence of three generations explained more of the structural variation—where grandparents were present, fostered-in children were more likely. The second form of family structure included more adults, but more often only two generations—including collateral relatives of the wife and/or husband in the household (joint families). Lastly, the third type of family is more characterized by who is not present—children have been fostered out of the family, and there are fewer adults. The family composition was related to resource strategies. Three-generational families were significantly more likely to have high-value pensions and to raise large animals—which in Timor-Leste often serve more like a local "bank account" than as a food source. Cows are sold on the hoof to finance large expenses (school fees, medical procedures) or purchases. High-value pensions and large animal husbandry were in different components and suggested two independent resource strategies rather than the use of pensions to acquire livestock. Larger two-generational families were more likely to engage in subsistence agriculture with less access to cash, whereas the smaller families of the third type were significantly less likely to engage in agriculture and were not associated with any particular type of resource access. The causal direction of such relationships cannot be determined from cross-sectional data; however, we can infer some causality to resource access given that the families with the least resources more often fostered children out and the families with loadings on both high-value pensions and on large animal husbandry were more likely to have fostered children in. This is clearly a recursive relationship; however, large animals require people to tend them, and families are unlikely to foster in children unless they have the resource wherewithal to do so—children cannot produce either pensions or livestock. Notably, the PCA for family composition explained 72% of the variance in composition variables, while the resource PCs explained only 56% of the variance overall. The economic environment in rural Timor-Leste is developing albeit slowly, and most strategies for earning income are limited and precarious. While grandparents may increase the likelihood of pensions (age pensions and veterans' pensions), it is likely that these household resources attract children from related families who are fostered-in where resources allow. We know from other contexts (e.g., Akresh 2009) that families tend to send children to higher-quality households within their network. It would be interesting to examine whether the families that load highly on the fostering-out and low resource components are sending their children to families that link highly on higher resource components and three-generational households. We are unable to perform this with the data at hand.

Families with more adults in residence and only their own biological children are associated with subsistence farming and a positive correlational trend toward large animal husbandry (Table 4). Thus, families augmented through fosterage or through co-residence with grandparents are likely to have some wealth either in cash or in herds of animals. Most salaries are the result of education, and thus, as would be expected, there is no relationship between salary income and family composition. Families not involved in salaried employment, in subsistence farming, or in large animal husbandry have the fewest members and the least complex family structure.

4.2. Differences in Strategies between Communities and Child Growth

Given the difference in family strategies and their relationships to resource acquisition strategies, it is important to consider whether various household compositions and strategies can be related to child growth. With a persistent problem of poor child growth in rural Timor-Leste and with various resource strategies, such an analysis may allow fine-tuning of development and aid strategies meant to address both economic development and human well-being.

Standardized height is an indicator of long-term growth. While poor conditions cannot cause stature to decline, it can result in achieved stature that is low for age (Black et al. 2013). Notably, only families with dependable access to cash income (salaries) had children who were significantly taller than their peers (Table 7), and families with larger numbers of adults and who engage in subsistence agriculture had children significantly shorter for age and sex. The children in three-generation families with both livestock and pensions did not show improved growth, perhaps because family size increases through fostering as resources increase. In addition to these contemporary influences, standardized height is strongly related to maternal height and shows an independent community effect even after resource strategies and family composition are considered. Spencer et al. (2018b) suggest that historically better conditions in Natarbora may express as greater maternal stature with epigenetic effects on their children's heights for age and sex relative to children in Ossu (work on this hypothesis is ongoing). Weight for sex and age is a better index of short-term nutrition as it can fluctuate more widely and as storing nutrients is requisite for linear growth to occur. Standardized body mass index is a problematic index of growth because it is a composite of stature and weight—poor growth in stature can present as good body mass index; however, WHO standardized values for weight end after 10 years of age. We look at standardized body mass index in order to include children throughout their developmental period.

The relationships of family structure, resource acquisition, and community of residence are complex. In the full model (Table 9), the only principal component that shows a significant independent effect on body mass index is living in a household with grandparents and fostered-in children. There was no community effect, and none of the resource strategies had significant influence. The lack of community effect may have to do with the community difference in height. Ossu children with poor stature may be artificially inflated in their BMI measure due to the manner in which BMI is calculated, and thus hide a community effect on weight. However, as resource variables were removed in the stepwise process, the community effect increased. When all of the resource components were excised, the community estimate increased from 0.143 (p = 0.165) to 0.167 (p = 0.074); the increase in parameter estimate increased until, in the final model, it was 0.228 (p = 0.011). This suggests that some of the persistent community effects in children's growth relate to differences in the resource strategies employed by the households in which they live, but not all.

Overall, three socioecological elements present may buffer children against poor growth—grandparents present, receiving income (salaries or larger pensions), and having more animals. Households with grandparents, households with high-value pensions, and households raising large animals are more evident in Natarbora. Furthermore, mothers are taller in Natarbora, suggesting that there is an intergenerational continuance of these differences. The interrelationships between family configurations and strategies linked to better growth suggest that nuanced and diverse resource development programs are likely to be necessary over longer periods of time to result in improved growth and well-being in rural Timorese children. If increased predictability and levels of resources attract child fosterage, then improvements in those resources may increase the number of children exposed to better conditions but be less quantifiable on a per children basis. Evaluations of aid programs may find more children showing only slightly better anthropometric indicators rather than larger changes in growth. This may explain why we find some family composition effects but few resource effects on growth. Children fostered into households with more (post-reproductive) grandparents reduce the benefit of improved resources to biological children in those households while also reducing the number of children in their natal households who share the lower levels of precarious resources. The social practice of child mobility buffers the effect of varying resource strategies on children.

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social sciences

Review

Married Too Young? The Behavioral Ecology of ‘Child Marriage’

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Abstract: For girls and women, marriage under 18 years is commonplace in many low-income nations today and was culturally widespread historically. Global health campaigns refer to marriage below this threshold as ‘child marriage’ and increasingly aim for its universal eradication, citing its apparent negative wellbeing consequences. Here, we outline and evaluate four alternative hypotheses for the persistence of early marriage, despite its associations with poor wellbeing, arising from the theoretical framework of human behavioral ecology. First, early marriage may be adaptive (e.g., it maximizes reproductive success), even if detrimental to wellbeing, when life expectancy is short. Second, parent–offspring conflict may explain early marriage, with parents profiting economically at the expense of their daughter’s best interests. Third, early marriage may be explained by intergenerational conflict, whereby girls marry young to emancipate themselves from continued labor within natal households. Finally, both daughters and parents from relatively disadvantaged backgrounds favor early marriage as a ‘best of a bad job strategy’ when it represents the best option given a lack of feasible alternatives. The explanatory power of each hypothesis is context-dependent, highlighting the complex drivers of life history transitions and reinforcing the need for context-specific policies addressing the vulnerabilities of adolescence worldwide.

Keywords: child marriage; anthropology; human behavioral ecology; global health; harmful cultural practices; life history theory; cooperation; conflict

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1. Introduction

Marriages taking place in the period between puberty and adulthood, i.e., ‘adolescence’, for girls are currently legal in almost all countries and were historically ubiquitous, including in the global north (Dahl 2010; Arthur et al. 2018). The last few decades have witnessed a dramatic increase in interest in ‘child marriage’ (legally defined as any marriage occurring before 18 years) and its apparent negative wellbeing consequences. Illustrating this trend, worldwide Google searches for child marriage have approximately doubled over the last 10 years (Lawson et al. 2020). This interest from the general public is paralleled by, and partially a product of, an emerging campaign to eradicate child marriage led by international development and global health actors. These efforts are exemplified by organizations like Girls not Brides, a global partnership founded in 2011 of now over 1000 civil society organizations committed to ending child marriage and increasing public awareness of its prevalence and purported harmful consequences (Girls not Brides 2017). Moreover, the United Nation’s (UN) 2015 Sustainable Development Goals, which guide global current health policy, have pledged to abolish child marriage within a generation, with an ambitious 15-year target (UN General Assembly 2015).

The current global campaign to end child marriage has its origin in a century of both legal and attitudinal shifts towards the concept of childhood in the global north (Dahl 2010; Lancy 2015) in which children have become increasingly viewed as vulnerable, in need of protection, and unprepared for ‘adult’ responsibility. The transition to this view of childhood culminated in legally defining childhood as ending at 18 years and attributing rights and protections to this demographic (UN General Assembly 1989), a legal framework now widely adopted (e.g., OAU 1990). Efforts to end marriages prior to this threshold are reinforced through studies that demonstrate statistical, although not necessarily causal, associations between marrying before age 18 years and outcomes for girls, including low educational attainment (Field and Ambrus 2008; Hodgkinson 2016), poor reproductive and maternal health (Irani and Roudsari 2019; Nour 2006), and even reduced country-level economic productivity (Wodon et al. 2017). Campaigns to end child marriage define it as a 'harmful cultural practice' akin to female genital cutting/mutilation or female infanticide (Longman and Bradley 2015) and posit that eradicating marriages before age 18 years will tangibly improve girls' lives and health (Girls not Brides 2014). Yet, despite growing investments in eliminating these marriages, marriage before age 18 years remains common with approximately 20% of women married before this threshold worldwide (UNICEF 2020). This proportion is highest in low-income countries, especially within sub-Saharan Africa and South Asia where in some countries over half of young women married as minors (Table 1; UNICEF 2020).

Table 1. Prevalence of female marriage under the ages of 15 and 18 years in the 10 countries with the highest rates of marriage among minors and total fertility rate (TFR). Data source: (UNICEF 2020).

Country	% Married by 15 Years	% Married by 18 Years	TFR
Niger	28	76	6.91
Central African Republic	26	61	4.72
Chad	24	61	5.75
Mali	16	54	5.88
Mozambique	17	53	4.85
Burkina Faso	10	52	5.19
South Sudan	9	52	4.70
Bangladesh	16	51	2.04
Guinea	17	47	4.70
Nigeria	16	43	5.38

In this paper, we outline and evaluate alternative hypotheses explaining the persistence of early marriage using the theoretical framework of human behavioral ecology (HBE) (Nettle et al. 2013; Smith and Winterhalder 2006). Note, while we purposely engage here with the global health literature on child marriage, we opt for the term 'early marriage' throughout because our hypotheses address relative marital timing generally, rather than any specific age threshold. HBE takes an optimality approach to understanding behavioral variation, grounded in the logic of evolution by natural selection. Inclusive fitness, i.e., the long-term production of genetic descendants, rather than health, status, or happiness, is positioned as the ultimate utility function guiding behavior. When strategies to maximize wellbeing and fitness are not aligned, natural selection is predicted to favor behaviors that optimize fitness. This perspective offers novel opportunities to consider the potential rationality of early marriages and draws attention to the conflicts of interest between genders or family members that may ultimately drive inequalities and restrict women's autonomy (Lawson and Gibson n.d.). As a branch of anthropology, HBE is committed to field-based and ethnographically grounded studies, and a dedicated exploration of context-dependent costs and benefits of alternative behavioral 'strategies' across and within socioecological settings.

Despite a large literature on marriage systems, HBE has rarely addressed the topic of 'child marriage' directly. This is understandable. The threshold of 18 years presents a largely arbitrary legal distinction between ostensive childhood innocence and adult responsibility. Not only does this arbitrary threshold not engage with cultural flexibility in the timing of onset of social and physiological features associated with adulthood (Dixon-Mueller 2008; Lancy 2015; Hart 2006), but it also ignores variation in conceptualizations of childhood itself that do not always assume innocence and need for protection (Lancy 2015). Moreover, unlike polygynous versus monogamous marriage (Fortunato 2015), marriages under 18 years are rarely qualitatively distinct from marriages over 18 years in terms of associated customs or social expectations. Indeed, in settings where early marriage is normative, girls who do not marry before reaching 18 years typically do so shortly after and may otherwise have largely similar experiences of married life. In other words, 'child marriage' as a dedicated study subject makes little conceptual sense outside of the global health framework, which itself is grounded in concepts of childhood's boundaries and characteristics specific to histories of the global north. Nevertheless, child marriage lends itself to the HBE approach due to potential fitness implications through associations with fertility and/or lifetime reproductive success (Onagoruwa and Wodon 2018). Further, HBE scholars have addressed questions related to early marriage surrounding the timing of life history transitions such as age at menarche or first reproduction (Nettle 2011), sexual conflicts of interest relating to marriage (Borgerhoff Mulder and Rauch 2009) and reproduction (Moya et al. 2016), and conflict between family members (Apostolou 2015; Moya and Sear 2014; Mace 2013). There has also been relevant work examining the intersection of global/public health and HBE perspectives on teenage pregnancy and motherhood (Kramer 2008; Kramer and Lancaster 2010; Johns et al. 2011). We build on these contributions here by extending the HBE perspective to early marriage, while emphasizing that the timing of marriage does not always align with other life history transitions—timing of puberty, sexual activity, or reproduction.

Along with academic insight, HBE has the potential to strengthen global health responses to the vulnerabilities of adolescence by identifying key socioecological features driving variations in behavior and wellbeing. To this end, we consider four main explanations for early marriage grounded in HBE, drawing out predictions about which socioecological conditions may make each explanation most relevant. We consider the possibilities that early marriage is the result of (1) adaptation to low life expectancy, despite reducing wellbeing; (2) parents winning a parent–offspring conflict in which parents benefit from girls early marriages at cost to their daughter; (3) daughters winning an intergenerational conflict in which daughters benefit from earlier marriages than their caregivers prefer; or (4) a 'best of a bad job' strategy whereby early marriage presents the best available option for daughters and parents alike in the face of a highly constrained environment. These explanations are not necessarily in conflict with common explanations for child marriage arising from global health. In fact, they are often complementary. Rather, HBE provides a unifying theoretical framework that attempts to disentangle the drivers of variation in human behavior by making testable predictions about socioecological characteristics influencing the optimality of alternative behaviors. This framework can help push forward research related to wellbeing, and in some cases be used to derive novel policy recommendations, including the design of interventions and impact evaluations (Gibson and Lawson 2015; Schaffnit et al. 2020).

2. Early Marriage Is a Response to Low Life Expectancy

Perhaps the simplest evolutionary explanation for why child marriage was universally common historically, and is still common in some contexts, is that marrying at young ages can be adaptive when mortality and/or morbidity rates are high. A basic tenet of life history theory is that harsh environments will favor accelerated transitions to reproductive maturity to ensure successful reproduction before death or physical deterioration (Charnov 1991; Stearns 1992; though extremely harsh environments may necessitate delays if early reproduction itself dramatically threatens survival). The underlying logic of this argument is that where life expectancy is low, early reproduction is a means of ensuring that a person will pass on genes to future generations (Kramer 2008; Nettle 2011). In cultural contexts where childbearing mostly takes place within marriages (as opposed to preceding or outside of marriage), it follows that girls and women may optimize their potential for successful reproduction through earlier ages at marriage. This motivation to reproduce, and thus marry early, may also be reinforced by benefits of capitalizing on essential allomaternal help from parents while they are still alive and healthy (Geronimus 2003). Critically, this model could explain why marriages at young ages happen even if girls' wellbeing is compromised. That is, cultural traditions and individual preferences for early marriage (and thus reproduction) have been favored by natural selection, despite trade-offs with wellbeing, to avoid missing the opportunity for successful reproduction altogether.

Support for this hypothesis is mixed. In general, early marriage remains most common in parts of the world with relatively high mortality and low healthy life expectancy, and in these contexts marriage at younger ages is associated with higher fertility and presumably reproductive success (Onagoruwa and Wodon 2018). That said, the strength of correlations between age at first marriage and first birth or fertility are variable (Harwood-Lejeune 2001). Indeed, in some contemporary contexts early marriage is combined with relatively low fertility. For example, Bangladesh combines one of the highest rates of marriage under 18 years and an early age at first birth (Islam et al. 2017) with a total fertility rate of only around two children per woman (Table 1). Further dedicated analysis of the historical and present-day relationships between age at marriage, reproductive timing, and lifetime reproductive success would therefore be desirable and should be possible with publicly available data. Moreover, even in areas where childbearing takes place exclusively within marriage and early marriage is linked to early reproduction, we might expect early marriage to be fitness maximizing for girls only when it occurs in late adolescence rather than immediately following puberty. Reproduction in early adolescence very soon after menarche is more likely to result in pregnancy complications, putting both the mothers' and their children's lives at risk and thus reducing fitness (Kramer and Lancaster 2010). Indeed, research in semi-urban Tanzania suggests a U-shaped association between age at marriage and fertility, such that those married in late adolescence have higher fertility than those married in early adolescence or early adulthood (Schaffnit et al. 2019a). As such, the hypothesis that early marriage as an adaptation to low life expectancy has clear explanatory potential, but may not extend as far as explaining very early marriages, especially when combined with very early reproduction.

Research on the timing of puberty further illustrates the limits of this hypothesis and introduces new considerations. While poverty tends to be associated with relatively earlier marriage in low-income countries, it also is associated with later menarche, most likely due to associated nutritional deprivation (Kyweluk et al. 2018; Leone and Brown 2020). This suggests that early marriage cannot be viewed as part of a coordinated physical-behavioral maturational shift to expedite reproduction. Further research disentangling the determinants and consequences of the timing of menarche, marriage, and reproduction is required to investigate these questions. If, in some contexts, relatively late menarche is combined with relatively early marriage, then it also seems unlikely that this would be adaptive for the girls/women involved, indicating that alternative factors, such as the conflicting interests of men or family members, must drive at least some very early marriages for girls.

3. Parents Winning a Parent–Offspring Conflict Drives Early Marriage

Our second hypothesis suggests that the timing of marriage may be a source of conflict between parents and daughters, and parents winning such a conflict could lead to early marriage. This idea has roots in Trivers' concept of parent–offspring conflict (Trivers 1974). While close relatedness between parents and daughters means that their interests often align, an individual daughter may benefit from higher parental investment even at disadvantage to her siblings, whereas parents will be motivated to prioritize their family unit. By extension, parents and their children may have conflicting optima over marriage decisions, and when conflicts arise, parents may manipulate or coerce their children in order to win the conflict (see also Agey et al. n.d.). Such a model for understanding timing of marriage aligns with policy discourse on 'child marriage', which emphasizes the role of parents in coercing daughters to marry early despite potential costs to her fitness and/or wellbeing. Parents are routinely portrayed as viewing daughters as economic burdens or commodities to be strategically married for benefit of the family unit (UNFPA 2012; Ministry of Health 2017; Petroni et al. 2017), as exemplified in Figure 1. Parents are said to benefit from girls' early marriages by reducing their economic burdens, thus freeing investments for other children, and sometimes benefiting from favorable financial transfers at the time of marriage. In contrast, daughters are presumed to benefit from delayed marriage so that they may capitalize on prolonged parental investments, such as investments in continued education.

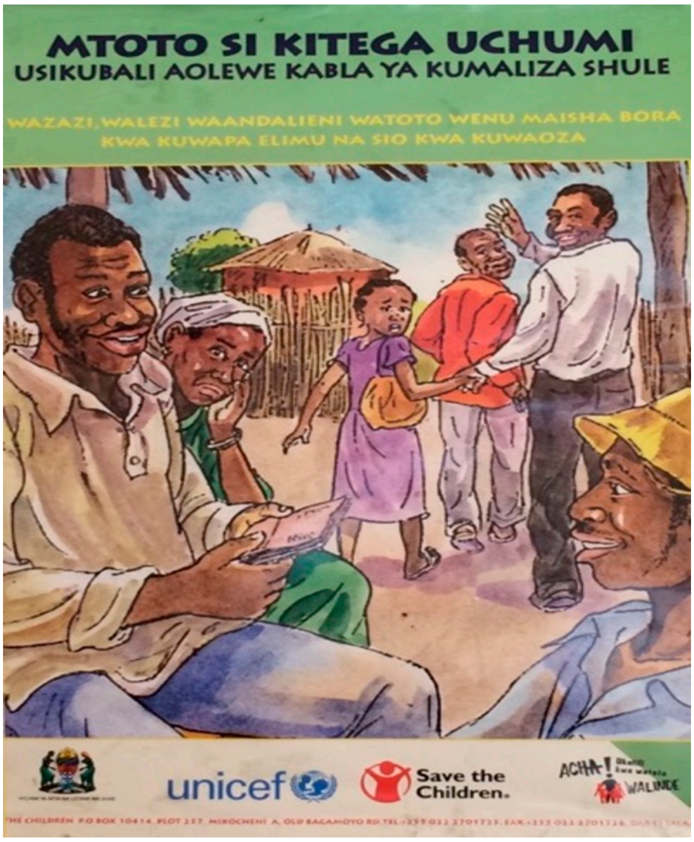

Figure 1. Photo of anti-child marriage poster displayed in a government office in Mwanza, northwest Tanzania. Swahili text reads: "A child is not a commodity. Do not let her marry before she finishes school. Parents and caregivers, give your children a better life by giving them an education and do not let them marry." Photo by: David Lawson.

There is indirect evidence that parent–offspring conflict, or more specifically parents winning such a conflict, could drive early marriage. Girls from poorer families are more likely to marry at young ages compared to those from wealthier families (Nour 2006; Raj 2010), supporting the idea that marriage can help reduce the financial strain of raising daughters for a family. Furthermore, several studies have noted that financial transfers that accompany marriage in many cultures are more advantageous to brides' families when brides are young; dowry costs (paid from a bride's family to the groom's) are lower (Chowdhury 2010) and bridewealth (paid from a groom's family to the bride's family) is higher (Hoogeveen et al. 2011; Schaffnit et al. 2019a) when brides are younger. Finally, child marriage rates have been observed to increase in response to extrinsic economic shocks (e.g., drought) in African regions where bridewealth is commonly practiced, with parents presumably marrying daughters early in order to access capital (Corno and Voena 2016). Global health actors expect a similar pattern may arise in response to the ongoing Covid-19 pandemic (Cousins 2020).

Even with this indirect support for the hypothesis, the idea that parent–offspring conflict drives early marriage has rarely been directly evaluated. Part of the reason for this is that while identifying domains of disagreement between parents and daughters over mating is relatively simple to evaluate via the study of stated preferences (Apostolou 2015; van den Berg et al. 2013), a true parent–offspring conflict in an evolutionary sense requires a broader understanding of the fitness costs and benefits to the loser/winner of the disagreement (Agey et al. n.d.). To our knowledge, there are two studies that consider this hypothesis explicitly. Weissner (2009) records conflict in the Ju/'hoansi foragers of the Kalahari Desert between parents and their children over marriage, including conflict over timing. Ju/'hoansi parents specified that they wanted children to marry early, partly so they would no longer rely on the parents for food. In contrast, Ju/'hoansi girls stated that they wished to delay marriage out of fear of childbirth and a desire to remain carefree. The costs of such conflicts were real: girls protested marriages by hiding in nearby bush to avoid a marriage and guardians of disobedient girls threatened suicide if a marriage was refused. While parents most often won these conflicts, Weissner found that over the past decades children have taken greater control of the marriage process, and as a result of this, marriage has shifted to older ages than in the past. In more recent research, Schaffnit et al. (2019a, 2019b) found that although parents in a semi-urban, primarily Sukuma, area of Tanzania benefited from their daughter's earlier marriages though higher bridewealth transfers, girls/women reported deciding when and who to marry, and estimated wellbeing costs to marrying below the threshold of 18 years were largely equivocal. In fact, there appeared to be fitness benefits for the girl because marriage in mid-late adolescence was related to relatively higher fertility than marriage at older ages. Later qualitative work identified that higher bridewealth payments for younger brides need not necessarily be an indication of their desirability on the marriage market, however. In this cultural context, sexual activity or marriage with schoolgirls is illegal and men face the threat of a 30-year prison sentence for violating this law (Makoye 2016). Community members report that higher bridewealth is sometimes required as a compensation for a man taking the girl out of school and as a measure to prevent the authorities being notified (Schaffnit et al. 2020). These considerations emphasize the importance of understanding the full context within which marriage decisions are made, and the value of mixed-methods research.

In all likelihood, parents winning a parent–offspring conflict is a good model for understanding high rates of early marriage in some contexts, like in the Ju/'hoansi examples, but not others, such as in the study of northern Tanzania where most girls decide when to marry themselves and where marriages are rarely forced or arranged. At this juncture, it is also instructive to highlight that even where marriages are arranged, they are not best understood as forced, with parents and children sometimes in agreement over the desirability of selected spouses (Shenk 2020; Agey et al. n.d.). The HBE framework facilitates consideration of the specific contexts in which parent–offspring conflict may be most relevant to understanding persistence of early marriages. For example, parent–offspring conflict is probably more relevant in areas where very young marriages (e.g., under 15 years) are common (Table 1) as opposed to marriages in later adolescence. This is because very young girls are less likely to have control over the marriage process and more likely to experience fitness costs to marrying early due to complications or death arising from early reproduction (Kramer and Lancaster 2010). Parent–offspring conflict could also be particularly relevant in places where parents have greater control over their children's marriages generally, such as in parts of Bangladesh where arranged marriage is nearly universal (Shenk et al. 2013), or in other areas where forced marriages are common. When parents have control over the marriage process of their daughters, they are more likely to enforce arrangements advantageous to their family unit as a whole even when there are costs to an individual child. Finally, in areas where divorce is not common or acceptable (e.g., Bangladesh (Shenk et al. 2013)) parent–offspring conflict may be especially relevant because opportunity costs of early marriage are higher for girls when they lose a disagreement with their parents because they may be stuck in a sub-optimal marriage. In summary, despite this model being a dominant framework in global health approaches to early marriage, a universal application is clearly inappropriate. More dedicated studies of the consequences of early marriage for both girls/women and their parents across cultural contexts are needed.

4. Early Marriage Occurs When Girls Win an Intergenerational Conflict

Early marriage could also arise due to an intergenerational conflict. In some cases effectively parallel to parent–offspring conflict, intergenerational conflict extends to conflict between girls and older co-resident adults– including parents, guardians, or others—and emphasizes the reproductive nature of conflicts arising specifically from having overlapping reproductive life-spans between generations. The intergenerational conflict hypothesis emphasizes contexts in which girls are motivated to invest in their own (future) children rather than investing in those in her natal home, to whom she may be more or less related (e.g., full siblings, half or step siblings, or other children). This hypothesis suggests that coresident adults can benefit from later marriage of girls in order to draw on their continued labor contributions to the household, which can benefit their own pre-existing or future children. Supporting this hypothesis, we know that girls provide important labor to their households in many contexts throughout the world, including directly helping to raise other children (Kramer 2005; Hedges et al. 2018; Bereczkei and Dunbar 2002). In contrast, girls may prefer earlier marriage to emancipate themselves from such responsibilities, gain benefits of marriage, and invest in their direct fitness by beginning their own families (Moya and Sear 2014).

Lower genetic relatedness between caretaker and adolescent, or adolescent and other minors in the household (e.g., step- or halfsiblings), may exacerbate intergenerational conflicts with adolescents less motivated to invest in the wellbeing or growth of that family unit than if they were more closely related. Rather, adolescent girls may be motivated to begin their own families, or at least emancipate themselves from the home of their guardians, as has been documented in the United States (Syrett 2016). Consistent with this perspective, girls who live with unrelated guardians (e.g., step-parents or foster parents) as opposed to their biological parents in adolescence have been found to reproduce earlier in several settings (e.g., UK: Nettle et al. 2011; Sheppard and Sear 2012; Malaysia: Sheppard et al. 2014).

Even in households where a girl lives with her biological parents, reproductive conflicts between caregivers and daughters arise (Mace 2013), reinforcing daughters' motivations to marry early due to tangible financial or social benefits, while parents aim to capitalize on longer periods of support/labor from their daughters to benefit their own reproduction. Indeed, girls have been documented to deem early marriage an attractive option in many settings for a variety of reasons: improving their standard of living and gaining self-sufficiency and respect (Stark 2017); improving their status within their community (Tanzania: Schaffnit et al. 2019b); fulfilling cultural expectations (Kenya: Pike et al. 2018; Review: Wodon 2016); avoiding risks of remaining unmarried, such as risky sexual behavior or unwanted attention from men (Pakistan: Nasrullah et al. 2014; Tanzania: Schaffnit et al. 2020); or simply fulfilling a desire to bear children (Kenya: Pike et al. 2018).

Overall, the intergenerational conflict model of early marriage is potentially a powerful explanation for some early marriages. However, similar to the parent–offspring conflict hypothesis, studies specifically aimed at testing this hypothesis and its multiple predictions are needed. It is likely that intergenerational conflicts in which girls fulfil their desire to marry earlier than their caretakers would prefer will be most relevant in settings where fostering is common (and thus girls are likely to live with guardians less related than a biological parent) and where unmarried girls provide important labor to their guardians at home, thus incentivizing guardians to encourage delayed departures. However, none of the studies cited above formally evaluate the proposed benefits to parents of having unmarried adolescent girls at home, as opposed to married. Furthermore, this hypothesis will logically be most relevant in contexts where marriage is associated with tangible benefits for girls that are disassociated from benefits their parents or guardians may receive from that marriage (e.g., when early marriage does not lead to more profitable or less costly marriage payments).

5. Early Marriage Is a Best of a Bad Job Strategy

Finally, early marriage may represent a 'best of a bad job strategy', that is, it will be common when it is the best locally available option. The notion of making the best of a bad job is a general concept in behavioral ecology that explains how seemingly non-ideal reproductive/mating strategies can persist in a population due to constraints placed upon some individuals that limit their option set of available or feasible behavioral strategies (Partridge 2017). Applied to marital timing, it could explain how marrying early may persist for people experiencing certain constraints, even though early marriage is not the optimal strategy for other girls living in different contexts in terms of their fitness and/or wellbeing. More specifically, this describes a situation where both daughters and parents from relatively disadvantaged backgrounds (e.g., with limited resources to pay for further schooling, living under patriarchal norms that restrict non-marital opportunities for girls and young women), favor expedited marriage as the best available option given their available choice sets. Central to this hypothesis is the point that marrying at young ages is not expected to be the best option for all girls or in all contexts, but rather that early marriage will occur when it is the best option available for certain persons given their reality. This hypothesis predicts that, all things being equal, when comparing girls and women experiencing similar constraints within a population, early marriage will either have no correlation or a positive correlation with fitness and/or wellbeing.

Conceptually, a best of a bad job model is ostensibly a good explanation for the persistence of early marriage in many settings where it remains common. Due to pressure from global health and development actors (Schaffnit et al. 2021), early marriage is increasingly not seen as ideal in populations where it is common. Further, early marriage can be costly to girls physically, as in the case of very early birth, and socially, for example, by limiting access to education (Field and Ambrus 2008). Even so, dangers to female adolescent wellbeing outside of marriage (e.g., via risky sexual behavior, including increased exposure to sexual transmitted infections and an increased likelihood of raising children without an investing fathers) are frequently equivalent or higher to those affecting married adolescents. Furthermore, marriages can bring immediate benefits to adolescent girls unavailable through other means, including increased power in household decision-making, access to money, and improved social status and community respect (Schaffnit et al. 2019b; Stark 2017, 2018). As such, marrying is sometimes seen as the best option and/or a strategic tool with which to address hardships and constraints, making it effectively the optimal choice within the constraints of local context. This logic is reflected in a number of recent qualitative studies that tease apart rationales for early marriage: in Brazil girls often attempt to delay marriage but 'give in' when things are going badly within their home (Taylor et al. 2015); in Kenya parents prefer for their daughters to delay marriage in favor of higher education, but when financial constrains make education unobtainable, marriage is seen as the best way to secure their daughter's economic wellbeing via the formation of advantageous alliances (Archambault 2011); and in Tanzania, girls and their parents weigh marriage against risks of school attendance, including rape and physical abuse, sometimes finding marriage to be the more desirable option (Schaffnit et al. 2020). Further examples of these rationalizations abound (e.g., Boyden et al. 2012; Clark et al. 2009; Knox 2017; Montazeri et al. 2016; and Stark 2017, 2018) and contrast starkly with statistical findings from large-scale studies that demonstrate correlations between early marriage and harmful outcomes at regional or national levels. Indeed, such large-scale correlations may often reflect statistical confounding rather than causal relationships since early marriage is typically most common among relatively less privileged communities and peoples.

The best of a bad job hypothesis emphasizes the need to better identify and understand the structural factors that restrict women's options and motivate marriage at young ages.

This feature makes this hypothesis potentially widely applicable because all humans are responsive to the structures and cultures they exist within. Structural factors like poverty, lack of employment opportunities, or access to reproductive and sexual health services are applicable in many contexts to varying degrees, though others will be context-dependent such as specific policies, histories, and customs. Social norms regulating women's behavior may be particularly important, redirecting our focus to understanding the determinants of patriarchy as a much broader cultural system that restricts women's agency and opportunities, often independently of the precise age of marriage. Among the Sukuma of Tanzania, for example, traditional songs about marriage both reflect and reinforce norms of women's subordination for all age groups (Masele and Lakshmanan 2021). HBE can provide a framework for analysis here too; scholars working in this tradition have long considered the socioecological and evolutionary roots of patriarchy, often placing emphasis on the role of livelihood shifts, such as the uptake of agriculture and its impacts on gendered divisions of labor and resource control, along with variation in post-marital residence norms that may influence a woman's ability to draw on support from kin when facing a conflict of interest with men and patrilineal relatives (Hrdy 1997; Smuts 1995; Borgerhoff Mulder and Rauch 2009; Lawson et al. 2021). Ultimately, these considerations leave us with a more nuanced perspective on early marriage, highlighting that marrying early can be indicative of and perpetuate patriarchal structures that restrict women's agency and yet, given that a woman lives within this system, participating in an early marriage may present the best available option.

6. Conclusions

In evaluating these four HBE-grounded hypotheses for the persistence of early marriage, we have identified that explanations are context-dependent (Table 2). For example, parental coercion is most likely to drive earlier marriage in contexts where dowry or bridewealth transfers provide incentives for parents to encourage early marriages for daughters and where norms of very young marriages (e.g., under 15 years) or traditions of arranged marriage increase the scope for coercion of daughters. Alternatively, intergenerational conflicts will be particularly relevant where non-nuclear family structures are common, wherein adolescent girls share less genetic relatedness with household heads and members and where unmarried adolescent girls and young women provide substantial labor to their natal household. These considerations emphasize the value in focusing on the role of socioecological context rather than presenting early or child marriage as a uniform behavior with monolithic determinants and consequences.

Understandings of early marriage that emerge from the HBE framework can help inform current global health efforts to improve girls lives throughout the world in several ways. Most importantly, explicit consideration of the potential costs *and benefits* of early marriage encourages us to treat the topic more empathetically. Global health discourse often presents child marriage and other so-called 'harmful cultural practices' (e.g., polygyny, female genital cutting/mutilation, etc.; Longman and Bradley 2015) through an exotifying and moralizing lens, frequently presenting traditions of early marriage as wholly irrational or even 'primitive' by only considering apparent harmful consequences and assuming those that marry early must, almost by definition, be either ignorant of the costs or actively coerced. Consequently, dominant global health narratives, and their presentation to the general public (Lawson et al. 2020; Figure 1), risk propagating stereotypes that the poor wellbeing of girls and young women in low-income countries is caused their own moral failings or ignorance (e.g., selfish parents forcing daughters into marriage for their own financial gain; under-informed girls choosing to marry early). Such stereotypes can detract from the more deeply rooted causes of early marriage, including systems of poverty that themselves are often perpetuated by the policies of countries who fund and set global health agendas. Recognizing the potential rationality of decisions to marry early is critical in treating communities at the receiving end of international development campaigns with dignity. This does not imply that child marriage is not a cause for concern or that decisions to marry early need to be viewed as 'good decisions' but correctly identifies that such decisions can be rational choices within specific circumstances, often motivated by desires to mitigate alternative risks.

Table 2. Summary of hypotheses explaining early marriage, their logic, and the specific socioecological contexts within which each hypothesis is expected to be most relevant.

Hypothesis	Logic	Relevant Socioecological Contexts
Early marriage is a **response to low life expectancy**	Marrying early in areas with low life expectancy or high morbidity increases chances of successful reproduction before death or loss of key alloparental support	• Low life expectancy • Premarital childbearing is rare, and childbearing typically occurs soon after marriage. • Grandparents play important role in childrearing
Parents winning a **parent–offspring conflict** drives early marriage	Parents prefer daughters to marry earlier than is optimal for them and parents coerce daughters to marry early	• Parents control marriage process • Financial transfers occur at marriage (i.e., dowry, bridewealth) • Divorce is unacceptable (especially combined with parental control over marriage) • Female youth is prized on the marriage market
Early marriage occurs when girls win an **intergenerational conflict**	Co-resident adults/caretakers wish to exploit girls' labor to improve their fitness while girls prefer to invest in their own families	• Multigenerational households are common and multiple women of reproductive age coreside • Unmarried adolescent girls play important roles in domestic labor • Girls commonly live with non-biological parents/caretakers • Marriage has direct benefits to girls unavailable through other means
Early marriage is a **best of a bad job** strategy	Given certain constraints, early marriage is the best option available for ensuring girls wellbeing and/or fitness	• Women are unable to support themselves outside of marriage (e.g., cannot own land or be employed) • Sex without marriage is risky (e.g., unwanted pregnancy, STI exposure) • Marriage has direct benefits to girls unavailable through other means

While the HBE perspective does not shy away from considering of the role of family conflict in driving early marriage under certain circumstances, engaging with the potential rationality of early marriage for girls offers important insights for policy-makers. For example, programs to end early marriage often include efforts to empower girls to exercise agency to delay marriage. Such efforts may fail when the assumption that girls are forced into adolescent marriages by others is not met or if risks associated with alternatives to marriage (e.g., education) are not fully engaged with. In such cases, efforts to empower girls to exercise greater agency may hasten rather than delay marriage. This raises the dilemma in which young people's agency is accepted by external actors only when they make the 'right' choice according to development agendas (Schaffnit et al. 2020). Critically, (re)conceptualizing early marriage as a product of specific sets of constraints strongly suggests that a robust strategy to address the vulnerabilities of female adolescence will require broader engagement with structural and culturally-specific factors that limit options. Such a strategy for improving girls wellbeing may not actually center on ending early marriage itself. For example, the criminalization of marriage under 18 years without accompanying adjustments to the wider constraints that motivate early marriage in the first place may not meaningfully improve women's lives, and may actually be harmful by limiting their ability to make strategic choices (Schaffnit et al. 2020). In fact, history demonstrates that ages at marriage increase as socioecological contexts change without external pressure of criminalization because that is largely what has happened in the global north. Indeed, 'child marriage' is still legal in most of North America and Europe (Arthur et al. 2018) and yet is very uncommon in these areas. This is likely due to many factors that together incentivize delayed marriage, including mandatory schooling laws complimented by high-quality education, fulfillable employment aspirations for girls, greater social recognition of women's roles beyond marriage and childrearing, and increased access to economic security nets for families. As we have argued elsewhere, "supporting adolescent girls to live the lives they desire may mean acknowledging and respecting the full range of their agency while simultaneously working to dismantle unduly limiting structures which shape all decision-making" (Schaffnit et al. 2020, p. 11).

Another major contribution of HBE to global health approaches to child marriage is a reiteration that context matters and one-size-fits-all explanations for any behavior are rarely appropriate (Gibson and Lawson 2015). HBE identifies multiple specific potential rationalities behind decisions to marry early or to favor early marriage for one's daughter (Table 2). In contrast, current global health discourse primarily focuses on the parent–offspring conflict hypothesis, albeit often implicitly (Figure 1). This narrow lens can only limit the effectiveness of current policy. We therefore advocate for greater consideration of the contextual factors that may lead to differing explanations and to variable potential solutions to tackle early marriage specifically and the wider vulnerabilities of female adolescence more generally. Policy-makers must consider what drives early marriage in each context and be open to the possibility that the drivers and wellbeing consequences of early marriage may vary not just between populations but within them depending on the age of the girl/woman involved, her family background, her economic situation, and the options available to her. HBE provides a broad, anthropologically-informed perspective to identify socioecological factors (e.g., demographic parameters, economic conditions, educational opportunities, and specific patriarchal traditions) that may incentivize early marriage and thus reliably predict such patterns. This contribution is highly complementary to frameworks in development economics but goes further by clarifying that the ultimate utility function guiding behavioral variation is inclusive fitness, leading to novel insights, including the possibility that early marriage may persist in the absence of wellbeing benefits to any party involved, provided it is fitness-maximizing (or was in prior environments) (Gibson and Lawson 2015).

Just as HBE contributes to our understanding of early/child marriage, we also note that a more dedicated study of marital timing, drawing on findings from across the social sciences, would benefit HBE more broadly. Specifically, considering the context-dependent drivers of early marriage highlights shortcomings of common notions of fast/slow life history continuums that are popular in the evolutionary behavioral sciences. This approach is characterized by assumptions about coordinated physical-behavioral strategies to time reproduction (Sear 2020, e.g., a 'fast life history strategy' may combine early puberty, marriage, and first birth in harsh environments, while a 'slow life history strategy' would combine delayed puberty, marriage, and first birth in more steady environments). However, while timing of marriage is often correlated with other life history transitions central to determining reproductive timing (e.g., puberty, first sex), marriage differs because it also reflects mate choice strategies sensitive to cultural institutions and norms regulating family alliance formation and transfers of wealth (Shenk et al. 2016; Fortunato 2015). The costs and benefits of marriage timing may therefore vary independently from physiological transitions to adulthood via puberty or decisions about when to start reproduction. For example, as we highlight above, at a global level early marriages are most common in areas where puberty is late. In these settings, social or financial benefits of marriage likely incentivize early marriage, while relative nutritional deprivation leads to later menarche. In contrast, in well-nourished populations puberty seems to be occurring at earlier and earlier ages than in the past (Herman-Giddens 2006) while entry to adulthood and perceived readiness to marry is being delayed, presumably due to a number of novel features of the environment that alter benefits of delayed marriages, costs of early marriages, and the dynamics of conflicts over ideal timing between girls and their extended networks. Remarkably, in light of these shifts, public health professionals in the global north now recommend that we extend conceptualizations of adolescence, and its implied vulnerability, into the third decade of life (Sawyer et al. 2018).

In summary, addressing early marriage remains central to current global health agendas, with large amounts of money and brainpower going towards its eradication. The HBE approach to understanding early marriage underscores the importance of context-dependency in both drivers of early marriage but also the likely effectiveness of policy responses. With improving girls' lives at the base of the global campaign to end child marriage, HBE can help identify and predict the constraining structures that lead to harmful early marriages. Critically, it also cautions against portraying early marriage as the lynchpin that, once dislodged, will dismantle the constricting structures within which it is common. Instead, it offers to situate our understanding of marital timing within a broader body of theory addressing not just marriage and reproduction but patriarchal norms and cultural institutions (Hrdy 1997; Borgerhoff Mulder and Rauch 2009; Smuts 1995; and Lawson et al. 2021) that pattern human behavior and wellbeing worldwide.

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Historical Context Changes Pathways of Parental Influence on Reproduction: An Empirical Test from 20th-Century Sweden

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Abstract: Several studies have found that parental absences in childhood are associated with individuals' reproductive strategies later in life. However, these associations vary across populations and the reasons for this heterogeneity remain debated. In this paper, we examine the diversity of parental associations in three ways. First, we test whether different kinds of parental availability in childhood and adolescence are associated with women's and men's ages at first birth using the intergenerational and longitudinal Uppsala Birth Cohort Study (UBCoS) dataset from Sweden. This cultural context provides a strong test of the hypothesis that parents influence life history strategies given that robust social safety nets may buffer parental absences. Second, we examine whether investments in education help explain why early parental presence is associated with delayed ages at first birth in many post-industrial societies, given that parents often support educational achievement. Third, we compare parental associations with reproductive timing across two adjacent generations in Sweden. This historical contrast allows us to control for many sources of heterogeneity while examining whether changing educational access and norms across the 20th-century change the magnitude and pathways of parental influence. We find that parental absences tend to be associated with earlier first births, and more reliably so for women. Many of these associations are partially mediated by university attendance. However, we also find important differences across cohorts. For example, the associations with paternal death become similar for sons and daughters in the more recent cohort. One possible explanation for this finding is that fathers start influencing sons and daughters more similarly. Our results illustrate that historical changes within a population can quickly shift how family affects life history.

Keywords: fertility; reproductive timing; family structure; life history strategies; educational attainment; cohort effects

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1. Introduction

Parental absences in an individual's early life are often associated with earlier reproductive development both physiologically (Matchock and Susman 2006; Surbey 1990; Sheppard and Sear 2012) and behaviorally (McLanahan and Bumpass 1988; Chisholm et al. 2005). However, a recent review suggests this phenomenon is not consistent across populations, particularly when considering associations beyond those of fathers' absences on daughters' development (Sear et al. 2019).

These empirical observations present two puzzles for evolutionary social scientists. First, why should fathers be so commonly associated with later reproduction for daughters? Natural selection favors strategies that increase reproductive success. Parents delaying reproduction contradicts one straightforward evolutionary prediction that help from family should improve individuals' fitness, in part by allowing them to reproduce earlier, and therefore more often. The human data also counters several observations of delayed or suboptimal reproductive behavior among non-human mammals experimentally reared without parents (Wuensch 1985; Bastian et al. 2003; Schradin and Pillay 2004). Second, how can we account for heterogeneity in the associations between parental absence and reproduction across populations? That is, which ecological and cultural factors moderate the role parents play in their children's life histories and reproductive careers?

Evolutionists have proposed several (not necessarily mutually exclusive) theoretical accounts suggesting causal effects between parental absences in childhood and faster reproductive strategies. These include roles for (1) inbreeding avoidance mechanisms (Matchock and Susman 2006); (2) intergenerational conflicts (Moya and Sear 2014); (3) parental guarding of children's reproductive value (Flinn 1988); (4) strategies for extracting parental investments for longer (Ellis 2004); (5) adaptive responses to one's own increased morbiditiy or mortality risks given the lack of parental investments (Geronimus 1991; Rickard et al. 2014); or (6) mechanisms for assessing environmental factors, be they mortality risks (Chisholm 1993), unpredictability (Del Giudice 2014), or the availability of investing partners (Thornton and Camburn 1987; Draper and Harpending 1982). Some of these accounts make further predictions about the circumstances under which parental effects on children should be strongest. For example, the intergenerational conflict model predicts that parental effects should be smaller for sons than daughters when paternity uncertainty is high (Moya and Sear 2014), and some life history accounts suggest parental delays on reproduction only make sense for intermediately harsh environments (Coall and Chisholm 2003).

In this article we focus on a form of the parental investment model; specifically, we examine whether parental presences delay reproduction in part because parents support and encourage education, which in turn trades off with early reproduction. Parental deaths in childhood are often associated with negative educational outcomes (Case and Ardington 2006; Willführ 2009; Gertler et al. 2004). There are several ways parents may influence educational outcomes. For example, parents may directly invest in their children's primary and secondary schooling, thus improving the socio-economic returns to university education for their children. In other words, students who are well-prepared for university, perhaps in part due to parental support, stand to gain more from continuing their education rather than starting to work. Alternatively, parents may directly support their children engaging in status-seeking behavior, which includes higher education in many societies. In this paper we do not differentiate these forms of cultural capital that parents may provide (Bourdieu and Passeron 1990).

The fact that higher education is a historically novel form of social status that can tradeoff with reproduction, may help explain some of the puzzling parental delays to reproduction in post-industrial contexts. It is not surprising that parents commonly have an interest in their children attaining culturally relevant forms of status. However, they also have an interest in encouraging pro-natal behavior, even in low fertility societies (Newson et al. 2005). Often, and arguably for most of human evolutionary history, these goals were not at odds. Culturally defined status is often associated with indicators of individuals' fitness—i.e., long-term number of descendants (Cronk 1991; Borgerhoff Mulder 1987; Hopcroft 2006; von Rueden et al. 2011). However, this relationship between reproductive success and indicators of socio-economic status has weakened, and sometimes reversed, in many post-demographic transition and transitioning contexts (Huber et al. 2010; Snopkowski and Kaplan 2014; Goodman and Koupil 2009; Beydoun 2001; Upchurch and McCarthy 1990; Goodman et al. 2012; Kaplan et al. 1995; see Stulp and Barrett 2016 for a recent review). Cultural evolutionary forces may recently—but perhaps also in societies such as ancient Rome (Caldwell 2004)—favor forms of status that are not necessarily associated with fitness (Boyd and Richerson 1985; Colleran 2016). This means a historical analysis is necessary for understanding how people adopt new forms of status and how the role of parents in shaping fertility behavior changes in the process.

Associations between indicators of status and reproductive outcomes are complex, however; they often show notable sex differences, can be non-monotonic, depend on which indicators of socio-economic position are used, and may change over time (Sobotka et al. 2017). A consistent finding across contexts is that education, for example, is negatively associated with fertility for women, who experience more tradeoffs between reproduction and education or market labor. In contrast, in some post-demographic transitions contexts, education may be positively associated with reproductive success for men, largely because it reduces the likelihood of childlessness (Kravdal and Rindfuss 2008; Jalovaara et al. 2019; Nisén et al. 2018). Similarly gendered-relationships between fertility and academic success (Goodman and Koupil 2010) and cognitive skills (Kolk and Barclay 2018) have been documented in Sweden. However, the strength of these associations may differ between contexts and change over time. As higher education becomes increasingly common, particularly for women; there is evidence that the negative gradient between education and fertility is nearly disappearing for women in some low fertility settings, including Sweden (Dribe and Smith 2020; Jalovaara et al. 2019). Nevertheless, higher levels of education are consistently associated with delayed first births for women (Neels et al. 2017), and often for men (Corijn and Klijzing 2001; but see Trimarchi and Van Bavel 2017 for discussion of inconsistent associations between education and first births), given cultural norms and economic constraints reduce the likelihood of childbearing until education is complete. There is some evidence that the association between education and age at first birth timing is also becoming more similar for men and women in more recent Swedish cohorts (Dribe and Stanfors 2009).

Despite the vast demographic literature on parental effects on reproduction and on historical changes in reproductive and educational strategies, little has been done to address the ways the role of parents can also change. Here, we address the following three questions in a longitudinal dataset from 20th-century Sweden:

1. Are parental deaths or separations in childhood associated with reproductive timing?
2. Are parental associations with age at first birth mediated via educational attainment, specifically university attendance?
3. Are there historical changes in the pathways of parental influence? More specifically, do changes in men's and women's university attendance accompany changes in how parental absences are associated with their sons' and daughters' reproductive timing?

In the next section we discuss the state of the literature. Section 3 introduces the dataset, historical and cultural context, and describes how they are uniquely suited to addressing these questions. We then discuss our analytical methods. Section 4 describes the results with respect to each question in turn. In Section 5 we discuss how well the answers to each question and other patterns in the data fit the various theoretical accounts.

2. Previous Work

2.1. Do Parental Deaths or Separations in Childhood Directly Affect Reproductive Timing?

Parental absences can be associated with both delayed and earlier first births. In some pre-demographic transition societies early parental absences correspond to delayed reproductive events suggesting the importance of parents for coordinating marriages, investing in childcare, provisioning grandchildren, and transmitting cultural knowledge about parenting (Scelza 2010; Lahdenperä et al. 2004; Lahdenperä et al. 2007; Jennings et al. 2012; Waynforth et al. 1998; Allal et al. 2004; Mattison et al. 2014; but see Winking et al. 2011 for a society where father absences have no effect). However, most research on the topic, conducted in post-industrial settings, shows the reverse pattern, namely parental absences in childhood expedite the onset of reproduction (Kiernan 1992; Ellis et al. 2003; Palermo and Peterman 2009; Lee 2001; Manlove et al. 2000; Wu and Schimmele 2003; Sheppard and Sear 2012; Chisholm et al. 2005; McLanahan and Bumpass 1988). The most consistent, and most studied, effects are those of fathers on daughters' reproductive timing. This partly reflects the fact that fathers are more often missing than mothers from children's lives, and the fact that daughters' puberty and ages at first birth are easier to measure than sons'. While father's presences are more consistently associated with later reproduction for daughters in contemporary high-income societies than in historical samples or those from lower income countries, this obscures much variation within high and low-income settings that has yet to be explained.

Although much of this literature treats parental absences of any kind similarly, it is increasingly clear that the causes of parental absence matter and likely reflect different pathways of influence. For example, in rural Bangladesh daughters with separated fathers reproduced earlier than those with fathers present, while daughters with fathers who had died or were working as labor migrants elsewhere reproduced later (Shenk et al. 2013). This diversity of parent absent effects suggests different causal pathways of influence. Few studies, however, have clearly demonstrated causal associations between parental absences and children's reproductive outcomes. As parents' deaths and separations are not randomly distributed, selection effects limit our ability to make strong causal claims. For example, some authors have suggested that associations between parental absences and reproductive development may be due to genetic effects that affect both certain behavioral traits, such as likelihood of divorce, and children's physiological development (Barbaro et al. 2016). However, some case studies of parental separation during war serve as pseudo-experiments that strongly suggest a direct causal effect of parental absences in expediting reproduction (Pesonen et al. 2008). Further, the diversity of associations suggests that environmental context matters, minimally making the genetic confounding a plausible mechanism only in some environments (Uchiyama et al. 2021). Here, we exploit a longitudinal dataset which allows us to assess whether such associations change over a period in which significant genetic change is implausible. This would provide further evidence against the suggestion that only genes matter for these associations.

2.2. *Are Parental Effects on Age at First Birth Mediated via Educational Attainment?*

Little work has been conducted to assess whether investments in educational capital mediate the relationship between parental absences in childhood and later reproductive outcomes. In part, this may be because research in this area has focused on physiological pathways of influence that are developmentally earlier than higher educational investments (Hoier 2003; Ellis 2004; Sheppard and Sear 2012). Independent relationships between parental absences and lower educational achievement (Case and Ardington 2006; Gertler et al. 2004), and between education and later ages at first birth (Rindfuss and St. John 1983; Bongaarts et al. 2017) are well documented, particularly in post-demographic transition and transitioning societies. There is indeed good causal evidence that parental divorces and deaths affect educational outcomes, even in late 20th-century Norway where, much like in our study population, robust social safety nets may buffer such family losses (Steele et al. 2009). Furthermore, across all cohorts born in Norway between 1940 and 1964, more educated women, and to a lesser degree men, begin reproducing later in life (Kravdal and Rindfuss 2008). Given these relationships in a similar cultural context, it is plausible that parental absence may result in earlier first births through this educational pathway across 20th-century Sweden.

2.3. *Are There Historical Changes in the Pathways of Parental Influence?*

To our knowledge this is the first paper that addresses whether the pathways of parental influence on age at first births have changed through time. However, several lines of evidence suggest that such changes are plausible.

All our variables of interest have changed markedly over the last 100 years in nearly every country. The 20th century has seen the spread of formal schooling, delays to first births and decrements in family orientation (Newson and Richerson 2009; van de Kaa 1987; Mills et al. 2011; Bongaarts et al. 2017), though the latter two outcomes did not change monotonically, for exampling reversing in many countries post WWII (Sánchez-Barricarte 2018).

Historical changes during the past century could have also changed whether, and how, parents influence their children's reproductive onset. We will consider an indirect path of parental influence through education, and a direct path of influence that collapses all other possible effects. We describe three mechanisms whereby the direct parental effects on reproductive timing and their indirect effects via education would be expected to decrease through the course of the 20th century, and one mechanism whereby the indirect effect through education might increase or decrease through time. These correspond to the following historical trends; (1) increases in state support for education, (2) increases in non-parental cultural transmission at university, (3) increases in state support for reproduction, and (4) convergence in educational norms between parents and offspring. We discuss each further in turn.

As states have democratized higher education, we might expect that parental support becomes less necessary to attend university, thus reducing the importance of the indirect pathway of parental influence on reproductive onset. We have previously shown that university attendance became both more common and more meritocratic in Sweden across the 20th century (Goodman et al. 2010). Sweden also followed other countries in shifting from a marked male dominance among university attendees to an overall female bias (Goldin et al. 2006). This implies that parental support in educational endeavors and intergenerational inheritance of cultural capital may matter less as state policies can make university attendance achievable for young adults from wider socio-economic and family backgrounds, and that this pattern may be gendered. This leads to the prediction that indirect parental influences on age at first birth via education should go down through the 20th century.

University attendance may independently change direct parental influences on reproductive timing, as it provides new opportunities for cultural transmission from peers and teachers. Several models have shown that the transmission of beliefs from teachers rather than parents facilitate the spread of low fertility behavior that would otherwise be selected against (Cavalli-Sforza and Feldman 1981; Ihara and Feldman 2004; Boyd and Richerson 1985). As peoples' social networks become less kin-based, anti-natal influences may well increase from university peers, mentors, and colleagues (Newson et al. 2005). This leads to an additional prediction that direct parental effects on age at first birth should decrease through the 20th century as university attendance, the importance of peer networks, and therefore non-kin social influences, increase.

The Swedish state has also introduced policies that lower the costs of reproduction and parenting beyond those that democratize university. For example, various expansions of subsidized day care and parental leave in the second half of the 20th century (Hwang and Broberg 1992) may have reduced the importance of alloparental help (i.e., child-rearing aid from non-parents) from grandparents and other kin (though see Schaffnit and Sear 2017 for evidence that emotional, rather than material, support from parents has pro-natal effects in the UK). If adolescents and young adults are relying less on their parents to help rear their infants, this could decrease the direct effects parents have on reproductive decision-making, independent of their educational roles.

The pace of historical change in the 20th century also means that parents and their children may belong to different generational cultures. Because of the extent of social learning that happens between peers, parents and children do not always adopt the same beliefs (Harris 1999; Kline et al. 2013; Moya et al. 2015). This can affect both direct and indirect parental effects. One possibility is that the more similar the parent and child generations' norms, the smaller the normative influence of parents on education and reproduction should be. That is, children need no convincing to behave as their parents wish them to. On the other hand, it is possible that parents can have stronger effects on their children's life history decisions if they share similar norms. For example, an adolescent may be more successful at attending university if their parent agrees with this goal. Historical changes in university attendance can produce intergenerational discrepancies in beliefs about the necessity, propriety, and prestige of higher education, especially for women. As cultural change in beliefs about education slows down there will be less of an intergenerational gap in expectations as the parent and child generations experience more similar social environments. This suggests that, earlier in the 20th century, parents may try to discourage their children's, especially daughters', university attendance given that the generations have more discrepant life experiences with higher education for women. On the other hand, later in the 20th century, parents may invest more in daughters' education, and thus delay first births more via this indirect pathway.

3. Methods

3.1. Dataset

To address our questions, we used data from two adjacent cohorts from the Uppsala Birth Cohort Multigenerational Study (UBCoS Multigen). This longitudinal and intergenerational dataset includes 14,192 people born in the Uppsala University Hospital in Sweden between 1915 and 1929, and their descendants, thus spanning most of the 20th century. Of the original cohort, 12,168 still lived in Sweden in the late 1940s and therefore received personal identification numbers that allows them to be linked across national registers. Their children and other descendants were identified through the Multi-Generational Register and could be followed throughout their lives to measure social and biological data of relevance to several health outcomes.

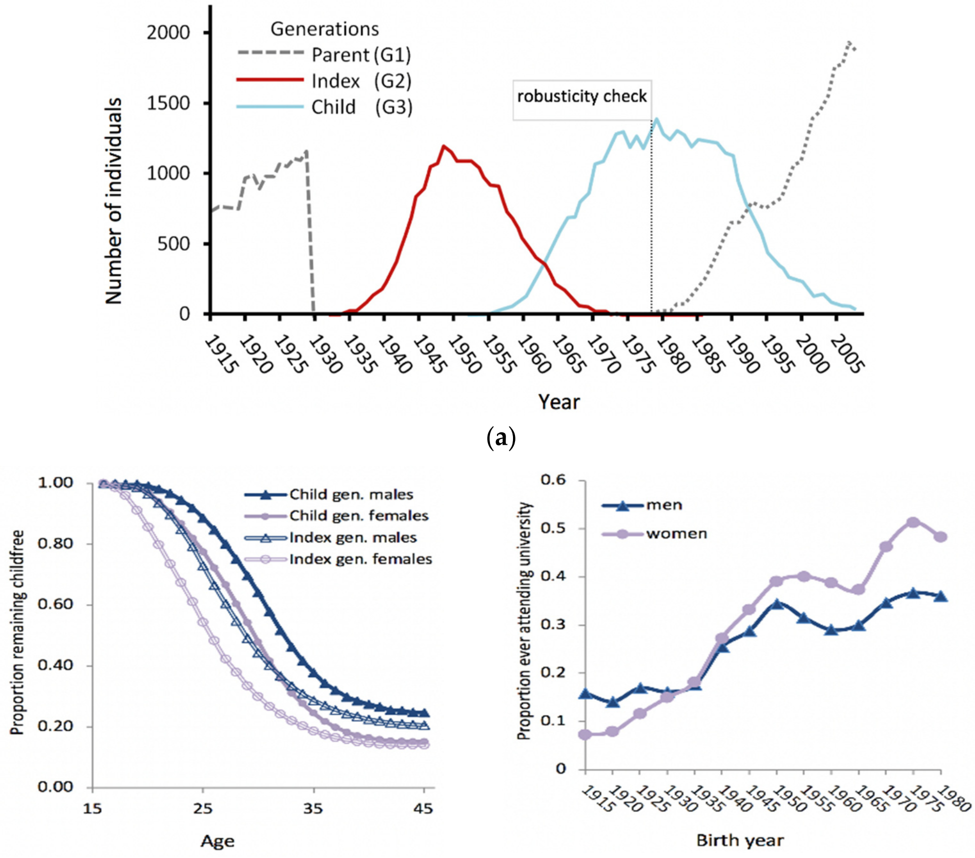
This dataset has various strengths for this investigation: (1) it includes individuals' complete reproductive histories and several socio-economic indicators across generations, (2) it represents a social context where education, healthcare and childcare have long been heavily subsidized by the state (Hoem and Hoem 1996) and (3) it spans a period with little change in fertility rates, but delays to reproduction (Hoem 2005) and a large historical change in higher education attendance, especially for women (Goodman et al. 2010).

The first strength allows us to control for the influence of an unusually large number of potential confounders, including parental and grandparental socio-economic position and parental reproductive history, several of which are known to be intergenerationally transmitted (Borgerhoff Mulder et al. 2009; Murphy and Knudsen 2002).

The two other strengths are of theoretical importance. This cultural context provides a strong test of the hypothesis that parental presence helps explain variation in reproductive and socio-economic outcomes, given that the Swedish state from the early 20th century onwards has provided much social assistance for individuals to attain their educational and reproductive goals (Hoem and Hoem 1996), thus potentially reducing the importance of kin support. On the other hand, 20th-century Sweden represents a context with relatively high rates of paternal care (Duvander et al. 2010), making it more likely that father absence would be important here. The third feature of this dataset is essential for testing our hypotheses about the relevance of historical changes for parental effects on reproductive timing. Shifting rates of university attendance, especially for women, may have consequences for parents' pro-natalism and educational investment strategies for their children. The fact that we can compare two adjacent cohorts, and specifically ones from the same families, allows us to hold many, if not all cultural factors constant.

3.2. Samples

We focused our analysis on the second index generation (G2, $n = 20{,}727$) of the Uppsala Birth Cohort Multigenerational Study (Figure 1a). We refer to the original cohort as the parent generation. The index generation of this multigenerational, longitudinal dataset represents the only cohort for which we have complete information about parental death dates and nearly complete information about their full reproductive lives. Members of the index cohort were born between 1932 and 1990, but 93% of them had reached 45 years of age by the last time they had been observed (see Supplementary Materials Figure S1). This means that to analyze first birth timing we can include the full second generation since the vast majority would have progressed to this event (Figure 1b). We exclude long-term emigrants from Sweden from the analysis because of the difficulty in linking their data. We also examine parental effects on total fertility with a subset of the sample, but these results are presented only in Supplementary Materials Section S5.



(**a**)

(**b**) (**c**)

Figure 1. Historical changes in UBCoS cohorts. (**a**) Birth years by generation. The red solid line represents the index generation, the primary focus of this study. The child generation in solid light blue was used to test for historical changes in parental effects on first births. Their children are represented by the most recent dotted line. Robusticity checks of individuals older than 35 years of age when last seen would include individuals born before the vertical dotted line. (**b**) Survival curves for progression to first birth. The index generation is shown with open markers, and the child generation with filled in ones. Individuals who were censored for non-reproductive reasons were taken out of the analysis. (**c**) Proportion of adults ever attending university by end of 2009. Plotted by sex and earliest birth year in 5-year birth bands.

To test whether family background associations with timing of first births and their pathways have changed in recent history, we also analyzed ages of first birth for the children of index individuals. We will call them the child generation (n = 37,118). There are more individuals in the child cohort who had yet to reach their first birth than in the index generation—i.e., they are censored since they have no age at first birth data. However, event history analyses can incorporate these censored individuals to provide less biased estimates (Singer and Willett 1993). While we use linear regressions that drop childfree people from the analysis in the main text, we find substantively similar results when using event history analyses (see Supplementary Materials Section 2 for robusticity checks).

Several historical changes between the index and child generations are likely to interact with parental effects on timing of first births. Of primary interest to us, (1) there is less intergenerational discrepancy between parents and children in university attendance rates in the more recent generation (Goodman et al. 2010). The gender ratio of university attendees is also more similar for the index and child generation than it is between the parent and index generation (Figure 1c, Table 1). These patterns reflect national level dynamics (Figure S2). Additionally, (2) the median age at first birth is delayed in the child cohort relative to the index cohort (Figure 1b), and (3) through time parental deaths in childhood and adolescence becomes rarer while having unmarried or separated parents becomes more common (Table 1).

Table 1. Descriptive statistics for all variables by cohort and gender. For clarity, standard deviations are omitted for categorical variables and means refer to proportion of individuals within that category. NB: many in the child generation had not completed reproduction.

	Index (G2)						**Child (G3)**					
	Men			**Women**			**Men**			**Women**		
	Mean	**SD**	***n***	**Mean**	**SD**	***n***	**Mean**	**SD**	***n***	**Mean**	**SD**	***n***
Age at first birth *	27.33	5.52	7935	24.76	5.31	8157	27.77	4.49	5864	25.98	4.54	6941
Fertility *	2.33	1	7935	2.28	0.94	8157	1.88	0.84	5864	1.99	0.89	6941
University attendance	0.31	-	7904	0.36	-	8143	0.29	-	5843	0.40	-	6893
Parental status (total)			7935			8157			5864			6941
married and cohabiting	0.82	-	6507	0.82	-	6678	0.61	-	3587	0.60	-	4193
mother dead	0.02	-	159	0.02	-	163	0.01	-	50	0.01	-	80
father dead	0.04	-	317	0.04	-	291	0.02	-	137	0.02	-	159
separated	0.12	-	952	0.13	-	1025	0.36	-	2090	0.36	-	2509
Birth year (total)			7935			8157			5864			6941
1930–39	0.02	-	159	0.02	-	177	-	-	-	-	-	-
1940–44	0.1	-	794	0.11	-	892	-	-	-	-	-	-
1945–49	0.26	-	2063	0.25	-	2046	-	-	-	-	-	-
1950–54	0.27	-	2142	0.27	-	2175	<0.01	-	6	<0.01	-	4
1955–56	0.2	-	1587	0.20	-	1655	0.02	-	98	0.01	-	71
1960–64	0.1	-	794	0.10	-	848	0.08	-	494	0.07	-	503
1965–69 **	0.04	-	317	0.04	-	364	0.21	-	1220	0.20	-	1371
1970–74	-	-	-	-	-	-	0.32	-	1879	0.30	-	2085
1975-79	-	-	-	-	-	-	0.25	-	1490	0.26	-	1828
1980–84	-	-	-	-	-	-	0.10	-	587	0.13	-	877
1985–89	-	-	-	-	-	-	0.02	-	89	0.03	-	188
1990–94	-	-	-	-	-	-	<0.01	-	1	0.00	-	14
Parent's education (total)			7935			8157			5864			6941
elementary, ≤8 years	0.40	-	3174	0.40	-	3283	0.05	-	312	0.05	-	353
elementary, 9–10 years	0.06	-	476	0.06	-	472	0.08	-	452	0.07	-	514
high school, <3 years	0.25	-	1984	0.26	-	2102	0.38	-	2216	0.37	-	2595
high school, 3 years	0.09	-	714	0.10	-	775	0.16	-	927	0.17	-	1146
<3 years after high school	0.06	-	476	0.06	-	475	0.15	-	884	0.15	-	1037
≥3 years after high school	0.11	-	873	0.10	-	855	0.17	-	990	0.17	-	1196
post graduate	0.02	-	159	0.02	-	145	0.01	-	82	0.01	-	98
Parent's household income	−0.02	0.89	7935	−0.04	0.86	8157	0.02	0.51	5864	−0.01	0.49	6941
Grandparent's socioeconomic status (total)			7935			8157						
higher and mediate non-manual	0.1	-	794	0.10	-	791	-	-	-	-	-	-
entrepreneurs and farmers	0.21	-	1666	0.20	-	1655	-	-	-	-	-	-
lower non-manual	0.07	-	555	0.07	-	582	-	-	-	-	-	-
skilled manual	0.15	-	1190	0.15	-	1253	-	-	-	-	-	-
unskilled manual, production	0.28	-	2222	0.29	-	2367	-	-	-	-	-	-
service	0.19	-	1508	0.18	-	1509	-	-	-	-	-	-
Fertility, mother's	2.85	1.42	7899	2.82	1.42	8133	2.52	1.05	5862	2.54	1.06	6941
Fertility, father's	2.91	1.46	7763	2.86	1.45	7999	2.55	1.12	5827	2.53	1.10	6887
Age first birth, mother's	24.34	4.41	7899	24.39	4.43	8133	22.23	3.58	5862	22.34	3.61	6941
Age first birth, father's	27.43	4.95	7763	27.41	5.00	7999	24.69	4.01	5827	24.89	4.03	6887

* does not account for censoring. ** all Cohort 2 members born after 1965 were coded as a 1965–1969 birth band due to small samples thereafter.

Swedish individuals born in the early 1930s represent the first cohort where women would outnumber men among university attendees. The UBCoS parent and index cohorts perfectly straddle this historic shift. All the original cohort members were born before 1930 while all index cohort members were born after 1930. This means that when studying index individuals we are examining a context where parents and children experienced different educational norms (statistical, if not prescriptive norms), but not remarkably different reproductive norms (compare parents' and children's ages at first birth in Table 1). The index generation and their children, on the other hand, belong to cohorts with relatively more similar university gender composition and attendance rates.

3.3. Variables

3.3.1. Dependent Variable

All variables used in regression models are described in Table 1. To test hypotheses regarding timing of first births we ran analyses in two ways; first as linear regressions on age at first birth (AFB), and second as discrete-time event history analyses predicting probability of progressing to a first birth from age 16 onwards given that one had not already done so. The former was used for the mediation analysis.

3.3.2. Independent Variables

As our primary predictor we considered any evidence of a parental absence within the first 20 years of life, including deaths and separations. Parents' marital status was available from decadal censuses (from 1960–1990) so we could only get rough estimates of the timing of separations. From this we extracted any evidence of parental separation or non-cohabitation during the first 20 years of one's life. This includes either parent being single, divorced, married but not living with the child's parent, or cohabiting with someone other than the child's parent. While we will refer to these as parental separations, this will admittedly capture many different kinds of families, including cohabiting parents who are not married, a family form that has increased in Sweden since the 1960s (Goodman and Koupil 2009). We construct a single categorical variable of parental availability; parents alive and married and cohabiting, mother dead, father dead, and both parents alive but separated. There were too few individuals whose parents both died in the first 20 years of their life to be analyzed so these were excluded. There are roughly twice as many people who experienced paternal deaths compared to maternal deaths in our sample, and separations are an order of magnitude more common than any parental death. This means that focusing on significance will mislead readers about the importance of each kind of associations. That is, we are more likely to find significant effects of parental separations than parental deaths all else equal, simply because of sample size differences. To avoid such misrepresentation, we focus our comparison of results on effect sizes rather than statistical significance.

3.3.3. Mediator

To examine whether parental effects on reproductive outcomes are mediated by their investments in children's education we considered university attendance as a mediator. Given that university, rather than primary or secondary, education most directly trades off with onset of reproduction in post-industrial societies, and years of schooling is very left skewed, we used a binary variable of having ever attended university.

3.3.4. Covariates

Given the importance of shared environmental and genetic effects between parents and children (Pettay et al. 2005), we included as many family background controls as possible to reduce confounding. We use three variables to account for family socio-economic background: grandparents' occupation, parents' income, and parents' education. The first is a 6-level categorical variable where grandparents labor is coded as higher and mediate non-manual, entrepreneurial/farming, lower non-manual, skilled manual, unskilled manual in production, and unskilled manual in service. This variable is only available for the index (G2) generation's grandparents. Parent's income reflects the average of parents' disposable income during their adulthood (ages 21–65) standardized by calendar year, age and gender. Income data was combined from the Longitudinal Database for Education, Income and Occupation (1990–2008), in addition to decadal censuses from 1960 onwards. This is modeled with a linear and squared term to allow for non-linear effects. Finally, the maximum educational level achieved by a parent is a categorical variable with 7 levels of schooling; 8 years of elementary or less, 9–10 years of elementary, fewer than 3 years of high school, 3 years of high school, fewer than 3 years beyond high school, at least 3 years beyond high school, and postgraduate schooling. We us two variables to account for family reproductive background; parents' fertility and ages at first birth. Parents' fertility was proxied by the mother's when this data was available, and the father's number of children otherwise. Similarly, the mother's age at first birth was included in models. For the few individuals for whom this data was unavailable, we estimated it by using the father's age at first birth minus the cohort-specific mean age discrepancy between male and female ages at first birth. Additionally, to account for historical changes within each cohort we adjusted for birth bands of roughly 5-year intervals. For further details about the construction of variables see (Goodman et al. 2012).

3.4. Analysis

All models were run in Stata v12 or 13. Stata scripts of the main models are provided in the Supplementary Materials Section 3. For ease of interpretation, we ran models on female and male participants separately given their systematic difference in timing of first birth and educational attainment. When model predictions are shown, average marginal effects were calculated (Bartus 2005) and confidence intervals around the predicted values were estimated using the delta method.

Linear regressions are used to model age at first births, and event history analyses for progression to first birth are provided in the supplement to account for uneven censoring across cohorts. Given the non-independence of observations within a family we use robust standard errors, clustered by shared mother, or shared father if mother identity was missing.

To address the role of higher education as a mediating factor, we model this binary variable with a logit model, employing the user-written command, binary_mediation, to do so. All the same covariates are included in the mediation analyses, but we did not cluster by shared parent. We report bootstrapped percentile confidence intervals (using 500 replications) since sampling distributions of indirect effects tend to be skewed (Preacher and Hayes 2008).

4. Results

4.1. Are Parental Deaths or Separations in Childhood Associated with Reproductive Timing?

Focusing on the index generation for now, all forms of parental absences in the first 20 years of life are associated with earlier first births for sons and daughters (Table 2, Figure 2). While many of these relationships are not significant, even the smallest among them amounted to decreasing the individual's predicted age at first birth by a quarter of a year. The associations are generally larger for daughters than for sons. For example, a father's death and parental separations are associated with an age at first birth that is nearly 1 year earlier for daughters. It is only a mother's death which is more strongly associated with lower ages of first birth for sons than daughters'—although the association was not significant in either sex. The patterns are substantively the same when only analyzing individuals who reached 35 years of age (Figure S3). Event history analysis of progression to first births generally replicates this pattern of sons' progressions to first births being more strongly associated with maternal deaths (but also separations), while daughters' tempo is more strongly associated with paternal deaths and separations (Figure S4).

4.2. Are Parental Effects on Age at First Birth Mediated via Education?

Parental absences in the first two decades of life are generally associated with lower likelihood of attending university (Figure 3, Table S1). Focusing on the index cohort (G2) for now, parental separations are associated with the largest, and most reliable, decrements in the log odds of university attendance. The effect sizes of early maternal deaths on daughters' university attendance rival those of parental separation for this generation. Mothers' and fathers' deaths show roughly the same associations with sons' educational attainment, though neither is significant, while fathers' deaths have effectively zero association with a daughter's university attendance in the index generation.

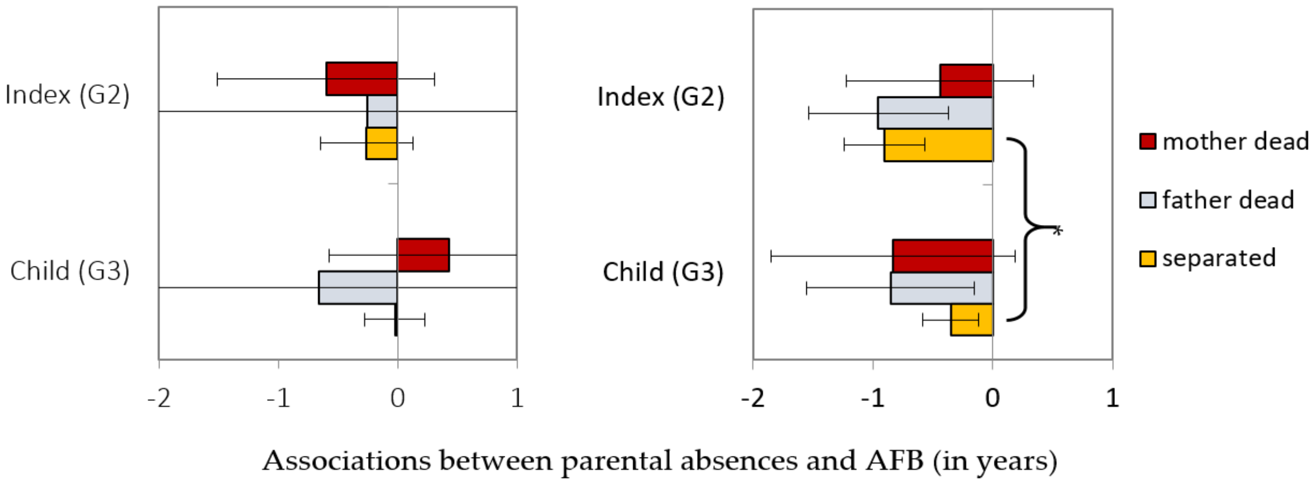
Table 2. Linear regression models predicting age at first birth from parental presence within first 20 years of life. Robust standard errors controlling for family clusters (parent's id) are given.

	Index (G2)						**Child (G3)**					
	Men			**Women**			**Men**			**Women**		
	B	**SE**	***p***	**B**	**SE**	***p***	**B**	**SE**	***p***	**B**	**SE**	***p***
Parental status (ref = married and cohabiting)												
mother dead	−0.6	0.47	0.2	−0.44	0.4	0.27	0.43	0.51	0.4	−0.83	0.52	0.11
father dead	−0.26	0.31	0.4	−0.96	0.3	0.001	−0.66	0.36	0.07	−0.85	0.35	0.02
separated	−0.26	0.2	0.18	−0.91	0.17	<0.001	−0.02	0.13	0.86	−0.35	0.12	0.003
Birth year (ref = 1932–39)												
1940–44	−0.52	0.46	0.26	0.01	0.35	0.99	-	-	-	-	-	-
1945–49	−0.05	0.45	0.91	−0.05	−0.34	0.89	-	-	-	-	-	-
1950–54	1.08	0.45	0.02	1.22	0.34	<0.001	-	-	-	-	-	-
1955–56	2.08	0.46	<0.001	2.56	0.36	<0.001	−1.14	1.9	0.55	2.32	0.75	0.002
1960–64	2.3	0.48	<0.001	3.32	0.38	<0.001	−0.89	1.84	0.63	2.61	0.53	<0.001
1965–69 **	2.07	0.53	<0.001	3.3	0.43	<0.001	−0.4	1.83	0.83	2.63	0.52	<0.001
1970–74	-	-	-	-	-	-	−0.24	1.83	0.9	3.38	0.52	<0.001
1975–79	-	-	-	-	-	-	−1.75	1.83	0.34	2.56	0.52	<0.001
1980–84	-	-	-	-	-	-	−4.6	1.83	0.01	0.19	0.52	0.71
1985–89	-	-	-	-	-	-	−8.23	1.85	<0.001	−2.88	0.53	<0.001
1990–94	-	-	-	-	-	-	−10.72	1.86	<0.001	−6.12	0.68	<0.001
Parent's education												
elementary, ≤8 years	0.76	0.68	0.26	−0.15	0.75	0.84	−4.28	0.66	<0.001	0.39	0.5	0.43
elementary, 9–10 years	1	0.72	0.16	0.32	0.78	0.68	−3.46	0.68	<0.001	1.08	0.51	0.04
high school, <3 years	1.13	0.69	0.1	0.58	0.76	0.44	−3.3	0.64	<0.001	1.35	0.49	0.01
high school, 3 years	1.63	0.7	0.02	1.45	0.77	0.06	−2.94	0.66	<0.001	1.89	0.51	<0.001
<3 years after high school	2.2	0.73	0.003	1.63	0.79	0.04	−2.96	0.66	<0.001	2.07	0.51	<0.001
≥3 years after high school	2.34	0.71	0.001	2.32	0.78	0.003	−2.49	0.66	<0.001	2.62	0.51	<0.001
post graduate	2.91	0.81	<0.001	3.12	0.89	<0.001	−1.9	0.78	0.01	2.95	0.64	<0.001
Parents' household income	0.38	0.1	<0.001	0.51	0.1	<0.001	1.43	0.16	<0.001	1.43	0.16	<0.001
Parents' household income	−0.03	0.02	0.22	−0.03	0.03	0.35	−0.27	0.05	<0.001	−0.27	0.05	<0.001
Grandparent's socioeconomic status (ref = higher & mediate non−manual)												
entrepreneurs and farmers	−0.19	0.27	0.48	0.2	0.24	0.4	-	-	-	-	-	-
lower non-manual	−0.52	0.3	0.09	−0.31	0.29	0.28	-	-	-	-	-	-
skilled manual	−0.73	0.27	0.01	−0.27	0.25	0.28	-	-	-	-	-	-
unskilled manual, production	−0.9	0.25	<0.001	−0.65	0.24	0.01	-	-	-	-	-	-
service	−0.55	0.27	0.04	−0.63	0.25	0.01	-	-	-	-	-	-
Parent's fertility	−0.15	0.05	0.002	−0.18	0.05	<0.001	−0.08	0.06	0.21	−0.34	0.06	<0.001
Parent's age at first birth	0.15	0.02	<0.001	0.19	0.02	<0.001	0.14	0.02	<0.001	0.15	0.02	<0.001
Constant	22.46	0.94	<0.001	19.15	0.91	<0.001	29.22	1.99	<0.001	19.71	0.88	<0.001
n	7935			8157			5864			6941		

** All Cohort 2 members born after 1965 were coded as a 1965–1969 birth band due to small samples thereafter.

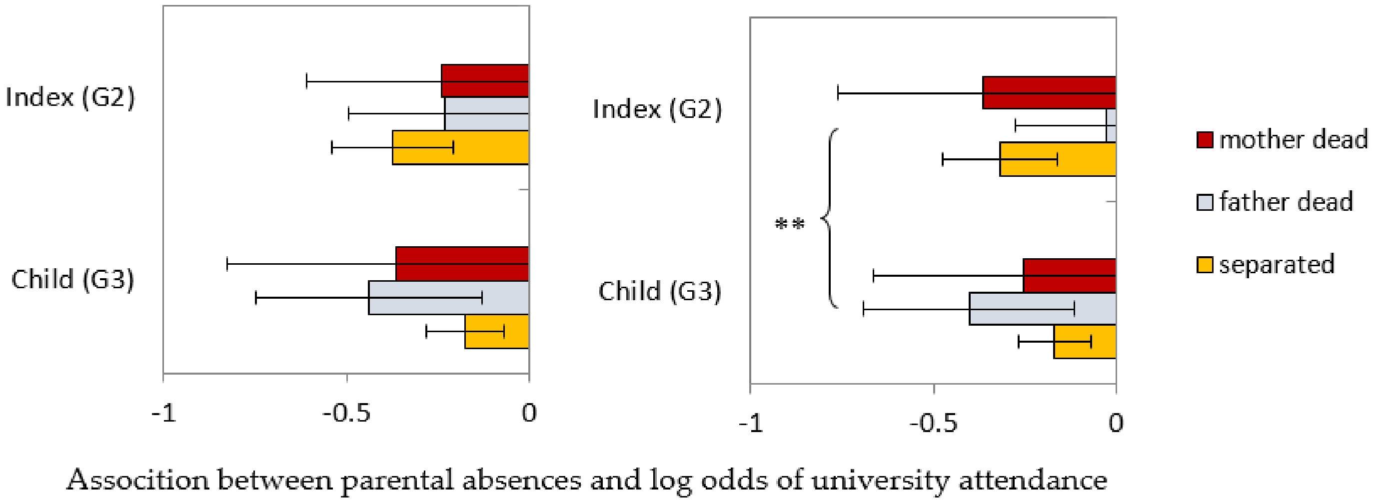
Mediation analyses show that these parental contributions to children's university attendance partly explain associations between parental absences and ages at first birth. This indirect effect via education corresponds to lines a*b in Figure 4, while parents' residual direct effect after accounting for university attendance is represented by line c. See Table S2 for all effects used in mediation analyses, and standardized direct and indirect effects.

In the index generation parental absences expedite first births primarily through direct effects rather than indirectly via education (Table 3, Figure 5). The main exception to this pattern is the effect of parental separations on sons' age at first birth, for which the indirect and direct effects are equally large. While we also find a significant, and similarly sized, indirect effect of parental separation on daughters' age at first birth via education, the overall effect of parental separations on daughters' age at first birth is much larger, and this is driven by their direct effects. The partial mediations result from parental separations being associated with lower probabilities of university attendance, which in turn are associated with earlier first birth.



(**a**) Sons (**b**) Daughters

Figure 2. Associations between parental absences and age at first birth (AFB), for (**a**) sons and (**b**) daughters by generation. All associations are shown relative to having married and cohabiting parents and are derived from separate models for each cohort and sex. Tests for differences between cohorts are derived from models with interactions between parental absences and cohort. Robust 95% CIs are shown. * $p < 0.05$.



(**a**) Sons (**b**) Daughters

Figure 3. Associations between parental absences and university attendance for (**a**) sons and (**b**) daughters, by generation. All associations are shown relative to having married and cohabiting parents and are derived from separate models for each cohort and sex. Tests between cohorts are derived from models with interactions between parental absences and cohort. Robust 95% CIs are shown. ** $p < 0.01$.

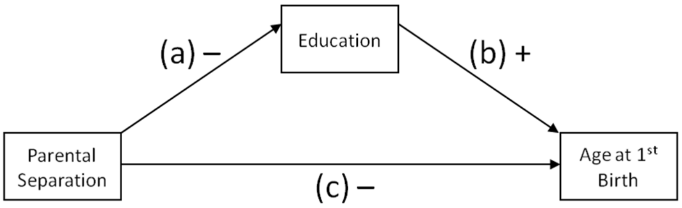


Figure 4. Schematic of mediation analyses run for each measure of parental absence. The direction of effects is accurate for most models. Deviations from these directions are specified in Figure 5.

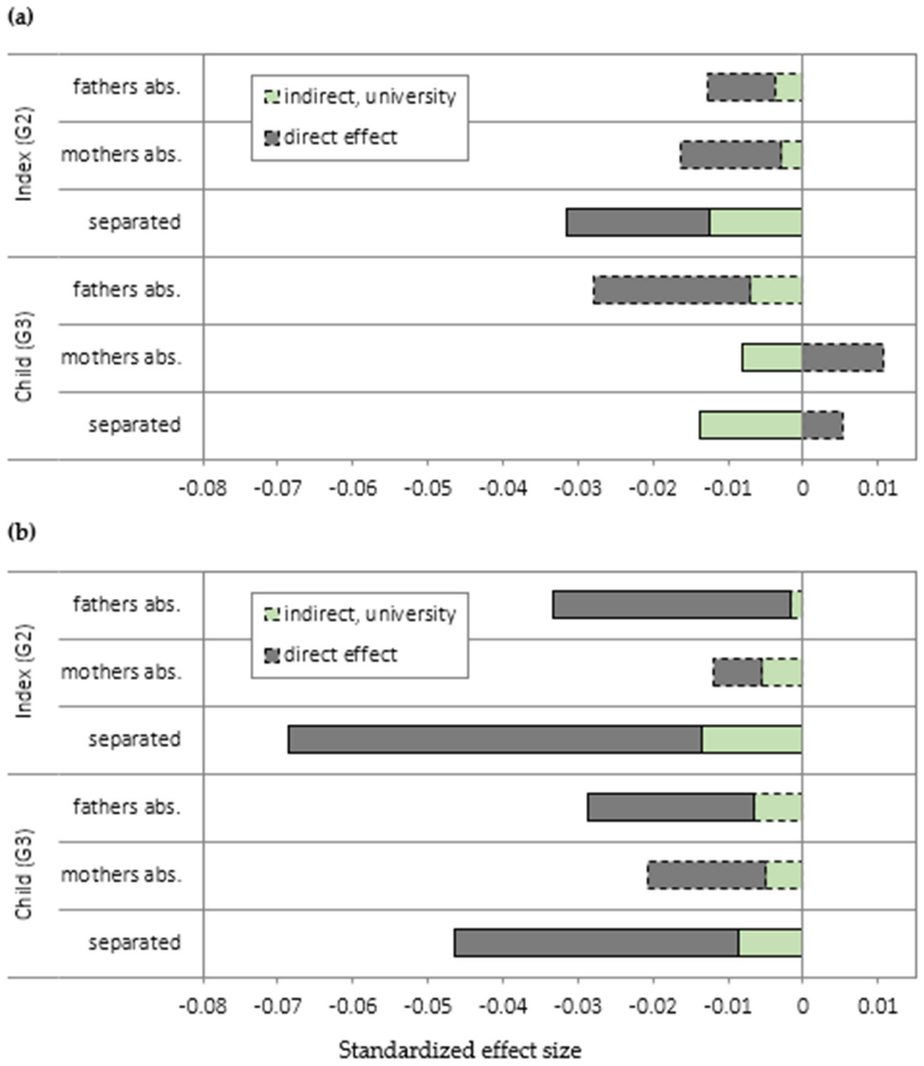


Figure 5. Standardized Direct and Indirect effects of parental absences on age at first birth for (**a**) sons and (**b**) daughters, by generation. Effects are relative to having married and cohabiting parents. University attendance is a mediator. Only effects with solid outlines have bootstrapped percentile 95% confidence intervals that did not include zero. NB: the directions of effects deviate from the Figure 4 schema in that for sons in the *child* generation (G3) maternal deaths and parental separations have positive direct effects on age at first birth (c is +).

Table 3. Standardized effects of mediation analysis by gender, generation, and type of parental absence. Bootstrapped standard errors are shown.

		Sons				**Daughters**			
		Index (G2)		**Index (G2)**		**Cohort 2**		**Child (G3)**	
		Coef	**SE**	**Coef**	**SE**	**Coef**	**SE**	**Coef**	**SE**
separations	indirect	−0.013	0.003	−0.014	0.004	−0.014	0.003	−0.009	0.004
	direct effect	−0.019	0.011	0.005	0.013	−0.055	0.009	−0.038	0.012
	total effect	−0.031	0.012	−0.009	0.014	−0.068	0.010	−0.046	0.012
mother death	indirect	−0.003	0.003	−0.008	0.005	−0.006	0.004	−0.005	0.004
	direct effect	−0.014	0.010	0.011	0.011	−0.006	0.011	−0.016	0.012
	total effect	−0.016	0.010	0.003	0.011	−0.012	0.011	−0.021	0.013
father deaths	indirect	−0.004	0.003	−0.007	0.004	−0.002	0.003	−0.007	0.004
	direct effect	−0.009	0.011	−0.021	0.012	−0.032	0.010	−0.022	0.012
	total effect	−0.013	0.011	−0.028	0.013	−0.033	0.011	−0.029	0.012

4.3. Are There Historical Changes in the Pathways of Parental Influence?

Compared to the index generation, most parental absences in the child generation are similarly associated with earlier reproduction (Figure 2). The only statistically significant difference between the generations is that the association between parental separation and daughters' age at first birth becomes weaker. In other words, there is a significant interaction between generation and parental separation (B(SE) = 0.44(0.2), $p = 0.03$) in the daughter model. However, several interactions with generation are even larger, though not significant. These include the association between a mother's death and a daughter's age at first birth becoming stronger (B(SE) = −0.53(0.65), $p = 0.41$), the association between a mother's deaths and sons' reproductive timing reversing (B(SE) = 0.88(.70), $p = 0.20$), and the strength of the association between a father's death and son's age at first birth increasing (B(SE) = −0.60(0.46), $p = 0.19$). This suggests that our analysis may be underpowered to detect historical changes in the consequences of parental deaths given that these are so rare. Examining progressions to first birth to deal with censored individuals in the more recent cohort reveals similar patterns (Figure S4).

All kinds of parental absences are associated with lower chances of university attendance in the more recent child generation (Figure 3). This stands in contrast to the lack of an association between a father's death and daughter's university attendance in the index generation. This is the only significant interaction between cohort and parental absence, i.e., a father's death is more deleterious to a daughter's higher educational prospect in the more recent generation (B(SE) = −0.51(0.19), $p = 0.008$). No other interaction between generation is of comparable size. Father presence also becomes a significant predictor of son's university attendance in the more recent generation reflecting the second largest interaction with generation B(SE) = −0.29(0.2), $p = 0.15$). While paternal deaths become more negatively associated with university attendance through time, the associations with parental separations become more muted for both sons and daughters through time, though not significantly so.

There are several qualitative differences between the pathways of parental influence on age at first birth in the two generations. Unlike in the index generation, fathers' deaths have very similar effects on daughters and sons in the more recent child generation (Figure 5). While the direct effects of a father's death on age at first birth in the child generation continue to play a larger role than indirect effects, their indirect negative effects via university attendance increase to similar levels for daughters and sons alike. Any suggestion that parents began influencing sons and daughters in more similar ways is tempered by the fact that maternal deaths show more different patterns for sons and daughters in the more recent child generation. Finally, while historical changes influenced the indirect pathway of father effects, the direct pathways of influence shifted more for parental separations. That is, the more muted associations between parental separation and age at first birth in the more recent generation are not due to changes in the ways they affect educational attainment. For sons this means that in the more recent child generation the association between parental separations and timing of their first births is completely mediated by their effects on his university attendance with no remaining direct effect. For daughters the direct effect of parental separations continues having a large, but smaller, expediting effect.

It is worth noting that the two generations' samples are slightly different for two reasons. First, the more recent generation's reproduction is censored. That is, individuals in the child generation who have reproduced are likely to represent young reproducers. Second, we did not have access to the 2000 census from which we derived parental separation measures, meaning that more recently born people might be incorrectly coded as having married and cohabiting parents when in fact a separation ensued by 2000. We conducted a sensitivity analysis restricting the mediation models to individuals who were at least 35 years of age when last seen, meaning that they are more likely to have undergone a first birth, and would have been at least 20 by the 1990 census. Figure S5 shows the very similar patterns of direct and indirect effects for this restricted sample.

5. Discussion

We show that parental absences in childhood have gender-specific relationships with life history strategies, that some of the effects are partially mediated by parental effects on university attendance, and that these pathways of influence change across the 20th century along with increases in university attendance, particularly by women. The changing patterns suggest that intergenerational genetic correlations or unmeasured socio-economic variance are unlikely to be the sole explanation for associations between childhood parental absences and reproductive outcomes (Surbey 1998; Comings et al. 2002).

5.1. Parental Absences Expedite First Births

The data suggest that parental absences expedite first births, though supplementary analyses suggest they have relatively little effect on total fertility. While several life history theorists have predicted such effects on reproductive timing rather than fertility (Quinlan 2007; Ellis 2004), it is possible that reproductive timing effects are simply more likely to be detected in low fertility populations.

If we had only focused on effects in the index generation, we might have concluded that opposite-sex parental deaths have larger effects on age at first birth than same-sex parental absences. However, this pattern does not hold in the child generation. In the more recent generation, the associations between mothers' deaths and daughters' ages at first birth are equivalent in size to those of fathers' deaths, even if only the latter are significant. Similarly, in the more recent generation paternal deaths are more strongly associated with earlier ages at first birth for sons than maternal deaths are. Most of the previous literature has focused on effects of father, rather than mother, absence, and some studies comparing fathers and mothers directly have suggested stronger developmental acceleration effects of father absence (Bogaert 2005). We only partially confirm this trend for daughters in the index generation and sons in the child generation. Our study illustrates the need to focus on effect sizes rather than significance for such claims given that some associations with maternal and paternal absences are of similar effect sizes but differ in their statistical significance in part because of the larger sample of dead fathers than mothers. This greater incidence of paternal than maternal deaths is typical of human datasets given the lower life expectancies and later ages of reproduction for men than women in nearly all societies.

Similarly, the literature has primarily focused on female children and adolescents' development for a series of methodological, policy, and theoretical reasons—menarche is easier to measure than adrenarche, women's teen pregnancies are seen as a larger social problem (Card and Wise 1978), and the tradeoffs between early reproduction, and somatic and educational investments may be starker for women (Ellis 2004). However, direct comparisons are rare and generally there seems to be few clear patterns regarding the interaction of parent and child sex on developmental outcomes (Russell and Saebel 1997). Our study shows that the developmental consequences of family disruptions on age at first birth tend to be larger for daughters, but can be as severe for sons as they are for daughters (e.g., mothers' deaths was more strongly associated with sons' than daughters' ages at first birth in the index generation).

Parental separations are more reliably associated with daughters' first births than sons' (Figure 2). Unlike some previous work (Biblarz and Gottainer 2000; Kiernan 1992; Shenk et al. 2013), we find that the associations between age at first birth and parental separations are not notably larger than those with parents' deaths. In fact, in the index generation the effect sizes of parental separations and father deaths are nearly the same, while the more recent child generation the effect of associations with father deaths are stronger. This pattern in the index generation may reflect that separations traditionally meant less interaction with fathers than with mothers, thus paralleling the effects of paternal death. On the other hand, the associations between parental separations and ages at first birth are much smaller in the child generation. This suggests that the social context has a large effect on the meaning of parental separations. In the recent generation being an unmarried or separated parent was less likely to be stigmatized, represented less self-selected families, may have been less of a financial burden for the primary caretaker, or may have resulted in relatively more equal parenting by mothers and fathers.

5.2. Parental Associations with Age at First Birth Are Only Partially Mediated by University Attendance

Most parental absences in childhood are associated with lower university attendance rates (Figure 3, Table S1), which in turn reduces age at first birth. These indirect effects are relatively small compared to the direct effects of parental absence on age at first birth, especially for daughters (Figure 5). Nonetheless, we can discern reliable indirect effects of parental separations via their effects on university attendance for both sons and daughters in both generations. Notably, paternal deaths are not associated with a daughters' university attendance in the earlier generation (Figure 3b), and thus have no indirect effect on their age at first birth. Those indirect pathways which are observed via education are most consistent with theoretical proposals that children delay their maturation when they get higher parental investments and can reap these benefits (Ellis 2004). The fact that fathers' absences were not detrimental to women's higher education in the mid twentieth century precludes such an indirect pathway of influence and may reflect the differential reproductive opportunity costs of university attendance for men and women (Dribe and Stanfors 2009). Arguments could also be made that the indirect pathway of influence through education is also consistent with hypotheses that adolescents speed up reproduction in parent absent contexts that either affect, or are associated with, higher mortality, morbidity, or few investing partners (Geronimus 1991; Draper and Harpending 1982; Chisholm 1993) if forgoing higher education is part of that strategy.

The generally larger direct pathways of parental influence may reflect a variety of mechanisms. For example, parents can improve their children's socio-economic success in ways not captured by university attendance. Conversely, parental absences in the first 20 years of life reflect continuing absences into adulthood in the case of death, and likely lower social support and investment in the case of separations. These different life trajectories may mean that people with investing parents can delay reproduction due to lower weathering (Geronimus 1991; Rickard et al. 2014) or benefit more from investing in non-reproductive skills (Ellis 2004). In line, with the idea that parents guard their children's reproductive value (Flinn 1988), the direct pathway may reflect parenting strategies that prevent their children from engaging in non-normative or stigmatized behavior. While this account was developed to explain parents' guarding of daughters' behavior, teenage fathering may also pose unwanted social and economic risks to sons that parents would be keen to prevent.

While the direct pathway could reflect mechanisms proposed by other theories, the results and cultural context give us reason to be skeptical of their importance. If inbreeding avoidance mechanisms are at play (Matchock and Susman 2006), we would have expected opposite-sex parental absence associations with their child's age at first birth. This pattern only holds for the earlier cohort. Intergenerational reproductive conflicts are relatively unlikely in this society where children do not particularly contribute to household production or childcare, providing little material incentive for parents to keep their children at home (Moya and Sear 2014). Finally, using parental absences as a cue to mortality risks (Chisholm 1993) or unpredictable environments (Del Giudice 2014) should result in similar effect sizes for parents and children of any gender, while using absences as a cue to the availability of investing fathers (Draper and Harpending 1982) would only predict father absence effects. The complicated patterns of variation across parent and child sex and across generations make it likely that multiple mechanisms are involved.

5.3. Pathways of Parental Influence Change across Time

If parental effects simply changed to reflect intergenerational changes in reproductive norms, parents would delay their children's first births more in the more recent generation, given that the mean age at first birth increased for both men and women across these cohorts. While we do not find this pattern for all parent-offspring dyads, we do see it for father-son and mother-daughter associations. That is, fathers are more strongly associated with later first births for their sons and mothers are more strongly associated with later first births for their daughters in the more recent child generation compared to the previous generation, though not significantly so. This may reflect the fact that children are also motivated to follow the reproductive norms of their generation leaving little room for parental social influence.

If the expansion of governmental programs facilitating reproduction changed parental effects on reproductive decision-making, we would have expected parental effects to become weaker through time. More specifically, parents should have become less necessary to carry out reproduction resulting in less expediting effects of parents. It is difficult to assess whether this mechanism is at play in the historical changes we see given that having parents around does not generally expedite reproduction. This means that we see little evidence that young adults are using their parents as alloparental resources that help them reproduce earlier. The only pattern consistent with this is that maternal deaths delay their sons' reproduction, but only in the more recent generation and not significantly so. If anything, this pattern argues against the hypothesis that more generous parenting policies in recent generations weakened parental effects.

Nor do we find that governmental policies supporting higher education reduced the effect of parental absences on university attendance. The only kind of parental absence that had a smaller effect on education in the more recent cohort was that of parental separations. We believe it is more plausible that this is due to changes in the meaning, stigma, and economic consequences of parents' marital status through time, than a reflection of policy changes improving educational access. In fact, the effect of parental separations on son's age at first birth is completely mediated by the effect separations have on education in the more recent cohort, suggesting that pathways via other psychological consequences are of decreasing importance.

In contrast we find that fathers' deaths are more strongly associated with lower university attendance in the more recent generation, though the cohort difference is only significant for daughters. This translates into larger relationships between fathers' deaths and age at first birth for sons only, while for daughters it changes the fathers' pathway of influence, but not his total effect on their ages at first birth. The fact that the direct and indirect effects of paternal deaths look similar for sons and daughters in the more recent generation suggests that changing gender norms around university attendance affect how fathers interact with, and invest in, their children. In other words, the more recent fathers, who themselves belonged to a cohort with greater female than male university attendance, may have supported relatively similar educational and reproductive timing strategies for both sons and daughters. In contrast the index generations' fathers, who belonged to a cohort with markedly higher university attendance for men than women, were only associated with increased university attendance for their sons. This interpretation does not explain why mothers had similar effects on their sons' and daughters' education across the generations. However, some recent evidence suggests that parents experience greater conflict over how to rear adolescent girls than boys and that this is driven by fathers having gender-role attitudes that are discrepant with their daughters' (Kabátek and Ribar 2020). The larger paternal effects on education overall may also reflect a greater involvement of fathers in child-rearing in the more recent generation.

Finally, if peer and non-kin social networks were influencing reproductive timing more as university attendance increased, we would expect to have seen decreasing direct effects of parents through time. This is only the case for opposite-sex parents and parental separations. As discussed previously, we believe the decreasing direct effects of parental separations are better understood considering the changing meaning, selection into, and social consequences of reproducing outside of marriage. The direct effects of mothers on sons are nearly equivalently sized but in opposite directions across cohorts, and those of fathers on daughters are nearly the same as their effects on sons in the child cohort.

This suggests that waning parental social influence might not account for these historical changes in pathways of effect either.

Consistency over time can also be of interest if it implies that more canalized mechanisms (i.e., those less susceptible to environmental changes) are at work. Interestingly, the reduction in the direct effect of parental separations across time seems to have been larger for sons than daughters. On the other hand, the indirect effects of parental separations on reproductive onset via university attendance are consistent across time for both daughters and sons. In both generations daughters' reproductive timing is more susceptible to the effects of separations, suggesting that at least some of the mechanisms at work are robust to changing and more egalitarian gender norms.

6. Conclusions

We present evidence that parental absences in the first 20 years of life are associated with reproductive timing—even using a rather weak approximation of presence and investment (by their vital or marital status), and even in a society that provides much governmental support for reproduction, education, and material well-being. We add to the growing literature showing that parental deaths and separations in the first two decades of a child's life are associated with earlier reproductive outcomes in post- demographic transition societies. Associations between parental absences and age at first reproduction are partly explained by their influence on university attendance that delays first births, but residual direct effects tend to be larger. Furthermore, we see that the historical context moderates the total effects, and pathways of influence, of parental absences. The associations with fathers' death become more similar for daughters and sons in the more recent generation suggesting the importance of gendered norms about higher education in how parents influence children. Fathers' effects via education may also have increased through time due to greater male parental involvement, but if so, the change is less pronounced for sons. Parental separations are less strongly associated with earlier reproduction in the more recent generation, suggesting that the social consequences of raising children outside of marriage are becoming less severe, and perhaps even normative. However, the fact that daughters' ages at first birth are more strongly associated with parental separations than sons' ages at first birth is robust to historical changes. This suggests that the pathways of developmental influence differ depending on the kind of parental absence tested, and that some are more likely to change with shifting gender and family norms.

Our results indicate some promising directions for future research. The fact that we find different patterns between two adjacent cohorts that share broad cultural similarities suggests caution is warranted in generalizing too widely across societies. For example, if parental separations have different effects across our cohorts because of their changing prevalence or social meaning, it would behoove researchers to understand how concepts about separation and selection into these categories differs cross-culturally. Perhaps more problematically for generalizing from this study to the rest of the world, 20th Sweden represents an atypical society in many ways. Particularly relevant to evolutionary and cross-cultural scholars, most societies through time have relied less on biparental care given that alloparents tend to invest heavily in child rearing (Hrdy 2009). Of course, kin and formal institutions such as daycare and schools still play important alloparental role in post-industrial societies like Sweden, but the nuclear family is usually a residential unit and bears a larger share of the childcare burden. In contrast, some non-industrial societies even have specific institutions like partible paternity or levirate for buffering paternal absences (Walker et al. 2015). This may help explain the more reliable effects of father absences in societies that are structured around the nuclear family (Sear et al. 2019). Further cross-cultural work will help us gage the extent to which our results generalize. It should also help us adjudicate between theoretical accounts. At present the literature on parental influences on reproduction offers multiple theoretical explanations, but relatively few attempts at selecting between them. By focusing on the mechanisms of parental influence and choosing study populations for their theoretical relevance we can make sense of a large empirical literature.

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Gender Differences in Social Networks Based on Prevailing Kinship Norms in the Mosuo of China

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Abstract: Although cooperative social networks are considered key to human evolution, emphasis has usually been placed on the functions of men's cooperative networks. What do women's networks look like? Do they differ from men's networks and what does this suggest about evolutionarily inherited gender differences in reproductive and social strategies? In this paper, we test the 'universal gender differences' hypothesis positing gender-specific network structures against the 'gender reversal' hypothesis that posits that women's networks look more 'masculine' under matriliny. Specifically, we ask whether men's friendship networks are always larger than women's networks and we investigate measures of centrality by gender and descent system. To do so, we use tools from social network analysis and data on men's and women's friendship ties in matrilineal and patrilineal Mosuo communities. In tentative support of the gender reversal hypothesis, we find that women's friendship networks in matriliny are relatively large. Measures of centrality and generalized linear models otherwise reveal greater differences between communities than between men and women. The data and analyses we present are primarily descriptive given limitations of sample size and sampling strategy. Nonetheless, our results provide support for the flexible application of social relationships across genders and clearly challenge the predominant narrative of universal gender differences across space and time.

Keywords: social relationships; matriliny; patriliny; cooperation; evolution; behavioral ecology

1. Introduction

> *In summary, we propose that men and women are equally social, but their sociality is directed differently. To caricature, female sociality is dyadic, whereas male sociality is tribal. In other words, men seek social connection in a broad group with multiple people, particularly by competing for a good position in a status hierarchy; women, in contrast, seek social connection in close personal relationships based on mutual, dyadic intimacy.* (Baumeister and Sommer 1997, p. 39)

Humans are a deeply cooperative species. Indeed, many have gone so far as to argue that humans cannot reproduce without the assistance of others (Hrdy 2009; Kramer 2010). Social relationships are sources of information, resources, and other support that promote reproductive success (Apicella et al. 2012; Page et al. 2017). Research suggests that men and women build, maintain, and leverage networks differently in ways that correspond with gender-specific reproductive and cooperative strategies (Benenson 2019; Seabright 2012). Prior work, however, in large part underrepresents low- and middle-income nations and participants from non-industrialized settings (see David-Barrett et al. 2015), and has predominantly relied on young children and adolescents rather than adult participants (see Vigil 2007). Thus, the generalizability of observed gender differences in the properties of social networks is potentially limited, as little attention has been focused on how gender differences in social relationships may vary across broader social contexts. This is despite well-characterized variation in population structure and household demography, which shape individuals' interactions and formation of social ties (Power and Ready 2019). In this paper, we compare gendered social networks in two villages—one matrilineal and one patrilineal—among Mosuo agriculturalists of Southwest China to test two hypotheses: gender differences in social network structure are universal versus gender differences in social structure are shaped by the social environment, including kinship.

Evolutionary hypotheses positing universal gender differences are based on the premise that male and female reproductive and cooperative strategies diverge (Geary 2006; Trivers 1972) and that social relationships therefore serve different purposes for men and women (e.g., Baumeister and Sommer 1997; Geary 2006). In particular, because females experience obligate parental investment in the form of pregnancy and lactation, women are generally expected to invest effort more intensively in relationships that enhance or do not conflict with childcare (Low 2005). By contrast, men are hypothesized to use social networks more frequently to achieve status-oriented objectives, and/or facilitate activities such as hunting, collective defense, or collective aggression (David-Barrett et al. 2015; Rose and Rudolph 2006; von Rueden et al. 2018). These hypothesized universal gender differences have generated the following specific predictions: 1. Men's social networks will be larger than women's networks and will include a higher proportion of casual and opportunistic 'weak' ties (e.g., Baumeister and Sommer 1997; Benenson 1990; Vigil 2007); 2. Higher-quality relationships in women's networks will manifest in more frequent communication ties, whereas higher-quality relationships in men's networks will be demonstrated through participation in joint activities (e.g., Pearce et al. 2021; Roberts and Dunbar 2015); 3. men will show a higher threshold for relationship conflict and will achieve post-conflict reconciliation sooner than women (e.g., Benenson et al. 2018; Benenson and Christakos 2003; Dunbar and Machin 2014); 4. men will preferentially socialize in larger and more hierarchically organized groups while women will gravitate toward more intimate, often 'dyadic' relationships (e.g., Baumeister and Sommer 1997; Benenson 2019; David-Barrett et al. 2015).

Taken together, these predictions, associated with what we call the 'universal gender differences' (UGD) hypothesis, have garnered a fair amount of support across a range of studies. For example, women have been reported to treat friends more like kin, and men to treat friends more like strangers and to pursue status-oriented relationship goals (Ackerman et al. 2007). In a study of American university students, men reported more friendships than women, and were more willing to sacrifice intimacy to secure more friends (Vigil 2007). In a study of American high school and middle school students, boys had more friendship connections than girls, while girls' networks showed more small-group clustering (Lindenlaub and Prummer 2021). In another university sample, Friebel et al. (2021) showed that women's friendships remained stable over time, whereas men's friendship connections were more flexible and opportunistic. In a large study of Facebook friendships, David-Barrett et al. (2015) found evidence consistent with women preferring same-sex dyadic relationships and men favoring larger, same-sex cliques. Similarly, an experience-sampling study of Dutch and American participants found that women engaged in collective activities in dyads more than men (Peperkoorn et al. 2020). In addition, studies of same-sex groups suggest that boys and men tend to organize their groups hierarchically more than women, whereas women are more likely to enforce egalitarianism (Benenson and Abadzi 2020; Berdahl and Anderson 2005).

In a review of available evidence, Rose and Rudolph (2006) concluded that girls were more likely than boys to engage in prosocial relationships and were motivated by 'connection-oriented' goals, whereas boys had larger, more hierarchical networks, with 'dominance' and 'self-interest' goals at the fore. These differences are generally thought to solidify in adolescence (Benenson 1990). However, some studies observe mid- to late-age gender reversal. A study of Europeans found that men have more social contacts than women, particularly in young adulthood, but then this gender difference reverses in middle age as the number of contacts for both genders declines and as reproductive priorities shift (Bhattacharya et al. 2016). There are also studies that find no gender difference in network structure (e.g., Mengel 2020) or find a higher number of network contacts in women compared to men, such as in the context of an online game (Szell and Thurner 2013) or online communication more generally (Psylla et al. 2017).

Non-human primate studies are often used as evidence of the primacy of evolutionary differences between men and women, but such claims are likely over-generalized. For example, female baboons exhibit female-'typical' behavior, building relationships to benefit infant survival (Silk 2007), and chimpanzee and bonobos females build coalitions to defend kin and friends against male aggression (Newton-Fisher 2006; Tokuyama and Furuichi 2016). Male baboons, chimpanzees, and bonobos, by contrast, build relationships to compete for high rank and the mating opportunities it affords. Male philopatry is often invoked as a primary driver of differences in gender-specific networks, on the premise that philopatry was common, long enough, or universal during much of hominoid evolutionary history (e.g., Campbell 2013; David-Barrett et al. 2015; Vigil 2007). In chimpanzees, male social networks are based strongly on maternal kinship relationships (Mitani 2009), and, in gorillas, male philopatry results in more dispersed networks for males (Bradley et al. 2004), for example. However, philopatry is variable among non-human primates, where the benefits of social bonds to females have been argued to be a causal driver of female philopatry in a majority of non-human primate species (e.g., Wrangham 1980). Even in non-human primates most closely related to humans, where male philopatry prevails, it appears that the importance of female social bonds has been under-emphasized (Emery Thompson 2019) and that males and females show less divergent use of social bonds than sometimes reported (Langergraber et al. 2009; Psylla et al. 2017). Among humans, contemporary hunter-gatherers are highly flexible in residence (Kramer and Greaves 2011; Wood and Marlowe 2011). More generally, although male philopatry and female exogamy are modal among human societies (Murdock and White 1969), humans are remarkably flexible in post-marital residence (e.g., Surowiec et al. 2019), creating varying constraints on the social relationships available to men and women (Power and Ready 2019).

In general, conditions that decrease the differences between men's and women's reproductive capacities may result in less divergence in their use of social relationships to achieve reproductive goals. Monogamy, for example, limits men's reproductive success so that it more closely matches women's (e.g., Brown et al. 2009; Fortunato and Archetti 2010). In monogamous contexts, men's interests should be more closely (if not perfectly) aligned with their partners' interests and their social relationships more tightly focused on household concerns. A society's means of subsistence influences the divergence of men's and women's reproductive success (Holden et al. 2003; Low 2005; Mattison 2011). Forms of subsistence such as pastoralism generally support men's reproductive agendas because animals can be converted into reproductive success at higher rates for men than for women (for example, via polygynous unions). In such cases, coalition-building and status-enhancing relationships may enhance men's chances to attain disproportionate reproductive success. For example, men may accrue more exchange partners than women due to public displays of wealth, e.g., in highland New Guinea (Lederman 1990), resulting in increased status and mating opportunities. Other forms of subsistence, such as foraging or horticulture, are less likely to produce surpluses that support disproportionate reproduction among men, while others such as offshore fishing may remove men from their households for long periods of time. In these cases, women often contribute significantly to household production, or run their households with less consistent involvement from men (Mattison et al. 2019). A relatively high degree of women's autonomy amidst a limited ability among men to convert resources to reproductive success should be associated with less divergence in men's and women's relationship-building strategies.

Because subsistence differences alter the possible divergence in men's and women's reproductive success, they have been tied to variation in kinship systems, whereby son-biased inheritance (patriliny) is favored when men's reproductive interests can be effectively supported, and daughter-biased inheritance (matriliny) when reproductive returns are greater via daughters than via sons (e.g., Cronk 2000; Fortunato 2012; Holden et al. 2003; Mattison 2011). Matriliny is also frequently, though not exclusively, associated with female philopatry (matrilocality; Fortunato 2019; Surowiec et al. 2019). Differences in the ecological conditions thought to give rise to matriliny are thus likely to alter the costs and benefits of gender-specific social strategies in ways that limit—and maybe reverse—the differences anticipated by the UGD. There are numerous pathways by which this might arise: first, men's absences in matrilineal systems may constrain the extent to which they can build large local networks; second, the relatively limited ability to convert resources to reproductive success may affect men's status differentials by limiting wealth differentials; and, third, women may adopt more 'masculine' social strategies as the opportunity costs of childcare are lessened by local kin support (i.e., increased presence of local allocarers). Such reversals are often deemed impossible in anthropology, where it is axiomatic that matriliny still involves men in authority (see Mattison et al. 2019). Yet, economic games in matrilineal communities have shown reversals in, e.g., risk taking (Andersen et al. 2008; Gong et al. 2015; Gong and Yang 2012), that support the view that matrilineal women may take on roles often assumed to be 'masculine'.

Forms of subsistence can also impact gender-specific social networks via their influence on culturally transmitted gender norms, particularly norms related to gendered divisions of labor. While highly variable, gendered divisions of labor tend to shunt women towards more intra-household labor and direct childcare, which has been argued to constrain childbearing women's socializing beyond the household (von Rueden et al. 2018). For example, women's group-level influence among the Mekranoti of the Brazilian Amazon was negatively associated with their parenting demands (Werner 1984), and among the Tsimané of the Bolivian Amazon, the number of women's but not men's cooperation partners was negatively associated with the number of dependent offspring (von Rueden et al. 2018). Women in many small-scale societies may tend to build larger social networks as they near menopause, in part due to fewer childcare demands (Brown and Kerns 1985). Subsistence practices may affect women's mobility and therefore their opportunities to form networks. For example, the transition to the plow may have made agricultural labor more strength-intensive and less compatible with childcare, thereby decreasing women's labor value outside of the home and decreasing their bargaining power in community-level politics (Alesina et al. 2013). Similarly, societies of historically pastoralist origins are more likely to promote norms restricting women's mobility and therefore their social influence (Becker 2019). Warfare can also promote greater gender differentiation in social networking, due to male coalition building (Rodseth 2012). In contrast, some local norms encourage women's work, and therefore social connections, outside the home. Among Shodagor fisher-traders in Bangladesh, for example, some women travel to rural villages to trade with ethnic Bengali women, whose religion restricts their interaction with unrelated men (Starkweather et al. 2020). These studies suggest that gender norms related to current and historical means of subsistence influence the relative sizes and natures of gendered social networks.

In this paper, we leverage variation in kinship norms and institutions among the Mosuo of Southwest China to investigate differences and similarities in gendered social networks. Evolutionary anthropologists have hypothesized that kinship systems are shaped by social and environmental circumstances (Alvard 2011; Shenk and Mattison 2011) in ways that alter the costs and benefits associated with gender-specific reproductive strategies (Holden et al. 2003; Mattison 2011; Mattison et al. 2016). We have argued previously that Mosuo matriliny is driven by limited reproductive differentiation between the genders due to a resource base (agriculture) that is expansive and not particularly productive and that does not therefore support a strongly divergent male reproductive agenda (see also Alesina et al. 2013; Brown et al. 2009), as well as norms and institutions that allow some men to limit investment in reproductive partners and parenting activities (Mattison 2011; Mattison et al. 2019; see also Fortunato 2012). By contrast, patriliny, which predominates in the Mosuo villages located in more rugged, mountainous terrain, appears to be reinforced by monogamous unions and the need for stable support from men of spouses and children (Mattison et al. 2021). This context presents an ideal test of the UGD hypothesis in humans—if men tend to pursue divergent strategies due to fundamental sex differences, which they inherit as part of humans' evolutionary legacy, then we would expect to see differences between men and women even among the matrilineal Mosuo. If typical gendered differences in social networks are due instead to flexible strategies that are sensitive to local socioecological circumstances affecting the costs and benefits of different social strategies, then we are unlikely to see the typical gendered differences among the Mosuo. We pay particular attention to matrilineal Mosuo women, who may, in their socioecological circumstances, build social ties in ways that are considered typically 'masculine' in the existing literature.

In a case study of two villages, one matrilineal and one patrilineal, we compare the universal gender differences hypothesis (UGD) and gender reversal hypothesis (GRH) with the following predictions: UGD: Men have larger networks (higher degree) across matriliny and patriliny; women's greater focus on intimacy and 'dyadic' relationships results in smaller networks (lower degree). GRH: Women will have larger networks (higher degree) than men in matriliny and men will have larger networks (higher degree) than women in patriliny. Further, we explore descriptive measures of centrality in social networks as evidence for or against consistent differences by gender (UGD).

2. Methods and Study Site

Population: The Mosuo are a population of roughly 40,000 agriculturalists residing in the Hengduan Mountains on the border of Sichuan and Yunnan Provinces in Southwest China. They are famous among anthropologists for their matrilineal traditions, involving inheritance that effectively moves through lineally related household women (Mattison 2011), prominent roles for grandmothers and maternal uncles (Shih 2010), and lack of consistent involvement in parenting by some, but not all, fathers (Mattison et al. 2014, 2019). Less well known are a geographically distinct population of Mosuo, who are patrilineal and whose norms involve transmission of wealth and status from parents to their sons, monogamous marriage, and more limited, if still relatively strong, autonomy for women (Mattison et al. 2021). Evidence suggests that the patrilineal Mosuo separated from the matrilineal region 500 years ago or earlier, establishing separate norms and institutions while continuing to identify as Mosuo and maintaining a variety of shared customs, language, religion, and attire (Mathieu 2003; Mattison et al. 2021). We have shown previously that these differences in kinship norms and institutions are associated with reversals in child gender preference (Mattison et al. 2016) and gender disparities in health (Reynolds et al. 2020). We speculated that some of this arises via more limited social support for women in patriliny (Reynolds et al. 2020), a pathway we begin to investigate here.

While little has been published about cooperation among the patrilineal Mosuo, ethnographic and quantitative evidence suggests that cooperation is extensive among the matrilineal Mosuo. Mosuo people routinely come together to help each other during planting and harvesting seasons, for example, and cooperate in the construction and repair of homes, preparations and costs of religious and cultural ceremonies, and joint economic ventures (Shih 2010; Thomas et al. 2018). Large households help with domestic activities such as childcare, and household sisters are said to reproduce as a communal effort toward ensuring lineage and household longevity (Ji et al. 2013; Shih and Jenike 2002). At the same time, tourism and acculturation have led to an increasing fraction of households adopting non-normative institutions and plausibly acting more autonomously than might otherwise be expected (Blumenfield et al. 2018; Mattison 2010; Walsh 2001; see also Wu et al. 2015). The villages sampled in this study were both relatively far removed from sites of tourism and are locally considered to be relatively 'traditional'.

Data collection: We carried out social network interviews as part of the ENDOW project in an attempt to capture full networks of households in one matrilineal (N = 40 households) and one patrilineal (N = 30 households) community of Mosuo in the summers of 2017 and 2018. Accompanied by local guides, we walked from house to house and asked any available adult member of the household, man or woman, who could also comment on the networks and kin relatedness of other adult members of the household, to participate. We explained the study to potential participants and addressed their questions before obtaining their informed consent for the interview (UNM IRB 06915). We employed a name generator approach in which respondents were asked to free list individuals with whom they had various kinds of social ties (Marsden 2005). We focus here on a question that asked respondents to identify whom they considered close friends ('pengyou') with whom one would hang out or 'chat' ('liaotian') after dinner, a common activity among friends. Our goal was to obtain responses to interview questions for one adult man and one adult woman in each household. In cases where the opposite-gender respondent was not available at the time of interview, the main respondent answered in their stead. We did not note the names of any additional people present during the interview. Because data collection included a complete household census, we were able to infer the identity of the opposite gender respondent in most cases (with certainty if they were the only adult member of opposite gender residing in the household and with high confidence if the friendship network consisted mainly of similar-age peers). In some cases, additional cues were available, such as the respondent indicating that friends were 'my son's'. For cases where multiple opposite-gender individuals of similar age resided in the same household, we did not assign an identity for the second household respondent. A census of households allowed us to identify and verify individual-level attributes for egos, inferred egos, and alters who were present in the census; we also collected some individual-level data on egos and alters at the time of social network interview.

Data Analysis: The populations of interest in this study were all adults in two geographically distinct communities: 312 adults in the matrilineal area and 219 in the patrilineal area. In order to estimate the patterns of friendship ties in each location, we constructed social networks as follows. First, we included each individual who was either interviewed directly or whose friendship ties were identifiable from an interview, an ego, as a node in a location-specific network, regardless of gender. Second, we drew an undirected edge between each ego and any other individual (an alter)[1] named in response to the question, 'With whom do you/women/men hang out after dinner?' Multiple edges, indicating that both termini of the edge were egos and had nominated each other (6.0% of raw edges in the matrilineal location and 9.5% of raw edges in the patrilineal location), were treated as a single undirected edge. Although the results of the name-generating process could have been considered a directed network, undirected edges were used because not all nodes had the same opportunity to be associated with both in- and out-edges.

Networks were characterized according to standard metrics (Wasserman and Faust 1994). We used several measures of centrality: degree, the number of reported friendships for an individual, whether by that individual or by others; betweenness centrality, the extent to which a node fall on the geodesic paths of others in the network, which we normalized to (0, 1) with 0 indicating no shortest paths include the focal node and 1 indicating all paths do; and closeness centrality, the number of edges between a focal node and all other nodes in a network, which is undefined for disconnected nodes and normalized to (0, 1) with higher values indicating relatively short distances to all other nodes. We also calculated transitivity, the number of a node's complete triads (a case in which three nodes were connected by edges between each of the three possible pairs) as a proportion of its connected triads (a case in which three nodes were connected by two edges such that one pair of nodes was not connected by an edge). Transitivity reflects clustering in a network—the extent to which friends tended to nominate the same individuals as friends. We further characterized the networks via density, the number of observed edges as a proportion of possible edges; centralization, the extent to which centrality is concentrated in a small number of nodes; network-level transitivity, calculated as the average of the node-level values; and the mean distance between nodes, calculated as the average length of all shortest paths in each network.

Our sampling procedure resulted in the exclusion of 57% of possible nodes in the matrilineal area and 58% in the patrilineal area—these individuals and any edges connecting to them are considered to be missing. Although these levels of missingness are relatively high, reasonable estimates of many network features may still be possible (Smith and Moody 2013). Furthermore, our strategy of interviewing heads of households and their closest household partners likely included individuals who were relatively more central to the overall network, potentially reducing the effects of missingness on estimation (Smith et al. 2017). Differences between the central tendencies of node-level statistics were tested with permutation tests; pairwise comparisons between categories of egos are reported here with equivalent analyses of all nodes reported in Supplementary Materials (SI). For each test, means were calculated for the contrasted sampled values (e.g., degree centrality for matrilineal men and women), where $\overline{X}$ was the larger mean and $\overline{Y}$ was the smaller mean. A *p*-value was calculated as follows. X and Y were concatenated, ordered randomly, divided into two new samples X' and Y' such that $n_{X'} = n_X$ and $n_{Y'} = n_Y$, where $n_{(\cdot)}$ represents the number of observations in the relevant data, and the difference $\overline{X}' - \overline{Y}'$ was calculated and stored. This procedure was repeated 10,000 times. The *p*-value was the proportion of simulated differences $\overline{X}' - \overline{Y}'$ that were more positive than the observed, empirical difference $\overline{X} - \overline{Y}$.

We constructed generalized linear models (GLMs) to test the primary hypotheses using the degree of each node as the outcome variable. Degree was approximately Poisson distributed and was not zero inflated. All nodes were considered in the GLM analysis, with controls included for whether the node was a primary respondent (interviewee), a secondary respondent, or not a respondent. These controls capture the fact that we did not interview all individuals represented by nodes and therefore not all nodes had the same chance to declare edges and were thus expected to have a lower observed degree.

All analyses were conducted in R (version 4.0.5) using the 'igraph' package (version 1.2.6, https://igraph.org, 22 May 2021); network visualization was done in Gephi (version 0.9.2, https://gephi.org, 25 May 2021).

3. Results

Descriptive Statistics: We interviewed 17 men and 23 women in the matrilineal area who provided information for an additional 15 men and 8 women, for a total of 32 men and 31 women. We interviewed 18 adult men and 12 adult women as primary respondents in the patrilineal area. In addition to their own information, these respondents provided information about 11 co-resident men and 17 co-resident women, for a total of 29 men and 29 women respondents (Table 1). We were unable to identify the second household respondent in 8 (20.0%) cases in matriliny and 2 (6.7%) cases in patriliny; we treated this information as missing. The full discovered network (all nodes) included 55 women and 78 men in the matrilineal community and 45 women and 47 men in the patrilineal community. The mean age of all nodes was 50.0 years versus 42.8 years for women versus men in the matrilineal community, and 46.8 years versus 47.8 years for women versus men in the patrilineal community. Mean years of education was slightly lower for both men and women in the matrilineal community.

Table 1. Sample characteristics.

ALL RESPONDENTS	*Matriliny*		*Patriliny*	
N	Women 31	Men 32	Women 29	Men 29
Individual characteristics: mean (standard deviation)				
Age (years)	48.9 (9.1)	45.9 (14.4)	43.5 (11.4)	47.4 (13.3)
Education (years)	1.7 (3.5)	4.3 (4.2)	3.5 (4.2)	5.2 (4.1)
Network centralities: median (interquartile range)				
Degree	4 (2, 6)	3 (2, 4.25)	2 (2, 4)	3 (2, 4)
Betweenness	0.012 (0.001, 0.037)	0.016 (0.001, 0.039)	0.017 (0.000, 0.063)	0.019 (0.000, 0.066)
Closeness	0.23 (0.21, 0.26)	0.22 (0.19, 0.23)	0.16 (0.14, 0.18)	0.17 (0.14, 0.18)
Transitivity	0.10 (0.00, 0.33)	0.00 (0.00, 0.067)	0.17 (0.00, 0.33)	0.17 (0.00, 0.33)
ALL NETWORK NODES	*Matriliny*		*Patriliny*	
N	Women 55	Men 78	Women 45	Men 47
Individual characteristics: mean (standard deviation)				
Age (years)	50.0 (12.5)	42.8 (14.5)	46.8 (12.9)	47.8 (12.9)
Education (years)	2.3 (4.2)	4.0 (4.1)	2.9 (3.9)	5.4 (4.0)
Network centralities: median (interquartile range)				
Degree	2 (1, 4.5)	1 (1, 3)	2 (1, 3)	2 (1, 3.5)
Betweenness	0.001 (0.000, 0.015)	0.000 (0.000, 0.013)	0.000 (0.000, 0.034)	0.000 (0.000, 0.031)
Closeness	0.24 (0.21, 0.26)	0.23 (0.20, 0.26)	0.16 (0.15, 0.18)	0.16 (0.14, 0.17)
Transitivity	0.23 (0.00, 0.63)	0.00 (0.00, 0.00)	0.17 (0.00, 0.33)	0.17 (0.00, 0.33)

Qualitatively, the matrilineal friendship network appeared to be more connected and contained many more cross-gender friendships than the patrilineal network (Figure 1, left). By contrast, the patrilineal friendship network (Figure 1, right) was markedly gender segregated, with distinct clusters of friends, linked loosely to each other. In the patrilineal network, 2 (1.8%) discovered edges were cross-gender; in the matrilineal network, 24 (14.0%) discovered edges were cross-gender. There were five isolates reporting no friendships in the matrilineal area and three isolates in the patrilineal area.

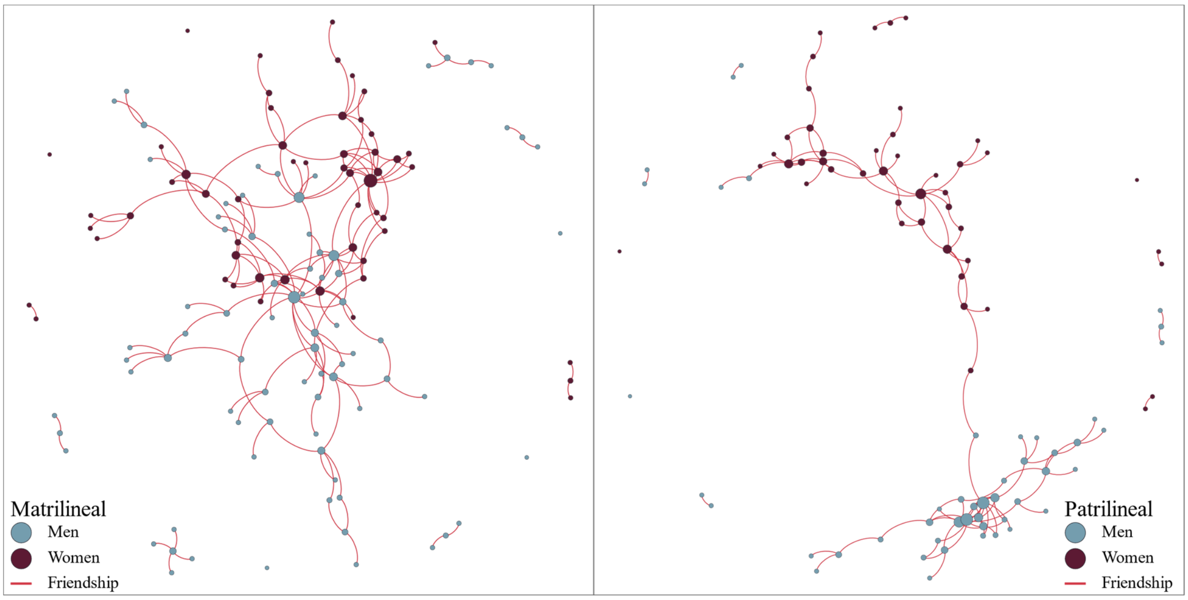

Figure 1. Social networks of men (blue) and women (purple) in matriliny (**left**) and patriliny (**right**).

Among respondents, the degree distribution of matrilineal women was distinct from the others (Figure 2A; Table 2); particularly, matrilineal women had a higher mean degree than matrilineal men (p = 0.019) and patrilineal women (p = 0.069). Men's degree distributions were roughly similar, with long right tails, which is consistent with a few men having relatively more friendships than the bulk of men and women. The degree distribution for matrilineal women stood out as being relatively flat, with a higher mean and median reported degree. The modal degree for respondents of both genders in both contexts was two to three. The direction of differences was similar when all nodes were considered (Table 1; SI Figure S1a).

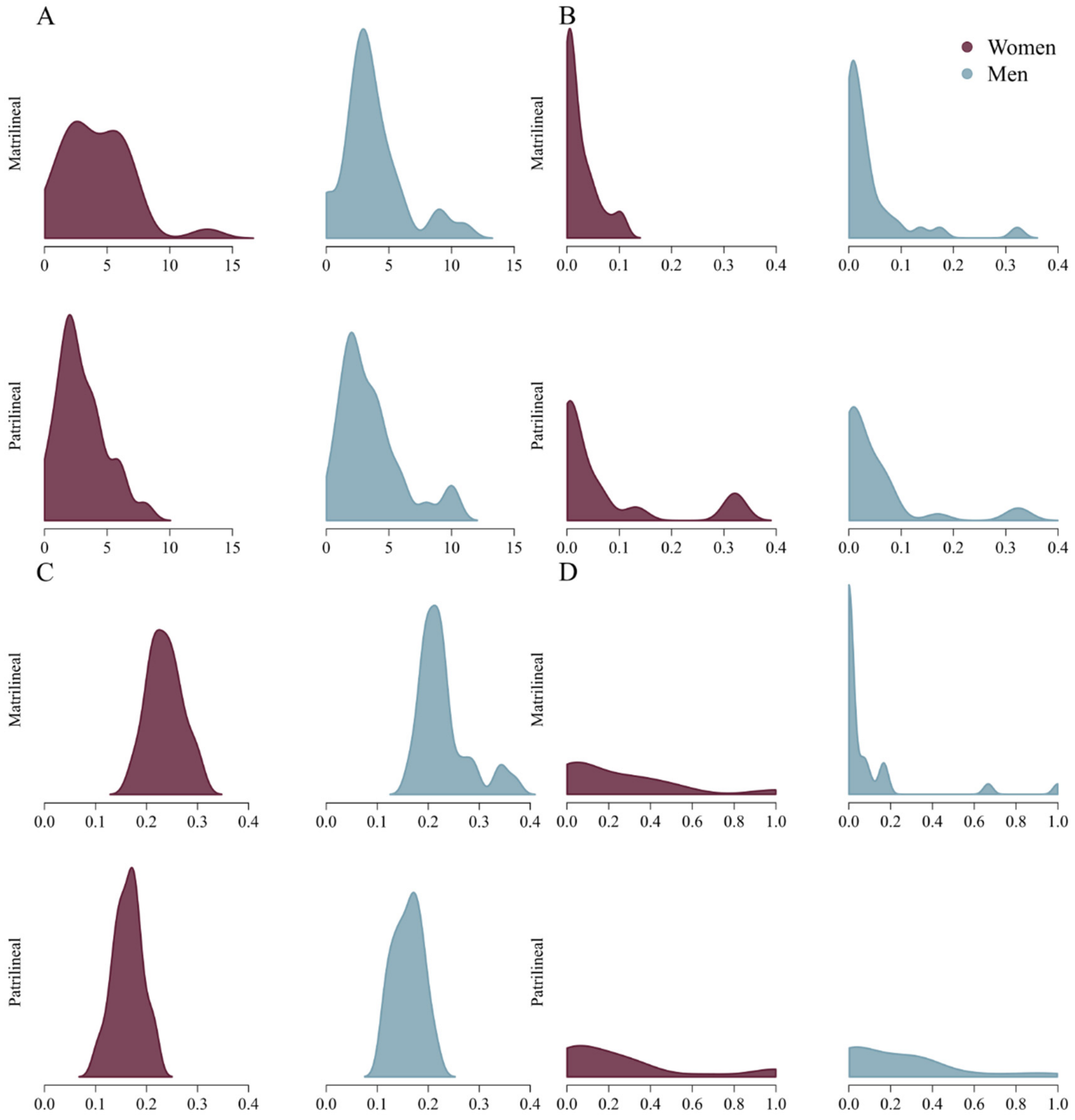

Figure 2. Kernel density plots for women (purple) and men (blue) in matriliny and patriliny, as labeled for (**A**) degree, (**B**) betweenness centrality, (**C**) closeness centrality, and (**D**) transitivity.

Table 2. Results of permutation tests comparing degree, betweenness, closeness, and transitivity distributions for patrilineal (pat.) and matrilineal (mat.) Mosuo respondents.

Distributions Being Compared		**Mean 1**	**Mean 2**	***p***
Degree				
Mat. Women	**Mat. Men**	**3.018**	**2.205**	**0.019** *
Pat. Men	Pat. Women	2.596	2.356	0.315
Pat. Men	Mat. Men	2.596	2.205	0.170
Mat. Women	**Pat. Women**	**3.018**	**2.356**	**0.069** †
Betweenness				
Mat. Men	Mat. Women	0.017	0.014	0.351
Pat. Women	Pat. Men	0.045	0.031	0.214
Pat. Men	**Mat. Men**	**0.031**	**0.017**	**0.096** †
Pat. Women	**Mat. Women**	**0.045**	**0.014**	**0.009** *
Closeness				
Mat. Women	Mat. Men	0.239	0.233	0.224
Pat. Women	Pat. Men	0.163	0.158	0.221
Mat. Men	**Pat. Men**	**0.233**	**0.158**	**0.000** *
Mat. Women	**Pat. Women**	**0.239**	**0.163**	**0.000** *
Transitivity				
Mat. Women	**Mat. Men**	**0.368**	**0.067**	**0.000** *
Pat. Women	Pat. Men	0.258	0.247	0.498
Pat. Men	**Mat. Men**	**0.247**	**0.067**	**0.001** *
Mat. Women	Pat. Women	0.368	0.258	0.211

† denotes significance at $\alpha = 0.1$. * denotes significance at $\alpha = 0.05$.

Additional measures of centrality revealed few strong differences between men and women. In betweenness centrality, the importance of one cross-gender edge in bridging the largely gendered clusters in the patrilineal community was apparent (Figure 2B); nodes along this path had correspondingly high levels of betweenness centrality. Matrilineal women demonstrated low levels of betweenness centrality, potentially suggesting matrilineal women were generally more connected within that network. Patterns in betweenness centrality were similar when all nodes were considered (Table 1; SI Figure S1b).

Under matriliny, the range in closeness centrality was wider for men than for women, although the means of the distributions were not obviously different (Figure 2C; Table 2). Among respondents from the patrilineal community, closeness centrality distributions were similar between men and women. There were no statistically significant differences in closeness by gender within either community; however, higher closeness in the matrilineal community was apparent upon both visual inspection (Figure 2C) and pairwise tests (Table 2). This was consistent with higher connectivity in the matrilineal friendship network and increased average distance between nodes in the patrilineal network due to the single set of edges connecting the two main clusters of nodes. Consideration of all nodes does not alter this conclusion (Table 1; SI Figure S1c).

The modal transitivity for both women and men respondents in both matriliny and patriliny was zero. Matrilineal women had a higher transitivity than matrilineal men ($p < 0.001$). The mean transitivity for men and women in patriliny was similar. Patterns were similar when all nodes were considered (Table 1; SI Figure S1d).

At the network level (SI Table S1), network density, degree centralization, and betweenness centralization were roughly equivalent between the two networks, while measures of network distance diverged. In particular, although all nodes were on average closer to each other in the matrilineal network, there was more concentration of closeness centrality in the matrilineal network than in the patrilineal network.

Generalized Linear Models: Modeling degree as a function of gender and community (matrilineal or patrilineal), with controls for respondent status (i.e., primary respondent, inferred respondent, or discovered node) and age did not reveal differences by gender (Coef for men: −0.04; 95% CI: −0.21, 0.12; Table 3). There was marginal evidence for a positive association between matriliny and degree (Coef: 0.15; 95% CI: −0.02, 0.32). The interaction between gender and community predicted by the gender reversal hypothesis was not apparent (Coef: −0.21; 95% CI: −0.56, 0.13). However, differences by gender across community were in the predicted direction: in matriliny, men had a lower degree (Coef: −0.13, 95%CI: −0.35, 0.09), while in patriliny, men had a higher degree (Coef: 0.09, 95%CI: −0.18, 0.35). The control variable for survey respondent was, as expected, positively associated with degree, as respondents had more edges than non-respondents; the control variable for inferred respondent was inversely associated with degree, suggesting fewer ties may have been reported for secondary respondents within a household. Predicted probabilities from this model supported a mild gender reversal in degree by descent system, providing tentative, suggestive evidence for a gender reversal in network size (Figure 3).

Table 3. Poisson generalized linear models of network degree by primary household survey respondent status, secondary household survey respondent status, age, gender, and community for all nodes of matrilineal and patrilineal Mosuo adults (n = 225).

Variable	Coefficient	Standard Error	95% CI	*p*
Intercept	0.04	0.20	(−0.35, 0.42)	0.84
Control for primary respondent	**1.11**	**0.11**	**(0.90, 1.33)**	**<0.0001** *
Control for secondary respondent	**−0.19**	**0.10**	**(−0.39, 0.01)**	**0.065** †
Age	0.00	0.00	(−0.00, 0.01)	0.37
Gender (man)	−0.04	0.09	(−0.21, 0.12)	0.62
Community (matrilineal)	**0.15**	**0.09**	**(−0.02, 0.32)**	**0.095** †
Intercept	0.00	0.20	(−0.40, 0.40)	1.0
Control for primary respondent	**1.10**	**0.11**	**(0.89, 1.31)**	**<0.0001** *
Control for secondary respondent	−0.17	0.10	(−0.37, 0.03)	0.11
Age	0.00	0.00	(−0.00, 0.00)	0.45
Gender (man)	0.09	0.14	(−0.18, 0.35)	0.53
Community (matrilineal)	**0.26**	**0.13**	**(0.01, 0.52)**	**0.04** *
Gender (man) * Community (matrilineal)	−0.21	0.18	(−0.56, 0.13)	0.23

† denotes significance at $\alpha = 0.1$. * denotes significance at $\alpha = 0.05$.

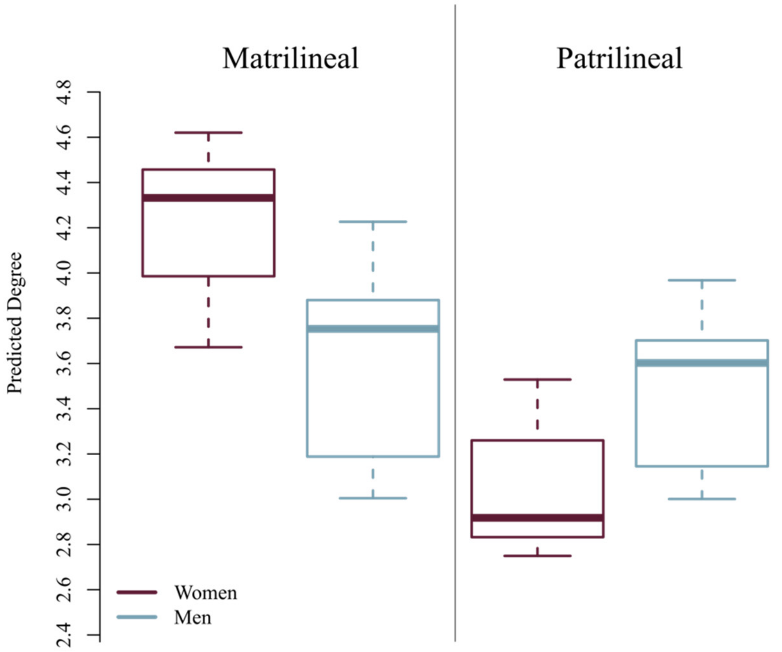

Figure 3. Predicted probabilities for network degree by gender and descent system controlling for survey respondent status and age.

4. Discussion

In this paper, we strove to test what we have called the universal gender differences (UGD) hypothesis, which posits, among other things, that men have larger networks than women, here operationalized as degree in an undirected social network. We tested this in two communities—one patrilineal and one matrilineal—that are organized differently in terms of gender, inheritance, descent, and ecology, but are otherwise similar (Mattison et al. 2021). This variation presented the opportunity to investigate whether the gender differences of the UGD hypothesis might hold in some ecologies, but not others, and whether gender reversals in node degree (a measure of network size) might be present in matrilineal communities where women are relatively autonomous (Mattison et al. 2019; Reynolds et al. 2020).

We find no evidence in either patriliny or matriliny in support of the UGD hypothesis. In patriliny, there are no marked gender differences in network metrics. In matriliny, there are some gender differences: although these differences are not substantial, they are generally in the opposite direction to predictions of the UGD hypothesis. Specifically, matrilineal women may have larger networks than matrilineal men. Additionally, both descriptive results and our generalized linear model suggest that matrilineal friendship networks are larger and more connected than patrilineal networks, with matrilineal friendship networks including more hetero-gendered social relationships and patrilineal ones clustering more strongly on gendered lines. In addition to rejecting the UGD in these contexts, we interpret this evidence as consistent with variation being structured by local socio-ecologies. These inferences are tempered by limitations of sample size (only two networks were sampled) and sampling strategy (not all relevant individuals were interviewed). Nonetheless, we believe this is a useful case study if it prompts additional research in small-scale settings where local gender norms and ecological variation may be likely to reveal additional nuances in the ways that men and women structure and use social support.

These findings suggest that local socioecological circumstances should be incorporated into understandings of women's and men's constraints, decision making, and associated outcomes (Winterhalder and Smith 2000). More specifically, the assumptions that underlie hypotheses of universal differences in men's and women's social and reproductive strategies are unlikely to be met across contexts. We highlight two such assumptions here, as neither is likely to characterize both subpopulations of the Mosuo. First, the UGD hypothesis assumes that reproductive variance is higher in men than in women and that this motivates men to cultivate larger ('diffuse') networks as a means to gain status (and, as a result, more mating opportunities). Furthermore, sexually selected motivations contribute to gendered divisions of labor, and these tend to anticipate more intra-household labor by women, which may, under some circumstances, constrain women's social-networking opportunities relative to men's (von Rueden et al. 2018). Among the patrilineal Mosuo, monogamy and the consistent need for men's labor (Mattison et al. 2021) likely constrains men who would otherwise attempt to pursue multiple reproductive partners (see, e.g., Fortunato and Archetti 2010; Kokko and Jennions 2008). More generally, although variance in reproductive success is higher, on average, for men than for women among humans, there is substantial population-level variation (Brown et al. 2009), with variance in female reproductive success occasionally outstripping male. Monogamy characterizes the bulk of relationships among both patrilineal and matrilineal Mosuo (Mattison et al. 2021), but exists within the context of relatively small, mostly nuclear domestic units in patriliny, suggesting that status-oriented pursuits may have more limited impact on male reproductive success among the Mosuo—even in patriliny—than it might in contexts where polygyny prevails.

Second, the UGD hypothesis often references male philopatry and female emigration as an ancestral pattern of community organization to which men and women adapted differently. Specifically, scholars have argued that general tendencies toward male-biased philopatry in humans should lead to stronger, kin-based coalitionary networks in men versus a focus on fewer, more intimate relationships in women (Vigil 2007; Wrangham 1980). Although patrilocality is the modal form of human social organization in contemporary societies (Murdock and White 1969), it is far from universal (Surowiec et al. 2019) and is unlikely to have been the single emigration pattern of Pleistocene foragers, who most likely displayed flexibility in residence (Dyble et al. 2015; Kramer and Greaves 2011; Wood and Marlowe 2011)—and in fact it has been argued that modern low levels of matriliny and high levels of patriliny may be in part due to the impact of colonialism on the ethnographic record (Shenk et al. 2019). In our study communities, patrilineal women initially have more limited access to social support than patrilineal men. By contrast, matrilineal women and men normatively reside in their natal communities throughout their lifetimes. Our findings provide preliminary evidence that matrilineal friendship networks are larger than patrilineal ones and are also more likely to involve hetero-gendered relationships. This pattern of natalocal residence may contribute to that (He et al. 2016; Shih 1993), as may the relative ease with which individuals travel from house-to-house in this relatively traversable terrain (Mathieu 2003; Mattison et al. 2021). This result, even if tentative, reinforces the importance of differences in the social and demographic constraints imposed by kinship systems in structuring access to social support and the costs and benefits to men and women of gender-specific strategies (Koster et al. 2019; Low 2005; Power and Ready 2019; Starkweather et al. 2020), with important implications for understanding strategies across diverse contemporary settings (David-Barrett 2019; Mattison and Sear 2016).

Our qualitative assessment of degree distributions suggests differences between genders, by descent system, offering very tentative support for our hypothesis that the 'typical' pattern of a higher degree for men would be reversed in the matrilineal setting. Our analyses did not bear out the predicted interaction between gender and community, potentially due to our fairly small sample size. Although our qualitative assessment hardly stands on its own, in the context of other studies showing gender reversals in aspects of behavior (Gong et al. 2015; Gong and Yang 2012; Liu and Zuo 2019) and outcomes (Mattison et al. 2016; Reynolds et al. 2020) among matrilineal Mosuo relative to other patrilineal populations, we suspect that future work in a larger sample may bear out this prediction.

Our findings provide additional motivation to reexamine existing dogma stipulating the absence of matriarchy and limits to women's roles in matriliny (see Leonetti et al. 2005; Parkin 2021; Schneider 1961). Women in matriliny are often implicitly or explicitly assumed to never fully take on roles analogous to those of men in patriliny, particularly as societal leaders. However, a variety of evidence points to the importance of women's leadership and status in securing evolutionarily relevant benefits, such as their own and their children's health and welfare, even if women's influence on average in the range of societies that generate the ethnographic corpus may be less overt than men's (Alami et al. 2020; Reynolds et al. 2020). Matrilineal women's social relationships as depicted here do not fully mirror men's; still, their relatively large network size suggests that aspects of women's social strategies can resemble men's when women are more central and have more authority and social support (Hrdy 2000; Mattison et al. 2019; Smuts 1994). The large households characteristic of the matrilineal Mosuo are likely to free many women from the demands of childcare by providing ample and capable allocarers, whereas the nuclear households characteristic of patrilineal Mosuo are likely to be conducive to more domestic-oriented activities among women, as suggested by our ethnographic observations. In other small-scale societies, women's time spent in childcare and domestic labor more generally can contribute to greater opportunity for men to socialize broadly within and between communities and to gain community-wide social influence (Werner 1984; Brown and Kerns 1985; von Rueden et al. 2018). Differences in network characteristics according to social and ecological contexts underscore the importance of general, rather than gender-specific, models of reproductive and cooperative strategies that consider social, demographic, and ecological constraints affecting the potential for complementarity, supplementarity, and divergence between men and women (Bliege Bird and Bird 2008; Mattison 2016; Starkweather et al. 2020).

Our study is subject to a number of important limitations. Our sampling strategy resulted in a network that is not complete in that we did not interview every person residing in the two communities, but rather members of, to the best of our ability, every household in each community. Households often included more adults than the two about whom friendship information was sought. Our expectation is that if more individuals had been interviewed, the number of nodes and edges would have increased as well, affecting, for example, the maximum observed degree. Furthermore, although node degree and transitivity in networks of a similar number of nodes as our potential networks (250–350 nodes) is relatively consistently estimated across a wide range of percent missingness, metrics such as betweenness and closeness are more sensitive (Smith and Moody 2013). This sensitivity may be problematic in the networks we studied because betweenness and closeness are driven in large part by the small number of cross-gender friendship ties, particularly in the patrilineal network. However, the difference in proportion of cross-gender edges between the two locations is stark: although our precise estimates of, for example, betweenness and closeness may differ from values that would have been obtained in the complete network, cross-gender ties would have to be substantially undersampled in the patrilineal network to approach the proportion of cross-gender ties in the matrilineal network. That said, a sampling strategy that focused on younger or older adults, or a more random sample of individuals (and thus less systematically likely to include higher centrality nodes (Smith et al. 2017)), may have found different patterns. Moreover, this is a static, descriptive portrait of social relationships, which are known to change across the life course (David-Barrett et al. 2016; Palchykov et al. 2012; Bhattacharya et al. 2016). Stability of relationships may have important implications for health, well-being, and reproductive success (Cheney et al. 2016) that we cannot capture here, perhaps particularly for women in patriliny where many relationships are established subsequent to marriage. Our ability to capture spatially and temporally diverse friendships that characterize humans and distinguish us from non-humans (Rodseth et al. 1991) is incomplete. Nor do we have information on the intimacy or specific exchanges implied by observed relationships that might help to test differences in the quality and intensity of relationships anticipated by some of the hypotheses reviewed in the introduction (e.g., Rose and Rudolph 2006; Vigil 2007). This, too, would provide important insights on how the strength of relationships relates to fitness and well-being (Scelza 2011; Silk et al. 2010), and whether this varies by gender across different social systems. Finally, we characterized networks based on self-reported, often unreciprocated ties. Although we have no reason to suspect biases in any particular direction, we also have no observation of benefits transferred along the reported ties. Observations of specific types of cooperation (e.g., working on someone's farm (Thomas et al. 2018)) would help to verify the importance of the patterns we describe here.

Certainly, the fact that respondents' social networks are larger than others' suggests the need for more complete sampling. Comparing our results to prior network studies based on more complete networks drawn from other settings, e.g., classrooms (Benenson 1990; Vigil 2007) or even relatively clearly bounded networks (Apicella et al. 2012; Nolin 2012; Page et al. 2017), is difficult. Considering the limitations of network methods and metrics in field settings, especially with loose boundaries among communities (Gerkey and Cronk 2014), will be important in future studies of gender differences in social relationships. Future comparative networks studies that build upon these results will facilitate attempts to generalize findings.

5. Conclusions

Despite the demonstrated importance of social relationships to human and non-human primate reproductive success and well-being, there has been remarkably little work in evolutionary anthropology investigating how social relationships may be structured and used differently by men and women in varying contexts. Our study is the first of which we are aware to compare men's and women's social networks in two very different kinship contexts: matriliny and patriliny. Because these contexts are part of the same culture yet differ in the extent to which they support divergent reproductive strategies, they are ideal for understanding how fixed (or flexible) gendered social relationships are. Women provide important forms of support that often go unrecognized in evolutionary studies of cooperative networks. We have shown here that gender differences in social network size can reverse in matriliny compared to patriliny. This suggests the need to evaluate common assumptions undergirding universal models of gender differences in social and reproductive strategies, which are only likely to be met in some socioecological circumstances, and which were unlikely to have fully characterized ancestral human environments. Our point is not to say that men and women never diverge or that they do not pursue complementary strategies, or that the patterns found by previous researchers are incorrect, but rather to suggest that more general models of human evolutionary strategies that incorporate non-gender-specific constraints and consider diverse socioecologies will offer a broader understanding of human flexibility. Given the links between social support, health, and well-being across species (Cheney et al. 2016; Power and Ready 2019; Silk et al. 2003), this is not merely a theoretical exercise.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/socsci10070253/s1, Figure S1: Kernel density plots for men (blue) and women (purple) in matriliny and patriliny, Table S1: Network-level density, centralization, transitivity, and distance statistics for Mosuo matrilineal and patrilineal networks.

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Notes

[1] This modification to standard use of the terms ego and alter is used in this study to reflect the fact that our sampling strategy resulted in individuals having systematically more or less opportunity to have their friendship edges represented in the network.

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Do Data from Large Personal Networks Support Cultural Evolutionary Ideas about Kin and Fertility?

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Abstract: The fertility decline associated with economic development has been attributed to a host of interrelated causes including the rising costs of children with industrialization, and shifts in family structure. One hypothesis is that kin may impart more pro-natal information within their networks than non-kin, and that this effect may be exacerbated in networks with high kin-density where greater social conformity would be expected. In this study, we tested these ideas using large personal networks (25 associates of the respondent) collected from a sample of Dutch women (N = 706). Kin (parents) were perceived to exert slightly more social pressure to have children than non-kin, although dense networks were not associated with greater pressure. In contrast, women reported talking to friends about having children to a greater extent than kin, although greater kin-density in the network increased the likelihood of women reporting that they could talk to kin about having children. Both consanguineal and affinal kin could be asked to help with child-care to a greater extent than friends and other non-kin. Overall, there was mixed evidence that kin were more likely to offer pro-natal information than non-kin, and better evidence to suggest that kin were considered to be a better source of child-care support.

Keywords: kin; affinal kin; density; personal network; social support; social pressure; fertility

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1. Introduction

Why do (post)industrial humans have so few children? This question has occupied economists, demographers, quite a few historians, and many evolutionarily-minded social scientists (see Sear et al. 2016). Over time, it has become clear that any explanation must combine both individual level and societal factors, and that industrial societies cannot be treated as monolithic, but have their own distinct reproductive ecologies (Stulp et al. 2016; Sear 2015; Burger and DeLong 2016). Identifying how and why reproductive decision-making shifts across space and time thus requires consideration of the diverse range of changes associated with economic development—from increased mobility to improved hygiene, and from ideas on contraception to child labor laws—any number of which could influence family size, whether alone or through potentially complex intersections (Newson et al. 2005).

Evolutionary approaches to the issue of fertility decline have included both individual-level explanations concerning the costs and benefits of producing children (see Lawson and Mulder (2016) for review) as well as more complex models that consider how cultural norms evolve, both within and outside the reproductive domain (see Colleran (2016) for review). With respect to behavioral ecology-inspired, individual-based models, early work by Turke (1989), for example, suggested that reductions in the size of extended kin networks during modernization meant that people could no longer call on kin for help with child-care (and/or their perceptions of the likelihood of such help declined), which served to raise the relative costs of children; family size therefore shifted downward to reflect the number of children that could be raised adequately by a smaller family unit. In this view, family size limitation reflects a rational, potentially adaptive response to ecological circumstances. Other authors, in contrast, have suggested that family size decline resulted from the misperception of child-rearing cues in a novel environment (Kaplan 1996); specifically, parents assume that greater investment per child is required than is strictly necessary to promote offspring survival and success. As a result, parents engage in an extreme quality–quantity trade-off that accords with life history considerations, but is functionally maladaptive. Although these individually-oriented optimality models offer genuine insight into how and why reproductive decision-making may have shifted with modernization, such models cannot account for why particular social norms regarding family size arise and take hold in ways that continue to influence behavior independently of changes in an individual's ecological circumstances (see e.g., Lesthaeghe and Surkyn 1988). There has, therefore, been an enduring interest in developing models that consider fertility decline from a cultural evolutionary perspective (see Colleran (2016) for review).

Models that incorporate social norms in addition to individual cost-benefit analyses have often considered how particular kinds of learning biases can shape decision-making such as imitating highly successful or prestigious individuals. An early example is Boyd and Richerson's (1985) suggestion that fertility decline is a culturally evolved process that reflects shifts in prestige and who people imitate. Under non-industrial conditions, Boyd and Richerson (1985) argued that prestige and success would be associated with high reproductive success, as individuals afforded prestige would likely be the matriarchs or patriarchs of large families. Modernization then generated new forms of success and associated prestige, often in roles associated with education and work outside the domestic sphere, such as teachers. As such high-investment social roles were likely to cause the individuals fulfilling these roles to limit family size, this would then result in smaller family sizes among those imitating high-prestige individuals, thus creating new reproductive norms.

As Newson et al. (2005) point out, however, the manner by which prestige is determined is itself a product of social values and group norms. Thus, this prestige influence model leaves unexplained why norms of social prestige should have changed to favor "the exotic expertise" of school teachers and the like. Newson and colleagues thus suggest we also need to incorporate *teaching* biases into cultural evolutionary models in order to generate a more complete explanation. Specifically, they suggest that kin and non-kin are likely to differ in the kinds of information they convey, with kin more likely to encourage behavior that leads to reproductive success. If modernization leads to shifts in the composition of networks, possibly along the lines Turke (1989) suggested, then this, in itself, would be sufficient to explain why family limitation took hold as pro-natal kin influence waned, and new cultural norms for small family sizes could develop.

Newson et al. (2005) offer evidence in favor of their hypothesis from the ethnographic literature, and also by reference to close-knit religious sects like the Amish and Hutterites. They offer further suggestive evidence from a study of family planning in Mozambique, where conversations about family limitation were more likely to occur between friends than relatives. More specific tests of their model require attention to the following two hypotheses: (a) among individuals in the same culture, those with more kin-based networks should be more inclined to behave in ways likely to lead to reproductive success, and (b) in conversations about reproduction, relatives should be more likely to condone or encourage pro-natal behavior. Of course, one has to keep in mind that the hypothesis is concerned with the kinds of teaching biases that serve to initiate a demographic transition and it is possible that these may have changed over time, such that kin and non-kin may converge much more closely in the present day. This is an empirical issue, however, and so it remains valid to test whether different kinds of teaching biases are conveyed via kin versus non-kin.

Here, we use data on the personal networks of Dutch women to investigate (i) whether kin-rich networks are associated with higher levels of social pressure to reproduce, and whether women feel they can talk to kin about having children to a greater extent than the non-kin members of their networks (that is, kin-related teaching bias may come about through both unsolicited and solicited advice). This speaks directly to Newson et al.'s (2005) ideas regarding teaching biases. We also consider (ii) whether people perceive kin as more likely to help with child-care than non-kin, as this may also increase receptiveness to pro-natal information, and so factor into kin-based influences on reproductive success (more in line with Turke's (1989) behavioral ecological approach).

In addition, we consider network density (i.e., the proportion of all possible ties between alters in the network that are present) as this has the potential to influence both the degree to which novel information is transmitted, and the extent to which social norms are adhered to and policed (Montgomery and Casterline 1996; Marsden 1987; Kohler et al. 2001). If kin-rich networks are also denser, this could amplify the influence of kin as proposed by Newson et al. (2005), because close kin relationships within the network could potentially enable close monitoring and maintenance of pro-natal norms and resist outside influence. This adds a further twist to Newson et al.'s ideas, as kin influence could potentially weaken with modernization due to changes in internal network structure in addition to changes in network composition. In line with this, Colleran (2020), using data from a large sample of Polish women across 22 villages, found that greater market integration was associated with a loosening of kin ties in women's networks (i.e., the proportion of all possible ties that were kin-based was lower), even though network size did not change.

Interestingly, in an earlier study on the same population, Colleran et al. (2014) found that less educated women, when living among more highly educated neighbors, had fewer children than expected and more highly educated social networks. This effect was not due to a greater presence of non-kin in the network, nor to horizontal transmission between strong ties in the network; rather, it seemed to reflect more frequent interactions with highly educated women. This suggests that reproductive decision-making was partly driven by cultural dynamics beyond the individual (i.e., women's personal circumstances alone could not fully account for their reproductive decisions). Taken together, these findings suggest either that prestige-based copying of educated women may, in fact, drive decision-making *contra* Newson et al., and/or greater contact with highly educated women combined with reduced kin density allows new social norms to diffuse more easily due to a reduced capacity for personal networks to resist change. One limitation of this earlier work is that, despite an impressive sample size in general, ego-networks were small, with respondents asked to name up to five other women to whom they could talk about important personal matters (mean network size was 3.11 individuals); such small networks may not be fully representative. Women in our sample were asked to name 25 alters (of either sex, kin and non-kin).

In what follows, we therefore begin by establishing whether network density relates to the proportion of kin in large networks, and whether network structure in our sample varies in ways that would reinforce or undermine Newson et al.'s (2005) hypotheses concerning kin-related teaching biases. We then go on to test our two main hypotheses. In our analyses, we consider the influence of both consanguineal and affinal kin, in line with Bogin et al.'s (2012) characterization of human reproduction as biocultural, rather than as cooperative per se; that is, unlike non-human cooperative breeders, the provision of care and resource transfers among humans is often decoupled from genetic relatedness—a distinction that is worth making explicit. In addition, the blood relatives of an individual's partner obviously have a vested interest in the reproduction of the couple (Burton-Chellew and Dunbar 2011; Hughes 1988). In our view, then, support, information, and pressure are likely to be exerted by both consanguineal and affinal kin in similar fashion (although it should be remembered that the interests of kin and affinal kin may diverge: Sear et al. 2003).

2. Results

2.1. Descriptives

Overall, we obtained data from 706 Dutch women between the ages of 18 and 41. Each woman reported on exactly 25 alters with whom they had been in contact within the last year and with whom they would be able to communicate if needed. This gave us information on 17,650 alters. On average, respondents reported seven kin in their personal networks, which equates to 28% (SD = 15%), although there was substantial variation with 16 respondents reporting no kin and five reporting 80% or more (Figure 1). The proportion of affinal kin was considerably lower at 10% (SD = 11%) (if we exclude women's partners this declines to 7% (SD = 10%) for those women who named their partner as an alter). This implies that, on average, networks consisted mostly of non-kin (62%; SD = 18%). Those who reported more kin reported slightly fewer affinal kin ($r = -0.05$), but many fewer non-kin ($r = -0.80$). Similarly, reporting more affinal kin meant reporting fewer non-kin ($r = -0.56$).

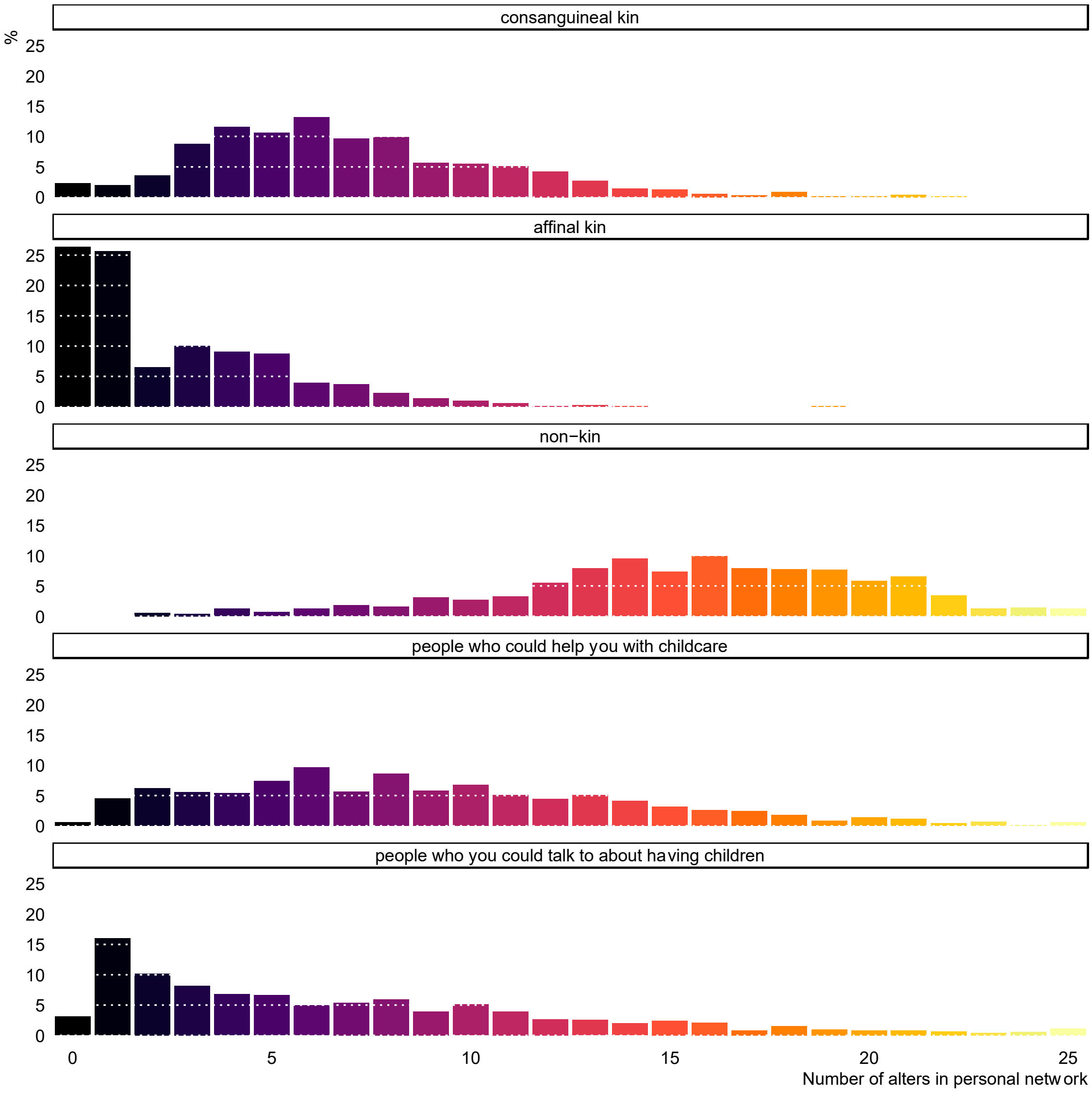

Figure 1. The number of people in the network that are consanguineal kin; affinal kin; non-kin; that can help you with child-care; or that you could talk to about having children. % refers to percentage of respondents ($N = 706$).

2.2. Are More Kin-Heavy Networks More Densely Connected?

Respondents were asked to indicate whether each alter in their network was in contact with each of the other alters, where contact referred to both face-to-face interactions as well as other forms of contact. This meant that respondents had to evaluate 300 alter-alter-ties. The nature of our question means that it need not be the case that all kin are connected (e.g., divorced parents may not be in contact) as is often assumed in kin networks (e.g., Colleran 2020; David-Barrett 2019). The average density of the network across respondents was 24% (SD = 11%), which means that, on average, 24% of the possible 300 ties between all 25 alters exist (Figure 2). Density was positively but weakly associated with the number of consanguineal kin that people reported in their network ($r = 0.30$; Figure 2), and even more weakly with the number of affinal kin ($r = 0.16$). A linear regression predicted a density of 23% with five kin alters in the network, which increased to 27% with 10 kin alters in the network. The number of non-kin was negatively associated with density ($r = -0.35$; Figure 2; combining the number of consanguineal and affinal kin would lead to an identical, but positive correlation with density of $r = 0.35$).

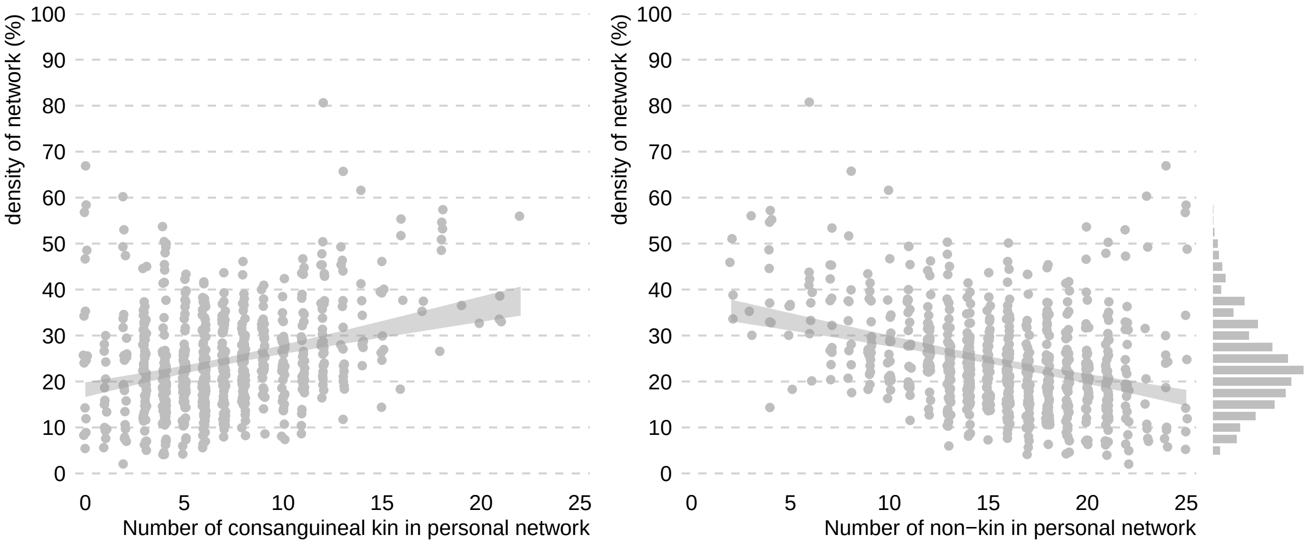

Figure 2. (**a**) The association between the number of consanguineal kin in the network and density ($r = 0.30$); (**b**) The association between the number of non-kin in the network and density ($r = -0.35$); (**c**) histogram of density (binwidth = 2.5%). Shaded band is 95% confidence interval around linear regression line.

2.3. Are Kin More Supportive with Respect to Child-Care and Communication?

For each alter, respondents were asked whether they could (i) ask the alter for help with child-care, and (ii) talk to the alter about having children. On average, 35% (SD = 21%) of alters were available for help with child-care and respondents stated they could talk to 28% (SD = 24%) of alters about having children.

Respondents reported that approximately 55% of consanguineal and affinal kin could help with child-care (Figure 3), but only 24% of non-kin. Non-kin were further broken down into those that were or were not considered friends: 37% of friends were able to help with child-care, whereas this was true for only 7% of non-friends.

Approximately 40% of affinal kin were reported as approachable for discussions about having children, compared to approximately 25% for consanguineal kin and non-kin. However, when partners were excluded from affinal kin, this percentage dropped to 21%. Thus, for kin beyond the potential reproductive partnership, respondents talk to affinal kin to the same degree that they talk to consanguineal kin or non-kin. Again, if we split non-kin into friends and non-friends, talking about children was more likely with friends (41%) than non-friends (9%). Thus, respondents were likely to speak to friends about having children to a greater extent than both kin categories, and most unlikely to talk about such things with non-friends.

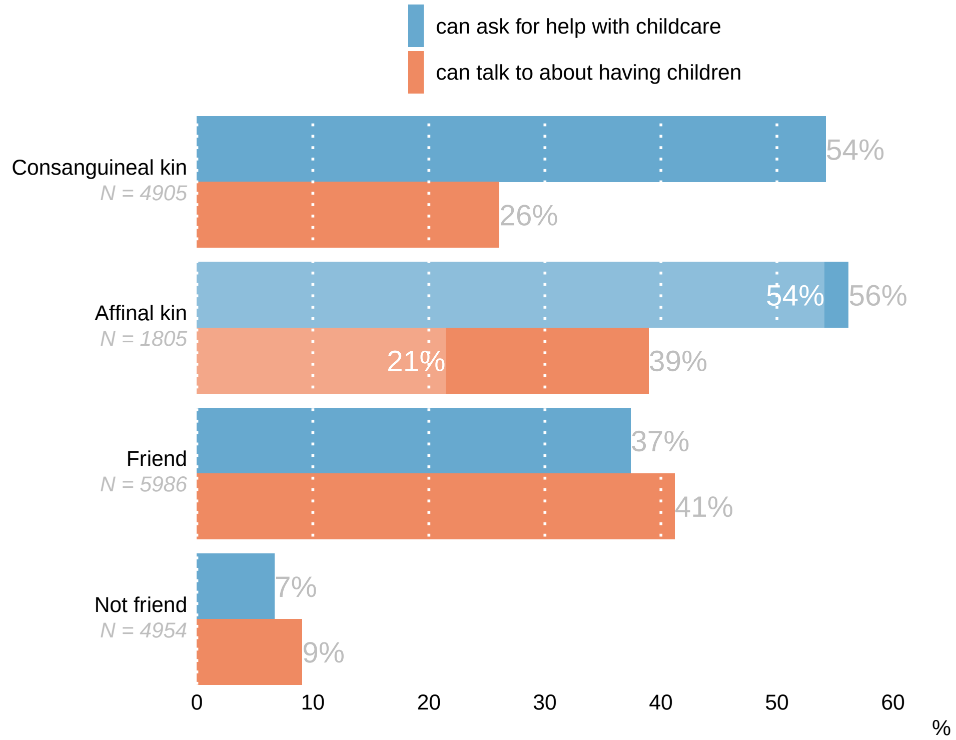

Figure 3. Percentage of kin, affinal kin, and non-kin (which are divided into friends and not friends) that respondents can ask for help with child-care or talk to about having children. Estimates presented in white are those for affinal kin excluding the respondent's partner (*N* = 1316).

We modeled these data with a binomial mixed model, controlling for respondent age, partnership status, and whether the respondent had children, and corroborated these results (Appendix A, Table A1). Compared to non-kin, non-friend alters, the odds of being able to ask for help with child-care was 10.2 (95% CI: 8.8–11.8) times higher for friends, 32.9 (95% CI: 28.3–38.3) times higher for consanguineal kin, and 36.6 (95% CI: 30.7–43.8) times higher for affinal kin. When examining whether respondents could talk to the alter about having children, weaker but still strong patterns emerged: compared to non-kin, non-friend alters, the odds of talking about children were 6.0 (95% CI: 5.2–6.9) times higher for consanguineal kin, 11.6 (95% CI: 9.7–13.7) for affinal kin, and 12.4 (95% CI: 10.8–14.2) for friends.

We then considered both the composition and density of the network on respondent perceptions. In order to do so, we needed to consider ties between groups of alters, and among kin in particular. We therefore modeled the four alter categories separately (i.e., consanguineal kin, affinal kin, friends, and non-friends). With respect to network composition (i.e., the number of alters in the network belonging to a given category), an increase in the number of consanguineal kin, affinal kin, and non-friends decreased the probability of being able to ask an alter to help with child-care (Figure 4; Table A2; controlling for the density among that group, the age of the respondent, partnership status, and whether the respondent has children). Specifically, the predicted odds of being able to ask an alter to help with child-care decreased by 8.1 (95% CI: 5.4–12.1) for consanguineal kin as we moved from no consanguineal kin alters in the network (composition of 0%) to all individuals in the network being consanguineal kin (composition of 100%). For affinal kin, the odds declined by 3.7 (95% CI: 1.5–9.5), and for non-kin/non-friend alters, the odds declined by 11.6 (95% CI: 5.6–24.1). For non-kin friends, in contrast, the odds increased very slightly by 1.4 (95% CI: 1.1–1.9).

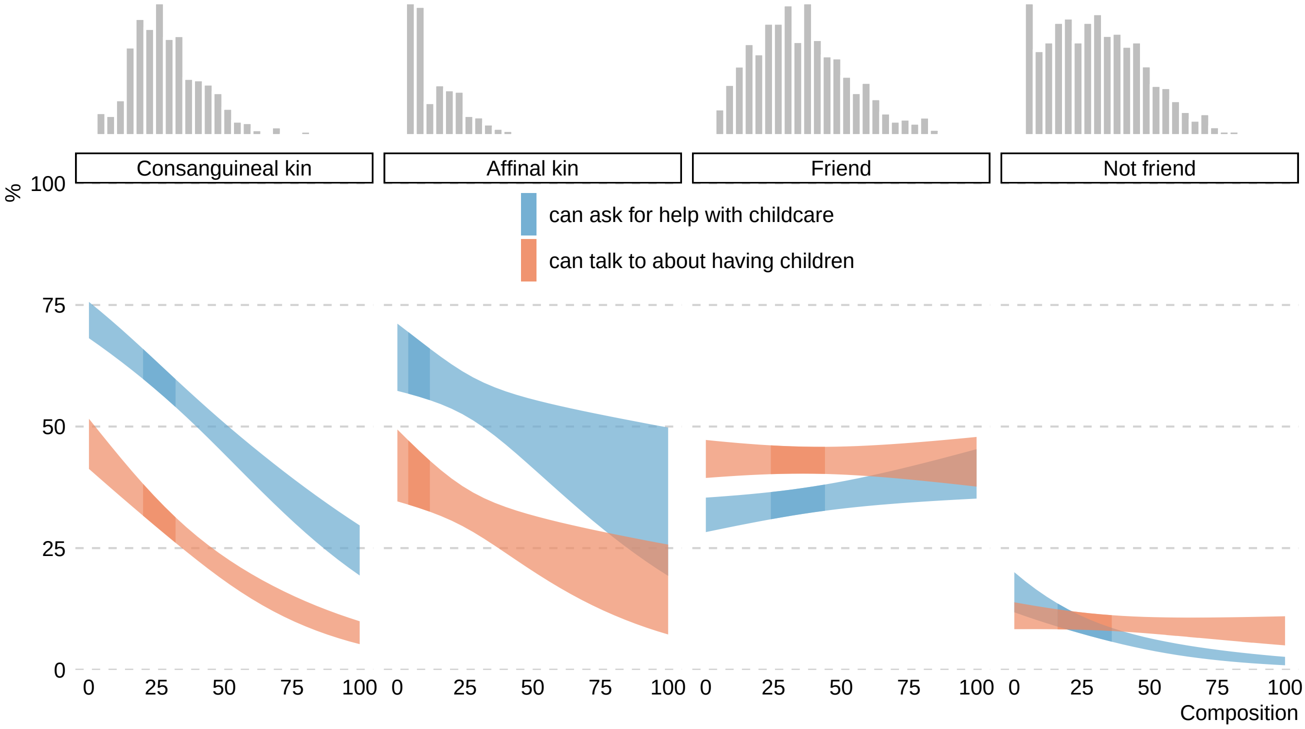

Figure 4. Predicted percentages (95% confidence band based on binomial regressions; see Table A2) of responses to the questions "can ask alter for help with child-care" and "can talk to alter about having children" depending on composition for consanguineal kin (*N* = 676 respondents), affinal kin (*N* = 339), friends (*N* = 668), and non-friend alters (*N* = 606). Composition refers the percentage of alters in the network belonging to that particular group. Darker shades represent the middle 50% of data. Sample sizes vary because density (which is included in the models) could only be calculated for particular groups when the respondent listed at least two of that group. An increase of 4% in composition means one extra alter is listed in the network of 25. Models were evaluated for 29 year-old women with a partner and children, and average density among the particular groups. On top of the panels, histograms of composition for each group are displayed (binwidth = 4%).

Reporting more consanguineal and affinal kin in the network also decreased the probability of being able to talk to these categories of alters about having children, whereas this was less pronounced for friends and non-friends (Figure 4). For consanguineal kin, the predicted odds of talking to an alter about children decreased by 11.1 (95% CI: 6.8–18.0) when moving from no consanguineal kin alters in the network (composition of 0%) to all individuals being consanguineal kin (composition of 100%). For affinal kin, the odds decreased by 4.4 (95% CI: 1.7–11.5), and for non-friend alters by 1.5 (95% CI: 0.8–2.7). The number of friends in the network produced no change in the odds of talking to an alter about having children (i.e., the predicted odds had a value of 1.0 (95% CI: 0.8–1.4), Table A2).

With respect to density, we also found a strong impact on whether an individual could be asked for help with child-care but, in this case, the relationship was positive for both kin categories in addition to friends (controlling for the number of alters in the network of that particular group, the age of the respondent, partnership status, and whether the respondent has children). That is, for consanguineal kin, affinal kin, and non-kin friends, increased network density was associated with a higher probability of women being able to ask for help with child-care, but there was no such relationship for non-friend alters (Figure 5). The predicted odds of being able to ask an alter to help with child-care increased by 5.6 (95% CI: 4.2–7.4) for consanguineal kin as we moved from no ties between the alters (density of 0%) to all ties existing between the alters (density of 100%), while for affinal kin, the odds increased by 10.7 (95% CI: 6.2–18.6). For friends, the odds increased by 2.0

(95% CI: 1.5–2.5), and for non-friends, the odds increased by only 1.1 (95% CI: 0.7–1.6) (Table A2).

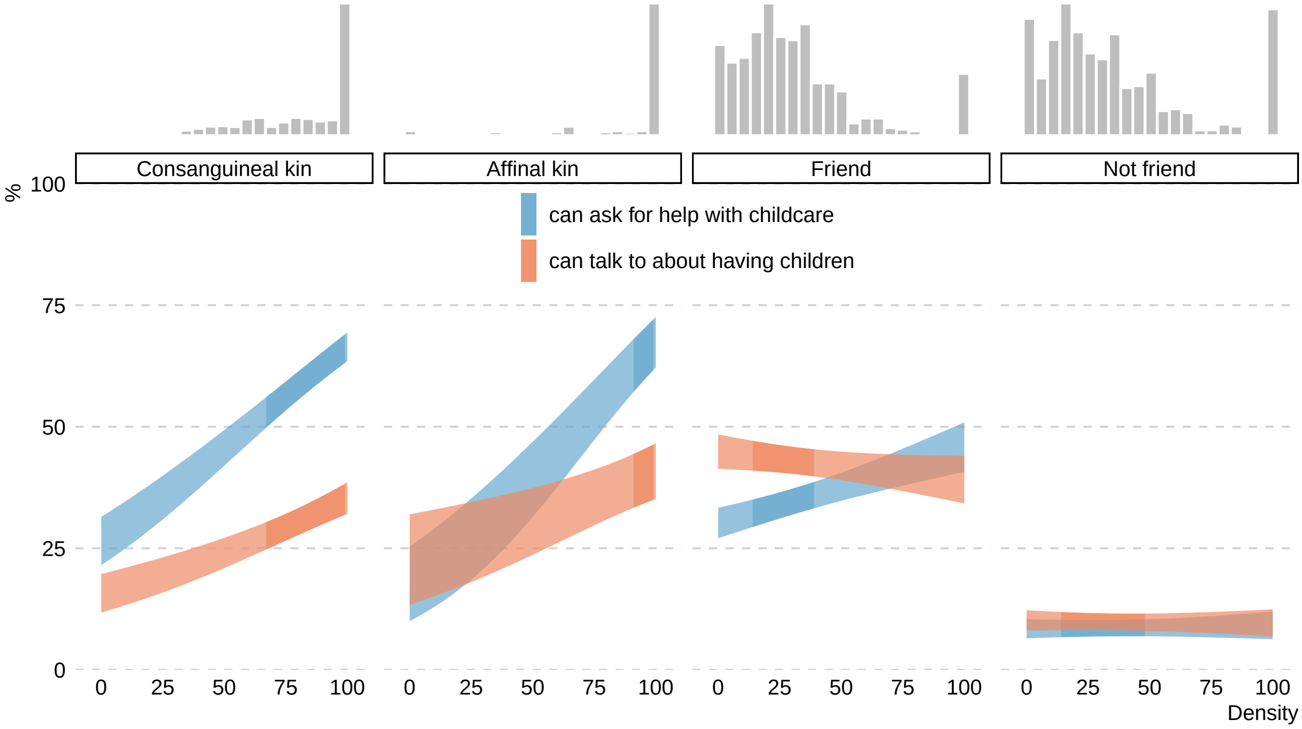

Figure 5. Predicted percentages (95% confidence band based on binomial regressions; see Table A2) of responses to the questions “can ask alter for help with child-care” and “can talk to alter about having children” depending on density for consanguineal kin (N = 676 respondents), affinal kin (N = 339), friends (N = 668), and non-friend alters (N = 606). Darker shades represent middle 50% of data. Sample sizes vary because density could only be calculated for particular groups when the respondent listed at least two of that group. Models were evaluated for 29 year-old women with a partner and children, and average composition among the particular groups. On top of the panels, histograms of density for each group are displayed (binwidth = 5%).

Different patterns, however, emerged for talking about having children. With respect to consanguineal and affinal kin, increased density was associated with being able to talk about children, whereas the relationship was reversed and weaker for friends (Figure 5): higher friend-density was associated with a lower probability that women could talk about having children. Density had little impact among non-kin/non-friend alters. The predicted odds of talking to an alter about children were raised by 3.0 (95% CI: 2.2–4.2) for consanguineal kin and 2.6 (95% CI: 1.5–4.4) affinal kin, when moving from no ties between the alters (density of 0%) to all ties existing between the alters (density of 100%), while they decreased by 1.3 (95% CI: 1.0–1.6) for friends, and by 1.1 (95% CI: 0.7–1.6) for non-friend alters (Table A2).

2.4. Do Women with Kin-Heavy Networks Feel More Pressure to Have Children?

In order to assess whether kin and non-kin differed in the kinds of information they passed to respondents, we investigated the extent to which respondents reported feeling pressure from their parents (or caretakers) and the pressure they felt from friends to have children (on a 7-point scale; ranging from strongly disagree to strongly agree). Excluding women that responded with “I don’t know” (N = 92 for pressure from parents and N = 162 for pressure from friends) and “not applicable” (N = 38 for pressure from parents), respondents reported slightly higher levels of pressure to reproduce from parents (mean = 4.21; SD = 2.19; N = 576) than from friends (mean = 3.97; SD = 2.12; N = 544;

t-test: t(1118) = 1.92; $p = 0.056$; $d = 0.11$; paired *t*-test: mean difference = 0.14; $t(510) = 3.00$; $p = 0.0028$; $d = 0.13$) (Figure 6). About half (53%) of respondents felt at least some pressure to reproduce from parents—defined as those responding with "somewhat agree", "agree", and "strongly agree"—whereas the rest (47%) did not (i.e., those responding with "neither agree/disagree" up to "strongly disagree"). Slightly less than half of respondents (46%) felt at least some pressure from friends.

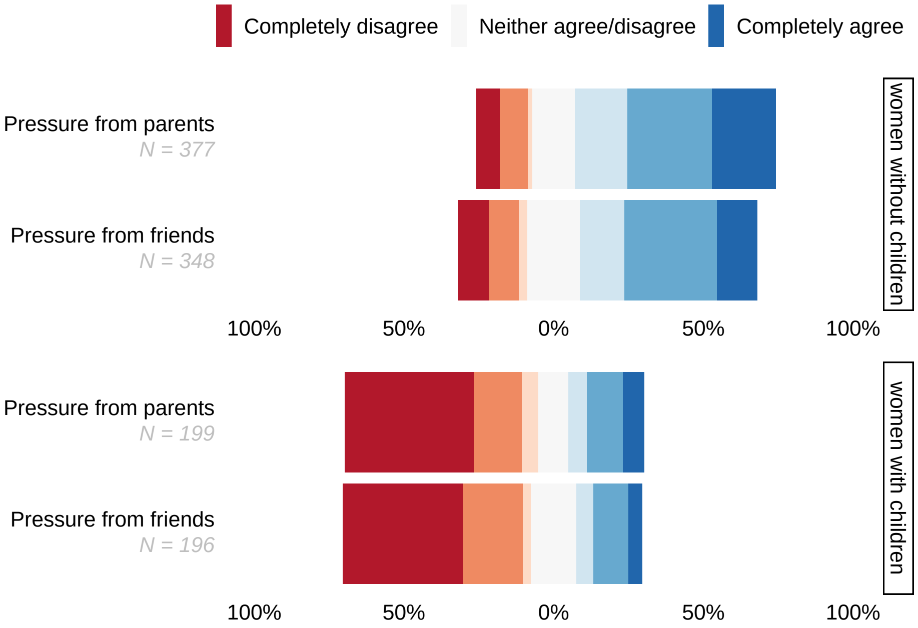

Figure 6. Do you feel pressure to have (more) children from parents and friends? Each stacked bar chart is of equivalent width, covering all responses, and centered on the response "neither agree/disagree". Responses "I don't know" and "not applicable" were excluded from the counts.

Perceived pressure was very different for women with and without children (Figure 6). Among those with children, only 25% felt some pressure to reproduce from parents and only 22% reported pressure from friends, whereas this increased to 67% and 59% among those women without children. Moreover, the most frequent response among those with children was "completely disagree", whereas for women without children it was "agree". The overall pattern of responses to pressure from parents and friends was very similar within women with children and within women without children (Figure 6). This resemblance is also apparent from the strong correlation between the pressure felt from friends and from parents ($r = 0.88$; $N = 511$).

Neither the number of kin nor the density among kin had a substantive impact on the degree of pro-natal pressure that women reported (Figure 7; Table A3). The strongest effect was observed for the number of kin, but the effect was negligible (and the 95% confidence interval included zero): more than 20 extra kin were predicted to be required to move the scale up by one point up (e.g., from somewhat agree to agree). Adding the number of kin to the model increased the explained variance by 0.5% in perceived pressure from parents, whereas kin-density increased this by 0.001%. Density among friends had a negative effect on perceived pressure from friends, but again, the effect was negligible (again, the 95% confidence interval included zero): moving from no ties between friends (density of 0%) to all friends being connected (density of 100%) decreased the perceived pressure on average by about half a point. Adding density to the model increased the explained variance by 0.4% in perceived pressure from friends, whereas the number of friends increased this by 0.002%.

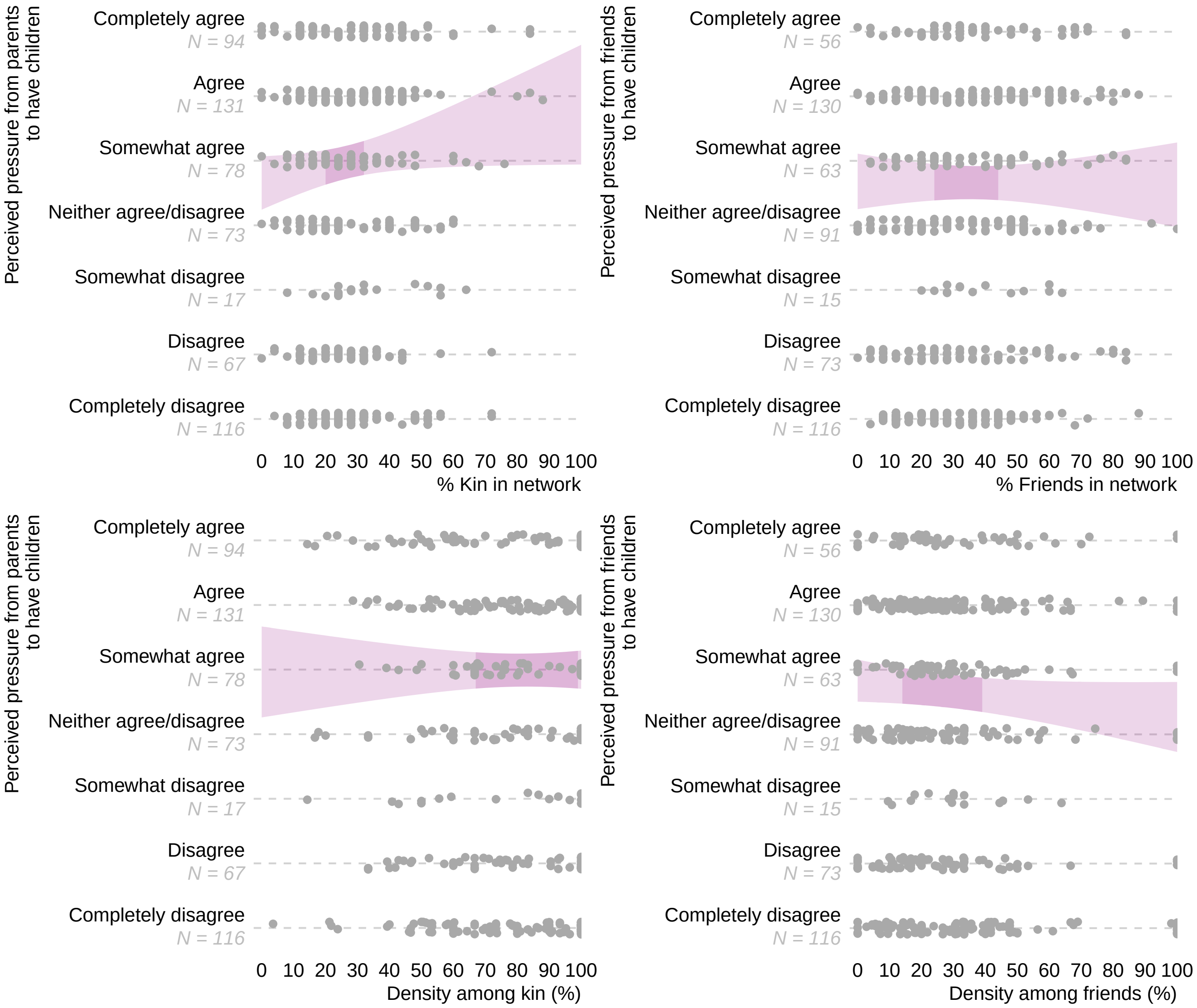

Figure 7. (**a**) The association between network composition (percentage of kin) (top) and density among kin (bottom) and the pressure felt to have children by parents. (**b**) The association between network composition (percentage of friends) (top) and density among friends and the pressure felt to have children by friends. The shaded band is the 95% confidence interval around predictions from linear regressions (see Table A3). Darker shades represent middle 50% of data. Models were evaluated for 29 year-old women with a partner and without children, and for average composition or density.

3. Discussion

Overall, we did not find strong support for the idea that kin and non-kin differ in the level of pro-natal information they impart and the degree of social pressure they exert. Although women, on average, experienced slightly more pressure from parents than from friends, the similarity in response was more striking than the differences. There were, however, stark differences in perceived pressure from both family and friends for women with and without children, with the latter reporting higher levels of pressure. This is no doubt to be expected: the decision to have any children at all is likely to be seen as more consequential from the point of view of parents, and so most pressure may be felt at this point in the life course. We found a negligible influence of overall network composition (proportion of kin and friends in the network) and structure (kin-density and friend-density) on the extent to which respondents reported experiencing social pressure. When we considered respondents themselves seeking advice on having children, we found that women reported that they could talk about having children with their friends to a greater extent than either their consanguineal or affinal kin. In this case, there was an effect of network density: for both kin categories, denser networks meant that women could talk more to their kin about having children compared to those with sparser networks. This was not the case for friends, where more ties between friends reduced the probability of talking to friends about children.

One limitation of our study is that we asked only about pressure from parents, rather than from all categories of kin. Thus, we did not capture how other categories of kin may reinforce pro-natal pressure received from parents—it may be that pro-natal social influence is a form of complex contagion (e.g., Hodas and Lerman 2014), and asking about parents alone fails to pick up on this. However, our findings showed a positive (if weak) relationship between density and the number of kin and a negative relationship with the number of non-kin. This implies that kin-dense networks should show more social conformity and relay more similar information than the more diffuse networks associated with larger numbers of non-kin, but we found no evidence that this was the case.

It could also be true that the norms transmitted and sustained within kin networks relate to the support and encouragement of any expressed desire to reproduce on the part of respondents, or a general emphasis on the happiness and fulfilment that children bring, rather than exerting a pressure to have children per se; the particular phrasing of our question cannot distinguish between different kinds of pro-natal sentiment, plus the word "pressure" may have been interpreted in wholly negative terms. The idea that density among kin increased women's perceptions that kin could help with child-care and that they could talk to kin about having children gives some support to this idea. Overall, then, we cannot rule out the possibility that a more fine-grained analysis would identify kin-based teaching biases, but our current analyses offer no consistent evidence that, in this sample at least, kin and non-kin differ in the kinds of information they are likely to pass on and circulate within networks. We should also note that Newson et al.'s (2005) hypothesis focuses on the origins of low fertility norms, which are potentially distinct from the processes that maintain such norms in the population once established.

More generally, our data show that, even in a low-fertility population like the Netherlands, personal networks contain a substantial number of kin: on average, seven consanguineal kin are reported plus an additional 2.5 affinal kin. This means that some 40% of people's self-reported personal networks can be considered kin. This reinforces the idea that, while the size of (extended) kin networks may have diminished (Murphy 2011), kin nevertheless remain important social contacts in contemporary populations (e.g., Marsden 1987; Höllinger and Haller 1990; Allan 2008). Again, it is worth noting that our findings come from much larger personal networks than is often the case. This is important because structural and compositional aspects of networks are only reliably estimated with a large number of alters (>15–20; McCarty et al. 2007a, 2007b; Stadel and Stulp 2021). With 25 alters, we can thus be fairly confident that we have reliable estimates of the density and the composition of the networks, and that we are tapping into weak links, meaning that people are not simply calling to mind the most readily available members of their network. Of course, 25 alters remains a low number compared to people's total social network size, and our estimates of density are thus confined to respondents' personal networks and will not hold for entire sociocentric networks.

These findings raise the further question of whether this level of kin representation would be sufficient to resist the influence of new norms being introduced into the network by non-kin and weak ties, and whether it would be sufficient to provide the level of support needed to act as an incentive for women to reproduce rather than postpone birth (or produce a smaller family size than they desire). With respect to the first issue, our answer is only speculative, but we consider this unlikely, given our finding that women talk to their friends about having children much more than their kin; if kin are not sought out for their advice, then their ability to influence decisions will be reduced, no matter how well they are represented (although, as noted above, density may need to be factored in here). With respect to the latter question, consanguineal kin and affinal kin were equally likely to contribute to child-care if needed, and did so at a higher level than non-kin friends and non-friends, which corroborates the idea that networks with many kin are able to ease the burden of child-rearing in ways that might open up opportunities for further reproduction (Turke 1989). The fact that women also reported a substantial likelihood of asking friends for help with child-care means that kin-based help is likely to be augmented by that from friends, and confirms that human reproduction should be considered to be biocultural (Bogin et al. 2012), where affinal kin and non-kin are important for raising children, in addition to biological kin.

One surprising finding was that women reported that they could ask for support from their consanguineal and affinal kin to a much greater extent than they could talk to them about having children. Compared to both categories of kin, friends were somewhat less likely to be asked for help, but they were spoken to about children to a greater extent. This suggests that there are certain social expectations around kin-based help with child-care, which makes it easy to request such help from a large proportion of kin, but that conversations about having children may be limited to network members with whom one shares a close relationship. This is supported to some degree by our findings on network composition: as the number of consanguineal and affinal kin in the network increased, women reported being less likely to ask for help and to talk about children, which suggests that we are perhaps capturing more distantly related kin, who are less approachable for help. Overall, these findings are in line with the notion that kin can be asked for more practical support, while people turn to friends for emotional support (e.g., Allan 2008; Voorpostel and Lippe 2007).

Modernization has dramatically changed personal networks, and people in contemporary populations experience greater freedom in their choice of interaction partners. Friends have taken a prominent role in people's social environment, but this does not mean that kin have lost their importance. The strong reciprocity that is considered important for (maintaining) friendships, does not hold to the same extent for family relations. Novel information and norms may spread more freely in a world with fewer kin, but help with raising children—a service that is not easily reciprocated—seemingly continues to fall predominantly on kin.

4. Materials and Methods

4.1. Participants

Here, we make use of data from the LISS (Longitudinal Internet Studies for the Social sciences) panel administered by CentERdata (Tilburg University, The Netherlands). This is a representative sample of Dutch individuals who participate in monthly Internet surveys. The panel is based on a true probability sample of households drawn from the population register by Statistics Netherlands (CBS). Households that could not otherwise participate are provided with a computer and Internet connection. Only households in which at least one household member spoke Dutch are included. A longitudinal study consisting of 10 core surveys are fielded in the panel every year, covering a large variety of topics. The representativeness of the LISS-panel is similar to those from traditional surveys based on probability sampling (Knoef and de Vos 2009; Scherpenzeel and Bethlehem 2011). Initial selection biases were substantially corrected by refreshment samples, and further refreshment samples were planned for attrition biases (Scherpenzeel 2011). The LISS-panel has information on over 10,000 individuals.

4.2. Social Networks and Fertility Survey

The LISS-panel allows researchers to do their own survey within the panel. We added a study named the Social Networks and Fertility survey (for further details see Stulp 2021; Buijs and Stulp 2019). This research involves investigating social influences on fertility desires and outcomes (i.e., how many children people have or would like to have). All women in the LISS panel between the ages of 18 and 40 (*N* = 1332) were invited to participate in this survey between 20 February and 27 March 2018. Due to constraints on our budget for renumerating respondents and concerns about statistical power, we focused on women only, rather than collecting data on smaller samples for both men and women. In total, 758 women completed the survey with a mean age of 29.2 (SD = 6.5). Respondents were similar to non-respondents based on a comparison of a range of measures that are collected for all respondents and are continuously updated including birth year, position in household, number of children, marital status, region of living, income, educational level, and (migration) background (Stulp 2021).

For this study, we only selected respondents that listed 25 alters. We excluded respondents that gave problematic responses to alter relationship questions, who did the survey on their phone (against explicit instructions), that had more than 10 missing values, and the one respondent that reported no alter-alter-ties (see Stulp 2021). This led to a final sample of 706 respondents.

Ethical approval for this particular study was obtained through the ethical committee of sociology at the University of Groningen (ECS-170920). For information on the ethical approval on the LISS-panel as a whole, see https://www.lissdata.nl/faq-page#n5512 (accessed on 17 May 2021). The survey was in Dutch. For the full survey in Dutch, an English translation of the questionnaire, further description of the survey, and code to clean and correct the LISS survey data, please visit: https://doi.org/10.34894/EZCDOA (accessed on 17 May 2021). R-code to produce the results in the current manuscript can be found here: https://doi.org/10.34894/DTCZWA (accessed on 17 May 2021). Data will become available on https://www.lissdata.nl (accessed on 17 May 2021).

4.3. Procedure

Respondents were invited to participate in a study on "social networks and fertility" and instructed that the survey would probably take around 25–30 min and that they would receive €12.50 for completing the survey. The first block of questions was about the fertility intentions and desires of the respondents and their partners if they had one.

The second part of the questionnaire involved generating 25 names. Respondents were asked: "Please list 25 names of individuals 18 years or older with whom you have had contact in the last year. This can be face-to-face contact, but also contact via phone, Internet, or email. You know these people and these people also know you by your name or face (think of friends, family, acquaintances, etcetera). You could reach out to these people if you would have to. Please name your partner in case you have one. The names do not have to match perfectly; you can also use nicknames. It is important that you would recognize these names in a future survey. For this research, it is important that you actually name 25 individuals!". This phrasing was based on the studies by McCarty and colleagues (McCarty et al. 2007a, 2007b). When a respondent proceeded with the questionnaire without listing 25 names, a pop-up screen appeared, reminding respondents that listing 25 alters was important for this study, and that if they had difficulties coming up with names, they could use a contact list. They were also informed that if they still wanted to continue without listing 25 names, that this was also possible. The choice to ask respondents to list exactly 25 names, rather than allowing respondents to freely name as many network members as they liked, was deliberate: allowing respondents a free choice of how many alters to report could lead to variation in network size that reflects motivation to complete the questionnaire and/or differences in how the question was interpreted. Some respondents may have found listing 25 alters hard, others may have found it easy, and this will be reflected in the characteristics of the alters. It is this latter kind of variation that is of interest to network researchers (McCarty et al. 2019). We chose 25 alters because people can easily do so (McCarty 2002; McCarty and Govindaramanujam 2005), because this size of the network is large enough to consist of weak(er) ties, and because networks smaller than 25 individuals reduce the reliability of estimates of the composition and structure of the network (McCarty et al. 2007b; Stadel and Stulp 2021). In total, 738 respondents (97%) listed exactly 25 alters, and 632 of those (90%) came up with the names from memory (Stulp 2021).

Subsequently, 16 alter characteristics were asked about (see Stulp 2021). Here we only list those relevant for this study: (i) type of relationship, with the choice of partner, parent, siblings, other relative, relative of partner, acquaintance/friend of partner, from primary school, from high school, from college/university, from work, from a social activity, through a mutual acquaintance/friend, from the neighborhood, and other. These categories were reduced to kin, affinal kin, and non-kin; (ii) whether the alter was considered a friend; (iii) which of these individuals could the respondent ask for help with the care of the child; and (iv) with whom of these individuals did the respondent discuss having children. Nineteen alters were not given a relationship and we assumed these to be non-kin.

The final question about the alters concerned ties between alters. The following question was asked: "With whom does the alter have contact? With contact, we meant all forms of contact including face-to-face contact, contact via (mobile) phone, letters, emails, texts, and other forms of online and offline communication".

The survey ended with some additional questions among which two were about the pressure felt to have children. Respondents were asked to state their agreement with the statement "Most of my friends think that I should have (more) children" (scale from completely agree (1) to completely disagree (7) and a "I don't know" option). They were then asked the same but for parents/caretakers (similar answer options except the possibility "Not applicable" was also added).

4.4. Data Analysis

In all our models, we control for respondent age (centered on 29), whether the respondent has a partner, and whether the respondent has children, all of which are important predictors for network composition and structure, and fertility behavior. For analyses where the dependent variable is a characteristic of the alter (e.g., can talk to this alter about having children, or can ask this alter for help with child-care), we presented results from binomial mixed models to accommodate the nested structure of the data (alters nested in ego; van Duijn et al. 1999). We performed linear regressions in the case of the pressure felt to reproduce from parents and friends. To examine the effects of composition and density on the probability of talking to alters about having children or being able to ask them for help with child-care, we used binomial models.

We used R (R Core Team 2018) for cleaning, transforming, analyzing, and visualizing all data and to write the manuscript. We made use of the following R-packages: ggplot2 (Wickham 2016), tidyverse (Wickham 2017), patchwork (Pedersen 2017), ggtext (Wilke 2020), rmarkdown (Xie et al. 2018), broom (Robinson et al. 2021), and kableExtra (Zhu 2019). We report on how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the study.

Author Contributions: Conceptualization, G.S. and L.B.; Methodology, G.S.; Data curation, G.S.; Writing—original draft preparation, G.S. and L.B.; Writing—review and editing, G.S. and L.B.; Visualization, G.S. and L.B.; Project administration, G.S.; Funding acquisition, G.S. All authors have read and agreed to the published version of the manuscript.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data will become available on https://www.lissdata.nl/ (accessed on 17 May 2021). Researchers wanting access to data need to submit a statement through https://www.lissdata.nl/access-data (accessed on 17 May 2021).

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Appendix A

Table A1. Binomial mixed model parameter estimates (95% CI) for the effect of type of alter on whether alter can help with child-care or can be talked to about having children while controlling for age, partnership status, and parenthood.

Estimate	Can Help with Child-Care	Can Talk to about Children
Intercept	−3.069 (−3.298; −2.839)	−3.126 (−3.386; −2.865)
Age	−0.024 (−0.043; −0.005)	0.018 (−0.004; 0.041)
Has partner	−0.055 (−0.284; 0.175)	0.139 (−0.138; 0.416)
Has child	−0.091 (−0.353; 0.172)	−0.102 (−0.417; 0.212)
Friend	2.321 (2.177; 2.465)	2.517 (2.377; 2.656)
Affinal kin	3.601 (3.423; 3.779)	2.447 (2.275; 2.618)
Consanguineal kin	3.495 (3.343; 3.646)	1.786 (1.644; 1.929)
SD random intercept	1.180	1.443

Age was centered around 29; women without partners or children were the reference category. Alters (*N* = 17,650) are nested within respondents (*N* = 706).

Table A2. Binomial regression estimates (95% confidence interval) for the effect of density on whether alters can help with child-care or can be talked to about having children while controlling for age, partnership status, and parenthood.

Outcome	Estimate	Consanguineal Kin	Affinal Kin	Friends	Non-Friends
Can help with child-care	Intercept	−0.415 (−0.739; −0.090)	−1.441 (−2.567; −0.315)	−0.723 (−0.914; −0.531)	−1.676 (−2.076; −1.276)
	Age	−0.034 (−0.046; −0.023)	−0.065 (−0.088; −0.042)	0.005 (−0.006; 0.016)	0.039 (0.017; 0.061)
	Has partner	0.067 (−0.074; 0.209)	0.050 (−0.964; 1.065)	−0.201 (−0.321; −0.081)	−0.273 (−0.549; 0.002)
	Has child	−0.107 (−0.268; 0.053)	−0.112 (−0.373; 0.149)	−0.043 (−0.199; 0.113)	0.231 (−0.063; 0.525)
	Composition	−0.084 (−0.100; −0.068)	−0.053 (−0.090; −0.015)	0.015 (0.003; 0.026)	−0.098 (−0.127; −0.069)
	Density	1.721 (1.439; 2.004)	2.372 (1.823; 2.922)	0.672 (0.411; 0.933)	0.061 (−0.365; 0.488)
Can talk to about having children	Intercept	−1.218 (−1.599; −0.836)	−2.028 (−3.393; −0.663)	−0.238 (−0.426; −0.050)	−2.259 (−2.62; −1.898)
	Age	0.001 (−0.012; 0.014)	−0.011 (−0.034; 0.012)	0.026 (0.015; 0.037)	0.023 (0.004; 0.042)
	Has partner	0.163 (0.004; 0.323)	0.988 (−0.281; 2.256)	−0.065 (−0.184; 0.055)	0.119 (−0.121; 0.360)
	Has child	0.014 (−0.165; 0.193)	−0.120 (−0.388; 0.147)	0.104 (−0.047; 0.255)	0.054 (−0.201; 0.308)
	Composition	−0.096 (−0.116; −0.077)	−0.059 (−0.098; −0.020)	−0.001 (−0.013; 0.011)	−0.016 (−0.040; 0.008)
	Density	1.101 (0.771; 1.431)	0.937 (0.390; 1.484)	−0.240 (−0.500; 0.020)	−0.078 (−0.469; 0.314)
	# respondents	676	339	668	606
	# in group	4891	1624	5961	4915
	# help	2649	899	2232	329
	# talk	1276	561	2454	445

Age was centered around 29; women without partners or children were the reference category. Composition refers to the number of alters in the network for that particular group (e.g., affinal kin). Density refers to the density among the particular group. The number of respondents vary, because density can only be calculated when respondents list at least two alters of that particular group. “# in group” refers to the number of alters in that group, “# help” refers to how many alters in that group can help with child-care, and “# talk” refers to how many alters in that group can be talked to about having children.

Table A3. Linear regression parameter estimates (95% CI) for the number of kin/friends and density among alters on the pressure felt to reproduce by parents and friends while controlling for age, partnership status, and parenthood.

Estimate	Pressure from Parents	Pressure from Friends
Intercept	4.044 (3.100; 4.989)	4.266 (3.677; 4.854)
Age	−0.045 (−0.076; −0.013)	−0.064 (−0.096; −0.031)
Has partner	0.581 (0.190; 0.973)	0.583 (0.175; 0.991)
Has child	−1.948 (−2.386; −1.511)	−1.546 (−1.991; −1.102)
Composition	0.049 (0.000; 0.097)	−0.002 (−0.040; 0.036)
Density	0.036 (−0.769; 0.840)	−0.562 (−1.237; 0.113)
N	557	521
R^2	24	22

Age was centered around 29; women without partners or children were the reference category. “Composition” and “Density” refer to number of kin and density among kin in the model on pressure felt from parents and the number of friends and density among friends in the model on pressure felt from friends. Analysis samples include respondents with minimally two kin or friends in their networks.

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Kin Ties and Market Integration in a Yucatec Mayan Village

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Abstract: The importance of kin relationships varies with socioecological demands. Among subsistence agriculturalists, people commonly manage fluctuations in food availability by relying on family members to share resources and pool labor. However, the process of market integration may disrupt these support networks, which may begin to carry costs or liabilities in novel market environments. The current study aims to address (1) how kin are distributed in household support networks (2) how kin support varies as households become more engaged in market activities, and (3) how variation in kin support is associated with income disparities within a Yucatec Maya community undergoing rapid market integration. Using long-term census data combined with social networks and detailed household economic data, we find that household support networks are primarily composed of related households. Second, households engaged predominantly in wage labor rely less on kin support than agricultural or mixed economy households. Finally, kin support is associated with lower household net income and income per capita. Understanding how kin support systems shift over the course of market integration and in the face of new opportunities for social and economic production provides a unique window into the social and economic drivers of human family formation.

Keywords: behavioral ecology; family; support networks; market integration; Maya

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1. Introduction

Behavioral ecology approaches to the study of the human family often focus on how the costs and benefits of kin support are shaped by the demands of subsistence and economic production. A fundamental approach to Human Behavioral Ecology (HBE) starts with a question of how social and ecological conditions determine the costs and benefits of different behavioral alternatives. Recent reviews of contemporary HBE work have identified a clear focus on resource sharing and differences in kin vs. non-kin interactions (Nettle et al. 2013). HBE studies of the family have recently used network approaches to understand how kin relationships are structured and maintained over the life course and their role in shaping divisions of labor and reproduction (Scelza and Bird 2008), the diversity and variation of kin and non-kin cooperation (Kasper and Mulder 2015; Hooper et al. 2013) and intergenerational transfers of resources (Hooper et al. 2015).

While many key features of human social structure are consistent across culture and ecology (Hamilton et al. 2007; Hill and Dunbar 2003), economic development appears to stimulate flux in the composition and structure of social networks. Populations recently exposed to market integration are argued to have less dense kin-networks, and more frequent interactions with unrelated strangers (Newson and Richerson 2009; Colleran 2020). Many prominent theories of economic development posit that changes in social networks are a primary driver of the sweeping transformations that accompany modernization, particularly as market and government institutions take on functional roles once held by kin relationships (Notestein 1945; Handwerker 1986; Inkels and Smith 1974; Gurven et al. 2015). Scholars have argued that these shifts in social networks away from heavy reliance on kin shift fertility dynamics (Newson and Richerson 2009), social norms (Santos et al. 2017), prosocial behaviors (Henrich et al. 2005), and even the pace of economic development (Eagle et al. 2010). Additionally, network relationships are important determinants of health outcomes in both pre-industrial and post-industrial contexts (Smith and Christakis 2008; Kramer 2010).

The decline in kin in social support networks has significant implications for how resources flow between individuals and families in populations. Traditional sharing and exchange networks including both kin and non-kin are strategies to minimize the risks associated with subsistence production (Dyble et al. 2016; Kaplan et al. 2012; Kramer 2018). However, exposure to markets and wage labor presents new options to manage risk besides reliance on social support networks. Cash, formal financial institutions, credit, and government subsidies and programs provide alternative means to access, store, and build resources. However, availability, efficiency, and familiarity with these new alternatives may limit how easily they replace informal kin and non-kin support relationships. Indeed, both HBE and economic explanations of how market integration alter social networks often emphasize either the costs of maintaining dense traditional networks composed primarily of kin (di Falco and Bulte 2011; Jaeggi et al. 2016; Gurven et al. 2015) or the social, economic, and informational benefits to adopting wider, more diverse relationships with a greater proportion of non-kin (Lin 2017; Burt 2017; Granovetter 1973; Derex and Boyd 2016).

Here, we aim to address (1) how kin are distributed in household support networks in a community undergoing rapid economic development and market integration, (2) how the role of kin in support networks vary as households become more engaged in market activities, and (3) how variation in kin support networks are associated with increasing wealth disparities within a Yucatec Maya community undergoing rapid market integration.

2. Background

2.1. Socioecological Changes Associated with Market Integration

Market integration is associated with a host of socioecological changes that have long been studied in the social sciences. Market integration studies (often also referred to as modernization and industrialization) have identified cascading effects of market involvements on subsistence and indigenous communities (Godoy 2001), health and well-being outcomes (Godoy et al. 2005a; Urlacher et al. 2016), changes in ecological knowledge (Godoy et al. 2005b, 2016), and increasing prosocial behaviors (Gurven et al. 2015; Henrich et al. 2005).

Primarily, market integration is associated with a key shift in household production, as new economic opportunities emerge alongside traditional subsistence practices. In these contexts, households face trade-offs in pursuing new social and economic opportunities, or maintaining traditional economic production. Mixed economies arise when households and communities are engaged in both the cash economy and subsistence production and maintain traditional sharing and cooperative relationships (Burnsilver and Magdanz 2019; Ready and Power 2018) as well as pursue new institutional and social relationships. This context creates unique trade-offs that households must navigate as they balance traditional economic and social behaviors with novel and often uncertain market opportunities (Kramer et al. 2021).

In communities where market opportunities are centered on cash cropping, a commitment to wage labor reflects a striking divergence from traditional household economics. Indeed, anthropologists have argued that the commitment to competitive wage-labor jobs is precisely what drives the cascading suite of changes associated with market integration (Handwerker 1986; Shenk 2005). The reliance on cash and cultivating new skill sets give rise to new time allocation and parental investment trade-offs, promoting a dramatic shift in household behavior (Colleran et al. 2015). Additionally, as networks expand and become composed of ties to diverse types of groups and individuals, households benefit in competitive wage-labor contexts by increasing exposure to novel information and contacts that can be leveraged into employment opportunities (Granovetter 1983; Burt 2017). Households with these types of outward looking networks may be more inclined to enter wage-labor employment and forgo traditional economic production. However, for households that double down on agricultural production as the means to generate cash and participate in the market economy, local and kin-based sharing networks may better serve to offset fluctuations in agricultural returns.

2.2. Costs and Benefits of Kin Support Networks in Mixed Economies

Support networks have well-documented effects on individual and household economic wellbeing (Szreter and Woolcock 2004; Poortinga 2006), particularly in subsistence economies where kin support is often associated with benefits for fertility, food security, and health outcomes (Gibson and Mace 2005; Hadley et al. 2007; Harder and Wenzel 2012; Hadley 2004). Furthermore, there is increasing evidence that kin support networks provide benefits in mixed economies (Burnsilver et al. 2016; Ready and Power 2018; Eakin 2005). However, the effects of kin support on economic outcomes may be strongly conditioned by the types of economic production a household engages in. For example, for households committed primarily to agricultural production, dense, homogenous, and kin-based networks may prove beneficial by reinforcing norms of sharing, reciprocity, and resource pooling (Portes 1998). Alternatively, households with few kin support ties, or more diffuse networks may struggle to mobilize labor and resources needed for peak times of agricultural production.

By contrast, these same network structures can become a liability when households branch out from agricultural production. For example, dense, kin-based networks may be a disadvantage in wage-labor households because of the costs imposed by obligations (Hoff and Sen 2006; di Falco and Bulte 2011). Economists have suggested kin systems play a role in poverty trap dynamics, where strong kin-based networks limit the incentives or opportunities for moving into the market sector. The mechanisms of informal mutual assistance that characterizes kin support networks can increase the costs to individuals and households moving into the wage-labor economy through increased demands by less successful kin members. These demands include monetary support, finding jobs, housing arrangements, transportation, and other time commitments that limit the ability to concentrate resources necessary for upward social mobility.

Additionally, kin dense networks can limit access to novel information about wage labor or market opportunities. More diffuse, heterogenous networks have been shown to provide advantages in wage-labor contexts through accessing and controlling the spread of novel information between disconnected clusters in the group (Newson and Richerson 2009; Burt 2017). Wage-labor households may benefit from cultivating unrelated, diverse and diffuse networks that foster novel information flow from diverse connections, or may help households realize returns to investments in education by accessing better-paying employment opportunities (Granovetter 1983; Matthews et al. 2009; Coleman 1988). Thus, the effects of kin support networks may hinge upon the economic activities of a household.

2.3. The Current Study

Here, we aim to address how kin support varies across households pursuing different economic strategies in a community undergoing rapid market integration. The Maya study population is located in a remote area of the Puuc region in the interior of the Yucatan Peninsula, Campeche, Mexico. The indigenous Yucatec Maya who inhabit this rural area live in small villages of subsistence maize farmers and in a few market and administrative towns. While not isolated, these Maya live in a dispersed and underpopulated region that is ethnically, socially and economically homogeneous.

In the early 1990s, all residents (n = 55 households, 316 individuals) made a living as small-scale agriculturists, the household was the unit of production, and each family grew and hunted for its food. As in many subsistence agricultural societies, high fertility is associated with large families that pool labor (Lee and Kramer 2002; Kramer 2005). Residents (n = 55 households, 316 individuals) lived primarily in households composed of nuclear families (82%). Other households included widowed or elderly parents or unmarried siblings. Without access to roads, vehicles, or mechanical farming equipment, there was little incentive to grow surplus crops or means to sell them at regional markets.

In this context of nuclear and multigenerational families, the household was the unit of production across which resources were pooled (Kramer 2002; Kramer 2005). These cooperative groups are readily identified by the Maya and are described as those who live, eat and work together. The composition of these households fluctuates with time, as children are born, mature and marry, and have children of their own (Lee and Kramer 2002). When young people marry, they often live temporarily with the husband's natal family as they work to clear sufficient land and accumulate resources to build their own house. Establishing an independent household may take up to 10 years. In some cases, husbands relocate to their wives' natal households. The majority of marriages are exogamous, occurring between community members, with ~10% of men and women marrying outside of the community.

Pooling resources and labor at the household level was essential for family survival. Older children contributed substantially to domestic and agricultural labor, as well as subsidizing the childcare costs of younger siblings (Kramer 2005; Kramer 2002, 2011). This traditional household organization, and the relationship between family size, labor and wealth, generate a context where labor allocation and economic production are seen as the result of household-level decision-making processes, rather than individual ones (Jessoe et al. 2018).

Rapid economic development began in the early 2000s when a paved road was built that facilitated access to new farming methods, the transportation of crops to market, children to schools and people to wage labor jobs. These changes expanded the ways in which households make their living. New subsistence options include mechanized farming, craft production, cash cropping, cultivating nut and seed crops for sale, and wage labor. Cash is now critical to pay for seed, fertilizer, pesticides and vehicles to transport crops to market, school fees, and to access market goods, and can be generated either through crop sales or wage labor. Many young adults work in unskilled part-time agricultural labor in neighboring communities or in a maquiladora several hours away. A few individuals work skilled jobs in larger towns, returning nightly or weekly. The community is transitioning from being unstratified to some families having a priority interest in access to land and other resources. The community is also undergoing changes in family formation, with both a decline in fertility and family size over the last 30 years, alongside an increase in uptake of tubal ligations at younger ages and lower parities (Kramer et al. 2021).

In sum, changes to farming practices, systems of land tenure, access to technology, cash, and wage labor have led to increasing economic and social variation. Additionally, the decline in fertility is shifting the demographic profile of the community. This growing diversity makes this an ideal case study to test how new economic opportunities shape kin-based support networks. We address three primary research questions. First, how are kin distributed in household support networks? Second, how does the role of kin in support networks vary as households become more engaged in market activities? And third, how does variation in kin support networks impact increasing wealth disparities within this community undergoing rapid market integration?

3. Methods

Data were collected from 97% of community households (n = 90) in 2017 using structured and semi-structured questionnaires regarding household composition, support networks, income and assets, and the primary economic activity of all members of the household. With the exception of individual-level relatedness and economic activities, data collection focused on the household level in order to capture whole networks and household economic status. Additionally, resource pooling occurs within the household, so economic variables such as income and material assets, such as vehicles, farm equipment, and consumer goods were collected at the household level.

3.1. Economic and Network Variables

Relatedness between households. Using census and reproductive history data collected in the community since 1992 we calculate the relatedness between all known individuals who have ever lived in the community (N = 710) using the kinship2 package in R (Sinnwell et al. 2014). The coefficient of r is used to express genetic relatedness between two individuals as a measure of the probability that the two individuals share the same allele variants. It is used to describe the degree of kinship between individuals, estimating the total proportion of genetic material shared through common ancestry. The average relatedness of all individuals included in the total census data was coef.r = 0.033. Considering the cross-sectional sample of individuals living in the community in 2017 (N = 544), average relatedness was coef.r = 0.036. The average level of kin depth, or generations per individual pedigree was 2.9 (sd = 1.5) (Table 1).

Table 1. Household-Level Variable Descriptives—Means (Std. Dev).

	Subsistence Agriculture	**Intensive Agriculture**	**Mixed**	**Wage Labor**
N Households	8	31	35	16
Household Characteristics				
Age of Male HH	31.4 (13.98)	50.18 (17.4)	42.74 (17.82)	38.62 (11.87)
Kin Ties	19.00 (9.4)	21.70 (6.9)	23.60 (10.4)	15.60 (5.72)
Helping Ties				
Total Support Ties	5.88 (1.73)	5.7 (2.84)	4.5 (1.74)	5.6 (2.92)
R5	3.75 (1.91)	3.37 (1.83)	3.43 (1.65)	2.47 (1.13)
R25	0.75 (0.89)	0.87 (1.04)	0.73 (1.01)	1.00 (1.00)
R125	0.25 (0.71)	0.40 (0.81)	0.17 (0.38)	1.00 (1.31)
R0625	0.25 (0.46)	0.13 (0.43)	0.03 (0.18)	0.60 (0.83)
R0	0.88 (0.99)	0.93 (1.68)	0.13 (0.35)	0.53 (0.92)
Economic Variables				
Net Income	15,950.75 (20578.82)	13,773.97 (26618.49)	61,685.87 (98,545.05)	74,697.87 (39,037.22)
Income Per Capita	2393.01 (3793.96)	2811.73 (5677.53)	8300.8 (10,508.09)	17,630.73 (9498.07)
Material Wealth	13,656.38 (11137.68)	32,289.45 (72909.21)	34,056.67 (82,482.91)	16,871.73 (8351.49)

Economic variables are reported in Pesos. Kin ties refers to the total number of relationships a household has to other households at the genetic relatedness of $r \geq 0.25$. HH refers to head of household.

Individual-level relatedness was then aggregated at the household level. *Max relatedness between household* is the maximum relatedness of any individual in household A to any individual in household B. Aggregating relatedness between households to the maximum relatedness of a given dyad in each household collapses nuanced distinctions that could be made within the data, primarily between patrilineal, matrilineal, and affinal kin. While these distinctions are undoubtedly important in many contexts (Lowes et al. 2020; Power and Ready 2019), these relationships may not be clearly distinguished at the household level. For example, if the female head of household identifies her brother in another household as a helper, for her it is a strong genetic tie, but for her husband the tie between households is affinal. We believe maximum relatedness provided the most parsimonious approach to testing our key hypothesis.

Household support networks. All male and female heads of household were asked network elicitation questions regarding support received and support given to the household, including targeted questions about whom the household would (1) borrow money (2) borrow items from, (3) ask for help in men's work, and (4) ask for help in women's work (Table S1 and Figure S1 for distributions). As questions were asked of household heads, in some rare cases, heads of household nominated another within the household (N = 93, ~16%). These within-household support ties were removed.

All support network questions were aggregated into a binary variable indicating if any member of one household nominated any member of another household, referred to here as support ties. This created a binary support network with all participating households within the community with a total of 437 support ties (Figure 1). From this household support network, summary measures were calculated to assess the overall support as well as the kin composition of the support networks. *Total support ties* are calculated as the degree of support ties, or the total number of households listed as giving any type of support to the ego household.

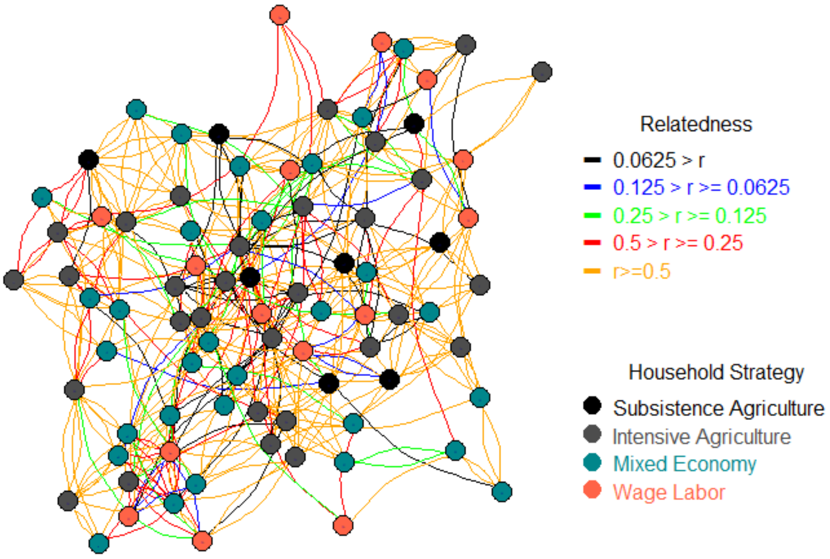

Figure 1. Household support networks showing the relatedness coefficient between households (lines), and household economic strategy (nodes).

Total close kin support ties are calculated as the total number of support ties that are composed of households that share a strong genetic kin relation (coef of $r \geq 0.25$). *Proportion of support ties composed of kin* is calculated as the proportion of the total support ties composed of households with a strong genetic relationship.

Household economic activities. Information collected in 2017 about how individuals spend their time revealed an expanding number of different types of economic activities, including agricultural production for subsistence or market, domestic work, craft industries, entrepreneurial activities, unskilled field wage labor and skilled wage labor. To estimate a households' level of market integration we focus on the economic activities of the adult members of the household. The primary economic activity of all adults was coded as a combination of agricultural worker, wage-laborer, domestic worker, piece-work, or student. Using this coding, alongside measures of household access to agricultural land, we developed a measure of market integration. A household's *Primary Economic Strategy* was coded as (i) subsistence agriculture if the amount of land cultivated is less than 3.0 ha (the minimum maize needed to sustain an average household of 8–10 individuals for a year); (ii) intensified agriculture if more than 3.0 ha are under cultivation; (iii) wage labor if the head-of-household works full-time for a salary; (iv) mixed strategy if the household maintains an agricultural base, but one or several household members (but not the head of household) is a full-time wage laborer. We include a sensitivity analysis of alternative measures of economic strategy (Tables S3 and S4) using the proportion of the adults in the household engaged in wage labor and the proportion of adults classified as agricultural workers.

Household economic status. Household economic status was measured using income and asset values (Figure 2). T*otal net household income* and *material wealth*. *Total net household income* was estimated using income from all sources, including wage labor, selling agricultural surplus, as well as including debts incurred from seed, pesticides, and non-agricultural expenses. For analyses, total net household income was centered and log-transformed. We also calculate *income per capita*, or the total net household income divided by the total number of adults age 15 or older in the household, to account for variation in household size. Lastly, *material wealth* is an asset-based measure of the total stocks of capital owned by a household. Material wealth was estimated using the sum of the total market value of all household assets, including furniture, household items, farm equipment, and vehicles. Three households were strong outliers in the value of their household assets (~10× the mean household asset wealth). For our primary analyses, we coded these as 60,000 p, or the next highest material wealth score in the distribution. Sensitivity analyses show no qualitative differences in the results of modeling material wealth (Table S5 and Figure S2).

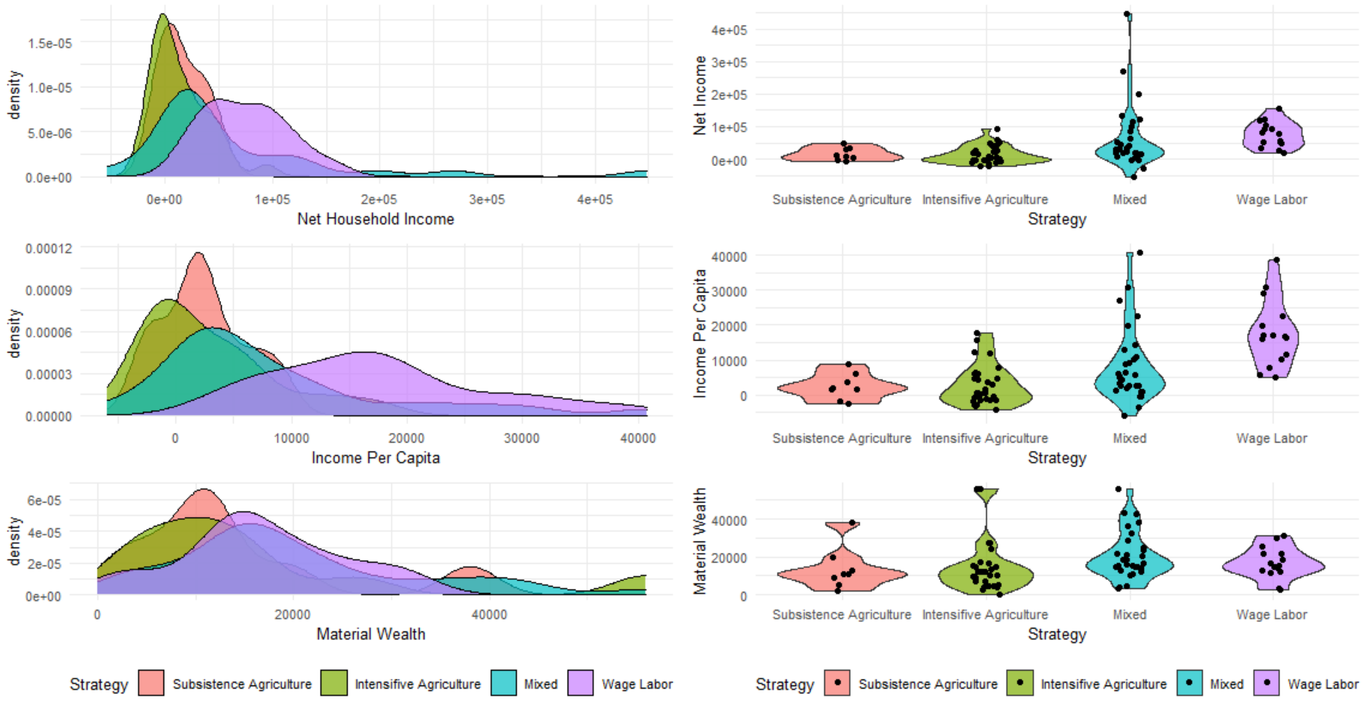

Figure 2. Distribution of household income and wealth variables by economic strategy.

3.2. Analyses

How kin are distributed in household support networks? To assess the amount of the total support network that is composed of kin, we first plot the frequency of different levels of between-household relatedness in the helping ties. We then employ a Social Relations Model (SRM) for binary outcomes using different levels of relatedness to predict the existence of a support tie between households. We further include a categorical variable for a household economic strategy to assess how the total number of support ties varies across households engaged in different types of economic activities.

The application of SRM models to network data in HBE has increased over the last decade, largely due to the interpretative advantages of decomposing directional node-level and relational-level effects, as well as accounting for both generalized and dyadic reciprocity (Koster and Leckie 2014; Koster et al. 2015). Node-level effects are the household characteristics, like household size and economic strategy, that capture variance in how often a household nominates others as helpers (Sender effects), and how often a household is nominated as a helper (Receiver effects). Relational effects are characteristics of dyads, such as the maximum relatedness between the two households, which capture variance in whether a tie exists between two households or not. Additionally, the SRM accounts for the correlations between giving and receiving, and within-dyad responses.

We fit the SRM using Markov chain Monte Carlo (MCMC) employing the amen package in R (Hoff 2018, 2015). Since the data are binary, we fit the model with a probit link function. We use a 1000-iteration burn-in with a distribution of 10,000 for the posterior parameter estimates. Model details and diagnostic plots are included in the supplemental materials (Figures S3–S5). We include three models in these analyses. First, we fit a model accounting for Relational effects, or the relatedness between households. We then include household characteristics as Sender effects, to assess how household economic strategy affects the household propensity for nominating helpers. Finally, we include household characteristics to assess both household likelihood of nominating helpers (Sender effects) and household propensity for being nominated as a helper (Receiver effects).

How does the number of kin in support networks vary as households become more engaged in market activities? To assess how the amount of kin in support networks varies as households engage in different economic strategies, we first compare the mean number of kin ties and the proportion of support ties composed of kin across different economic strategies. We use the non-parametric Kruskal–Wallis tests for global comparison, and the Dunn's test with a Bonferroni alpha correction to account for multiple tests.

We then use regression analyses to assess if a household's economic strategy predicts the total number of kin support and the proportion of helping ties composed of kin. For the total number of kin support ties, we use a Poisson regression model. However due to the under-dispersion of the count data (Figure S3), we use a Conway–Maxwell Poisson model, fit using the package COMPoisson in R (Sellers and Shmueli 2010). The Conway–Maxwell Poisson provides more accurate standard error estimates for under-dispersed Poisson count data (Shmueli et al. 2005).

To model the proportion of support ties composed of kin, we employ a zero-one-inflated beta model. While beta-regression models are commonly used for closed-interval, proportion data, one inflated model can account for the non-negligible amount of 1's present in our data (Figure S3) (Ospina and Ferrari 2010, 2012).

For both models, we include the categorical variable indicating household economic strategy. Both models control for the total number of helping ties. Because kin nominations by a household may be constrained by the availability of kin, we include a variable for the total number of strong kin ties ($r \geq 0.25$) in the community. To assess whether the effect of kin availability varies by economic strategy, we include an interaction term for economic strategy and the total number of kin ties in the community.

How variation in kin support networks are associated with increasing income disparities? To assess how kin support is associated with economic outcomes, we employ OLS regression with the total number of kin ties and proportion of kin in support networks predicting household income and asset-based wealth. We include household economic diversity and age of male head of household as control variables. To assess how the effects of kin support on income might vary across economic strategies, we test the interactions between household economic strategy and the total number of kin support ties and proportion of kin support ties in the regressions.

4. Results

How kin are distributed in household support networks? Support ties between households are composed primarily of households with at least one strong genetic tie (Figure 3). On average, households nominated six other households for support, with nearly two-thirds (65%) of nominations composed of households with at least one strong genetic relationship (Coef. $r \geq 0.5$). Additionally, regression estimates show strong relatedness significantly predicts a support tie between two households (Table 2).

The SRM models highlight the importance of relatedness between households, represented by the dyadic effects. Relatedness at the level of $r = 0.5$ and $r \geq 0.25$ positively predicts the existence of support ties in all models. Interestingly, low levels of relatedness between households, $r \geq 0.625$ to $r < 0.125$, held a negative association with helping ties. That is, households with very low levels of relatedness were less likely to share a helping tie compared to households that were completely unrelated.

Table 2. Social Relations Model Results.

	Dyad Only			**Dyad + Sender**			**Dyad + Sender + Receiver**		
	Coef	**Std Dev**	***p*-Value**	**Coef**	**Std Dev**	***p*-Value**	**Coef**	**Std Dev**	***p*-Value**
Intercept	−2.19	0.09	0.00	−2.09	0.14	0.00	−2.23	0.20	0.00
Relational Effects									
R5	**2.16**	**0.10**	**0.00**	**2.21**	**0.10**	**0.00**	**2.21**	**0.10**	**0.00**
R25	**0.59**	**0.11**	**0.00**	**0.61**	**0.10**	**0.00**	**0.61**	**0.11**	**0.00**
R125	0.04	0.12	0.72	0.03	0.11	0.79	0.04	0.11	0.71
R0625	**−0.24**	**0.14**	**0.08**	**−0.28**	**0.13**	**0.04**	−0.25	0.14	0.07
R0 *	-	-	-	-	-	-	-	-	-
Sender Effects									
Household Size				**−0.07**	**0.02**	**0.00**	**−0.06**	**0.02**	**0.01**
Wage Labor				**0.33**	**0.13**	**0.01**	**0.33**	**0.13**	**0.01**
Subsistence				0.23	0.15	0.13	0.24	0.15	0.12
Intensive				0.17	0.10	0.09	**0.19**	**0.10**	**0.06**
Mixed *				-	-	-	-	-	-
Receiver Effects									
Household Size							0.02	0.02	0.34
Wage Labor							−0.03	0.13	0.84
Subsistence							0.01	0.15	0.96
Intensive							0.09	0.09	0.32
Mixed *							-	-	-
Variance	Mean	Std Dev		Mean	Std Dev		Mean	Std Dev	
Sender Variance	0.08	0.02		0.07	0.02		0.06	0.02	
Sender-Receiver Covariance	0.00	0.01		0.01	0.01		0.01	0.01	
Receiver Variance	0.05	0.01		0.05	0.01		0.05	0.02	
Dyadic Correlation	0.67	0.04		0.68	0.04		0.67	0.05	

* Reference Category. Model diagnostic plots and descriptions are presented in the Supplemental Materials. Bold values indicate significant effects. Coefficents reflect the mean of the posterior estimates, and should be interpreted as probit model coefficients.

In the models that account for sender effects, the household economic strategy had significant effects on the existence of a helping tie. Compared to mixed-economy households, wage-labor and agricultural households had higher numbers of support ties, though the effects were only significant for wage-labor and intensive agricultural households (in the full models). Accounting for receiver effects showed that household economic strategy had no effect on the number of times a household was nominated as a helper. Additionally, household size had a negative sender effect, indicating that larger households were nominated fewer households than smaller households. However, household size had no significant receiver effects, indicating that larger households were not more likely to be nominated as helpers compared to smaller households.

How does the number of kin in support networks vary as households become more engaged in market activities? Non-Parametric mean comparison tests show significant differences in the proportion of kin ties across economic strategy (Figure 4). Dunn's pairwise tests show that mixed economy households have a significantly higher proportion of strongly related kin in support networks compared to wage-labor households (Figure 4, Table S2). While mixed economy households are less likely to have a support tie in general (Tables 1 and 2), but of the ties that exist, they are primarily composed of strongly related households. When controlling for the total number of ties, mixed economy households have both significantly higher numbers of kin support ties compared to wage-labor households, and significantly larger proportions of support ties composed of kin compared to wage-labor households (Table 3). There were no significant differences between mixed economy households and both types of agricultural households. Perhaps unsurprisingly; for both models, the total number of helping ties and the total number of kin ties in the community had positive effects on the number of kin support ties a household reported and the proportion of helping ties composed of kin. In the one-inflated beta regression, the total number of helping ties and the total number of kin ties had an effect on the probability of listing all kin in the support network, while economic strategy held no significant effects.

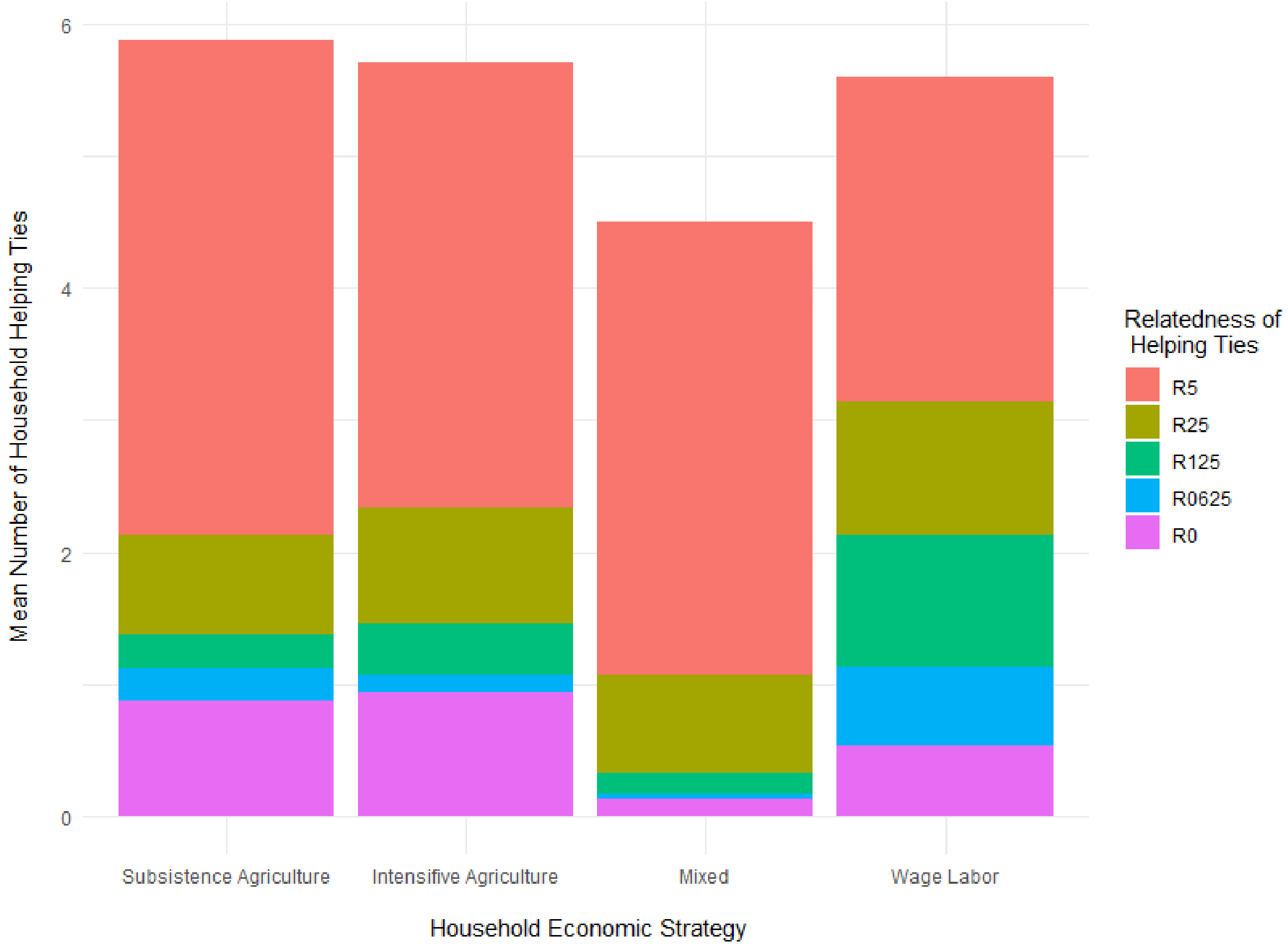

Figure 3. Kin composition of between household support ties.

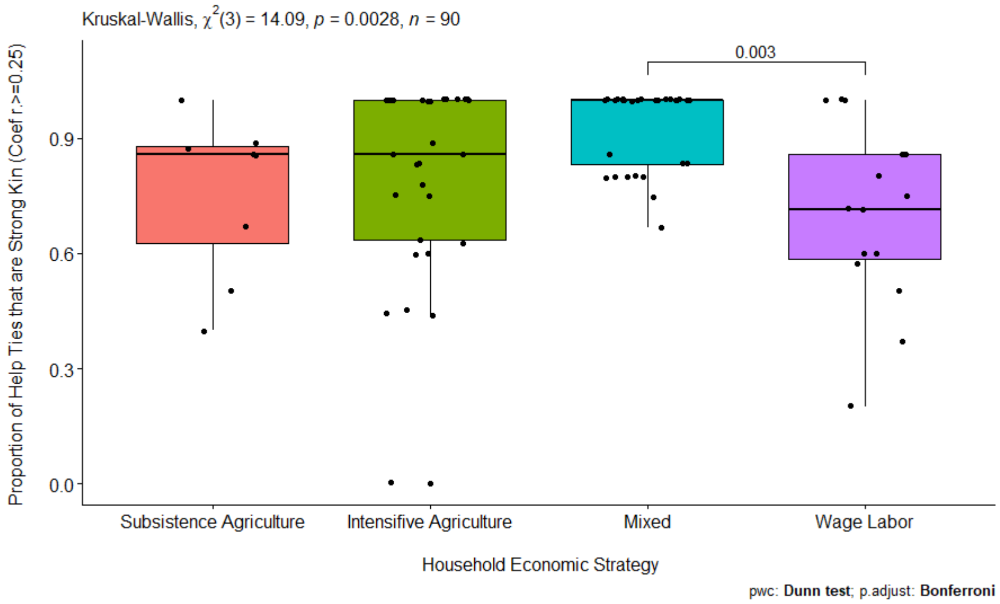

Figure 4. Proportion of support ties composed of kin stratified by household economic strategy.

Table 3. Regression Models of Kin Support Ties.

	Total Number of Kin Ties			**Proportion of Ties Composed of Kin**					
				Mu (Excluding 1's)			**Nu (Probability of 1)**		
	Estimate	**SE**	***p*-Value**	**Estimate**	**SE**	***p*-Value**	**Estimate**	**SE**	***p*-Value**
Intercept	1.760	0.437	0.000	0.867	0.415	0.042	0.787	1.310	0.551
Wage Labor	−0.526	0.273	0.054	**−0.772**	**0.317**	**0.018**	−1.616	0.991	0.109
Intensive Agriculture	−0.284	0.198	0.152	−0.444	0.303	0.149	−0.802	0.732	0.278
Subsistence Agriculture	−0.079	0.283	0.781	0.030	0.403	0.940	−2.095	1.262	0.103
Mixed Economy *	–	–	–	–	–	–	–	–	–
Total Helping Ties	**0.237**	**0.047**	**0.000**	**-0.085**	**0.040**	**0.037**	**−0.398**	**0.186**	**0.037**
Total Kin Ties	**0.024**	**0.010**	**0.019**	**0.044**	**0.019**	**0.021**	**0.095**	**0.044**	**0.036**
AIC	298.814			41.3					

* Both models set mixed economy households as the reference category. Total number of kin ties was modelled using the Conway-Maxwell Poisson Distribution. Proportion of ties composed of kin was modelled using a one-inflated beta distribution. This mixture model is composed of two sub-models. Mu models the beta distribution (0–1) excluding the excess 1's. Nu models the probability the response variable being a 1.

Additionally, the interactions between the total number of kin ties in the community and household economic strategy were insignificant. This suggests that kin availability plays little role in the differences in kin support across households with different economic strategies. Furthermore, supplemental analyses show the proportion of household workers identified as agricultural workers is positively associated with total kin ties as well as the proportion of kin ties in support networks (Table S3).

How variation in kin support networks are associated with increasing income disparities?

The proportion of support ties composed of kin is associated with both lower log income and lower-income per capita (Table 4, Figure 5). Both mixed economy and wage labor households have higher overall incomes compared to agricultural households. However, neither proportion of kin ties nor household economic strategy was associated with increased asset-based wealth. The interaction between kin support and household economic strategy was not significant, indicating the negative association between kin support and income did not vary across the economic strategy. In our supplemental analyses, we find the proportion of adults identified as wage labor is positively associated with income measures, whereas the proportion of adults identified as agricultural workers was negatively associated with income measures. Finally, using these alternative measures of economic strategy, results still show a negative effect of the proportion of kin help on income measures (Table S4).

Table 4. OLS Regression Models Predicting Household Economic Status.

	Log Income		**Income Per Capita**		**Asset Based Wealth**	
	Beta	**95% CI**	**Beta**	**95% CI**	**Beta**	**95% CI**
Economic Diversity	0.15 *	(−0.002, 0.31)	2569.40 **	(317.93, 4820.88)	20,792.16 **	(1797.63, 39,786.69)
Age of Male Head	−0.005	(−0.01, 0.003)	−100.79	(−220.54, 18.96)	−871.46 *	(−1880.07, 137.14)
Intensive Agriculture	0.15	(−0.30, 0.59)	3427.89	(−3038.15, 9893.93)	41,430.75	(−13,143.01, 96,004.51)
Mixed Economy	0.41 *	(−0.05, 0.88)	6967.95 **	(140.72, 13,795.18)	2573.35	(−54,921.86, 60,068.57)
Wage Labor	0.76 ***	(0.27, 1.25)	12,482.24 ***	(5332.13, 19,632.36)	−13,539.09	(−73,715.36, 46,637.19)
Proportion of Kin Help	−0.85 **	(−1.47, −0.22)	−10,025.77 **	(−19,163.28, −888.26)	25,073.48	(−52,604.86, 102,751.80)
Total Help Ties	0.03	(−0.03, 0.08)	729.34 *	(−79.76, 1538.45)	−2750.84	(−9596.07, 4094.39)
Intercept	9.29 ***	(8.49, 10.10)	1187.78	(−10,525.36, 12,900.93)	−20,512.21	(−120,255.80, 79,231.35)
Observations	82		82		81	
R^2	0.41		0.44		0.12	
Adjusted R^2	0.35		0.38		0.04	
Residual Std. Error	0.53 (df = 74)		7736.93 (df = 74)		65,111.41 (df = 73)	
F Statistic	7.26 *** (df = 7; 74)		8.23 *** (df = 7; 74)		1.46 (df = 7; 73)	

Note: * p, ** p, *** $p < 0.01$. Subsistence agriculture households were set as the reference category.

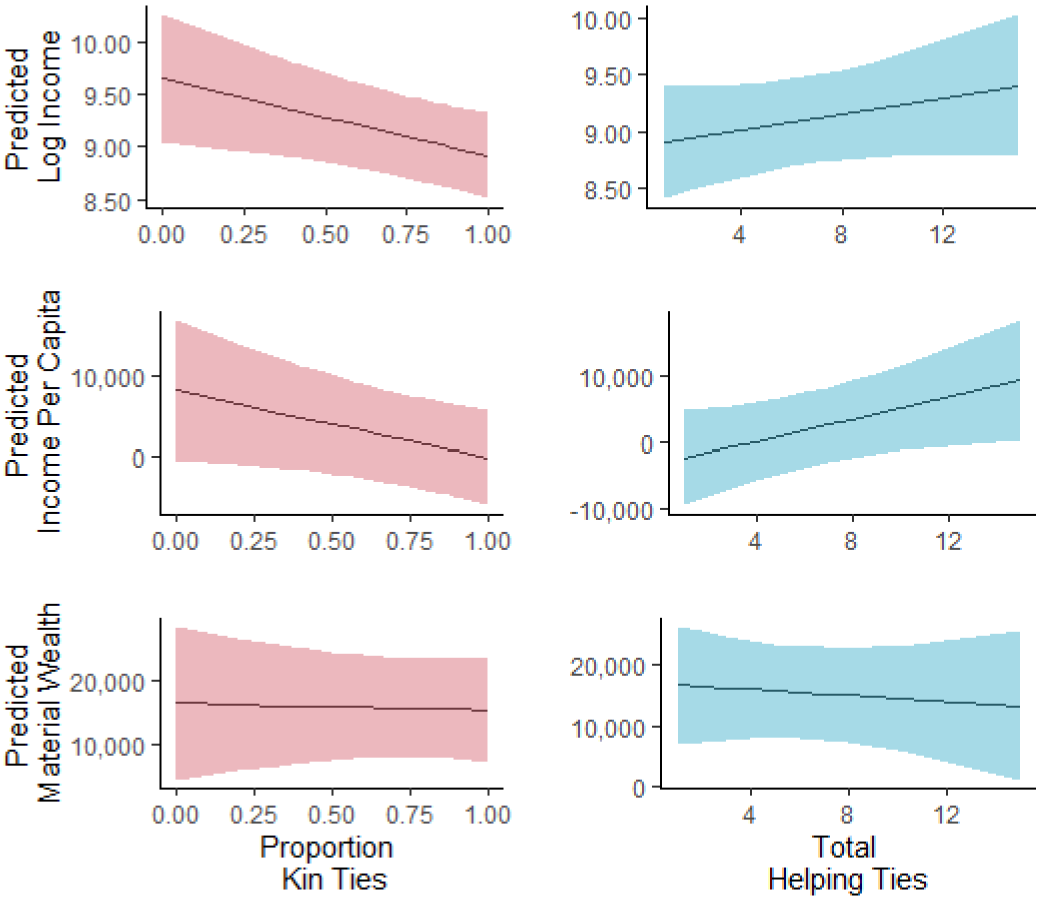

Figure 5. Marginal effects plots of Proportion of Kin Ties (**Left**) and Total Helping Ties (**Right**) on economic outcome variables. Marginal effects are calculated by holding constant all other variables in the model. Economic Diversity = 3.38, Age of Male HH = 44.15, Subsistence Agriculture = 1, Total Helping Ties = 5.41, and Proportion of Kin Help = 0.81.

5. Discussion

The results suggest that despite increasing market integration, between-household support networks are centered primarily around strong kin-based ties. However, we do find variation in kin support across different types of economic strategies. Mixed economy households tend to have fewer total supporting ties, yet their support networks are composed of significantly more kin relationships. By contrast, wage-labor households tend to have significantly fewer kin in their household support networks compared to mixed-economy households. This finding appears consistent with patterns observed in other populations undergoing market transitions, where increasing market integration is associated with lower kin density in networks (Colleran 2020). However, the greater reliance on kin support in mixed economy households is an interesting counterpoint to the narrative of a linear decline in kin density (Baggio et al. 2016; Burnsilver et al. 2017; Ready and Power 2018). As mixed economy households diversify economic production, taking up new wage-labor opportunities in addition to intensifying traditional economic production, reliance on kin support may remain a stable strategy for mitigating risk in the face of economic uncertainty (Baggio et al. 2016; Burnsilver et al. 2017; Ready and Power 2018).

Additionally, reliance on kin in household support networks is associated with lower overall income and income per capita for all economic strategies. The HBE framework suggests two potential explanations for this association, both emphasizing the costs and benefits of kin support (Gurven et al. 2015). One explanation is that better-off households are less likely to need kin support given their greater economic liquidity regardless of their economic strategy. Accordingly, households with more income benefit less from kin support, either because of the costs to accrue kin obligations or because reliance on cash is a better means to deal with fluctuations in resource flows. An alternative explanation is that kin support may be ultimately costly, whereby households who rely too heavily on kin may face the economic consequences of returning support for closely related households. The causal question still remains; do low-income households need kin support, or does kin support prevent the accumulation of more income? Our cross-sectional analyses are not suited to determine the direction of causation; however, we provide a baseline for future longitudinal analyses. Follow up-network studies could identify the role of network position in shaping future economic outcomes for households, including how and why households might adopt new activities.

Interestingly, our results highlight an important distinction in how household economic success is measured (Kaiser et al. 2017). Here we found significant effects of network composition on household income measures, but not material wealth measures. Income reflects the flow of resources through a household and in many low- and middle-income contexts may be highly variable. Material assets, or stocks of wealth, are much more stable temporally and can reflect the long-run economic capacity of a household. Our results suggest that network effects may have a short-term temporal impact on household economics. Rather than influencing a households' stocks of wealth, one might argue that the effects of kin support networks on household economic status may play out on a short-term temporal scale, influencing the variable flows of resources a household has access to.

Our network approach emphasizes ties between households. A key limitation of this approach is that with market integration, individual and household economic interests may increasingly diverge. As new market opportunities arise, individuals may wish to diversify their networks beyond familial ties, in ways that may conflict with the interests of the household and thus are not captured in the aggregate household networks. While some research suggests household-level networks accurately approximate individual networks in subsistence populations (Koster 2018), an important question remains whether this holds true as household increasingly diversify their economic strategies. One might expect as households become more involved in the wage-labor economy; individual networks may increasingly diverge from household-level aggregates.

Another important limitation of our approach is how we measure relatedness between households. We chose to use the maximum relatedness between households as our key relational variable. However, households can be related in a number of different ways. Marriage ties between households may prove to provide an important means of extending kinship ties between households. Furthermore, relatedness through patrilines or matrilines may provide distinct or diverging advantages or disadvantages depending on the cultural contexts. However, one of the defining characteristics in human support networks is the flexible means by which kin are identified, and accessed through residence patterns, often in ways that maximize the number of support ties available to individuals and households (Power and Ready 2019; Hill et al. 2011; Kramer and Greaves 2011). One important question remains how different types of household relatedness ties may gain or lose prominence in support networks over the course of market integration.

These analyses offer a glimpse at how networks of kin support are changing in the contexts of increasing economic diversity in a population undergoing rapid economic development and market integration. Household commitment to solely wage labor appears to lessen the need for reliance on kin support, while economic diversification appears to increase the number of kin in support networks, though potentially decreasing the size of the overall support networks. Both economic strategies are novel in the community, as the opportunities for consistent wage-labor employment are relatively new. How and why a household might diversify economic production or intensify commitment to a single strategy, such as wage labor or agricultural production, is an important open question. Mixed economic strategies may serve as a safe means of entering the market economy, by maintaining traditional economic production and social support to combat the risk and uncertainty of precarious wage-labor positions (Eakin 2005).

Mixed economies are an opportunity to examine the wide range of social, economic, and demographic changes associated with market integration. The combination of traditional and novel, market-oriented economic opportunities means that social relationships may not only strengthen in importance for mitigating risks, but may also take on new functional significance. The importance of kin in support networks may also shift with changing demographics and reproductive dynamics. While fertility is declining in this community, and thus the future availability of both ascendant and collateral kin to recruit for support, households engaged in mixed economic strategies may benefit from balancing fertility with the need for enough productive adults to sufficiently diversify economic activities. The household's capacity to both intensify agricultural production and engage in wage-labor opportunities may crucially depend on the availability of not just the support of related households but the reproductive decisions required to produce relatives.

6. Conclusions

HBE approaches to the family in contemporary populations have focused on the costs and benefits of kin support in diverse socioecological settings. In the contexts of market integration and economic development, HBE approaches have mirrored approaches in economics regarding the duel-edged sword of strong kinship networks. Here, we show that kinship ties strongly structure support networks despite market integration and economic development. Furthermore, a household's economic strategy predicts the kin composition of support networks, with mixed-economy households relying more on kin than wage-labor households. Lastly, kin support is associated with lower overall incomes and income per capita, regardless of economic strategy. Taken together, kin support remains an important strategy to mitigate risk in this community, even in the face of greater opportunities for engagement in wage labor and with increasing economic inequality.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/socsci10060216/s1, Table S1: Distribution of Kin Ties in Household Support Networks, Table S2: Dunn's Mean Comparison Tests of Average Proportion of Kin in Support Networks by Economic Strategy, Table S3: OLS Regression of Total Number of Kin Ties and Proportion of Kin Ties in Support Networks, Table S4: OLS Regression Predicting Household Economic Status, Table S5: Material wealth with uncoded outliers, Figure S1: Distribution of Kin in support networks by support type, Figure S2: Economic outcomes with un-recoded material wealth distributions, Figure S3: Distribution of proportion of kin help and total kin support ties, Figure S4: SRM Diagnostic Plots for Dyad only model, Figure S5: SRM Diagnostic plots for Dyad+Sender Effects, Figure S6: SRM Diagnostic plots for Dyad+Sender+Reciever Effects.

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social sciences

Article

Timing, Initiators, and Causes of Divorce in a Mayangna/Miskito Community in Nicaragua

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Abstract: There exists a paucity of evolution-oriented research focusing on why relationships end, particularly in comparison to the substantial literature centered around individual preferences that define the beginning of relationships. In contrast, there is a long tradition in the fields of sociology and family studies of exploring divorce; however, this body of research is largely limited to studies of Western populations. We address these gaps in the literature with an examination of patterns of divorce among a small-scale horticultural population in Nicaragua. We test a number of hypotheses derived from behavioral ecology perspective regarding the timing and causes of divorce. Results lend support to all but one of the hypotheses. Overall divorce rates are comparable to U.S. rates; however, they tend to occur earlier in marriages. Children appear to provide a slight buffering effect against divorce, although age in marriage does not. Gender differences in the reported causes of divorce fall along the lines that would be expected due to differences in partner preferences reported in previous research. Finally, this population also exhibits a similar peculiar pattern exhibited by Western populations, in which divorce is more costly for women, and yet women are slightly more likely to initiate divorces than husbands.

Keywords: divorce; marriage; small-scale; behavioral ecology

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1. Introduction

Across the globe, rising divorce rates over the past half century have meant that marital dissolution, single/co-parenthood, remarriage, and step-relationships are increasingly a part of family life the world over (Wang and Schofer 2018). Although there exists a considerable amount of cross-cultural diversity surrounding the institution of marriage, divorce generally carries a negative connotation (Broude and Greene 1983). It often represents the undesired outcome to relationships that begin under much more positive circumstances, and as research has shown, it is often associated with less favorable outcomes going forward. It thus makes sense that there exists such an extensive literature exploring the predictors and outcomes of divorce. This literature is dominated by studies rooted in the research and theoretical traditions of the fields of sociology and family studies. Here, we add to this by contributing a study founded on a behavioral ecology perspective. Evolutionary-based research has largely focused on the factors that influence the beginnings of relationships—gender differences in romantic and sexual strategies, partner preferences, etc. (Buss 1989; Gangestad and Simpson 2000). Aside from the large bodies of literature focusing on conflicts within relationships, such as jealousy (Scelza et al. 2020; Buss et al. 1992), far fewer evolutionary studies have examined the predictors and outcomes associated with the ending of such relationships (although, see: Apostolou et al. 2019; Betzig 1989; Gurven et al. 2009).

Another major limitation in the literature is the scarcity of studies which incorporate samples outside the U.S. or Europe. Marriage is an institution that exhibits a great deal of cross-cultural variation, and thus, the factors leading up to and the processes and rituals associated with divorce undoubtedly vary quite substantially across the globe. This limitation in the literature greatly undermines our ability to determine whether seemingly robust cross-cultural patterns, such as the role of infidelity in motivating divorce, represent pan-human patterns or if they are simply artifacts of the culturally circumscribed record. Here, we contribute to the literature by providing the first exploration of the predictors, causes, and costs of divorce among a small-scale population. To contextualize this study, we begin with an examination of the literature regarding the predictors, causes, and outcomes of divorce; we then explore what a behavioral ecology approach to the study of divorce might look like.

1.1. Existing Literature on Predictors, Outcomes, and Initiators of Divorce

1.1.1. Predictors and Causes of Divorce

Aside from the impacts of divorce on the wellbeing of children, perhaps the most common topic of divorce research is the predictors and causes of divorce. These studies usually take two primary forms—one explores the impact of external factors and/or individual states (e.g., economic factors, youth, marital history, etc.) that associate with the likelihood of divorce, and the other explores reported causes of divorce (e.g., infidelity, abuse). Some factors, such as poverty, might be included in both.

Regarding predictors of divorce, literature reviews reveal a number of factors that are consistently associated with divorce in Western populations (Amato 2010; Clarke-Stewart and Brentano 2006; Raley and Sweeney 2020). These include factors that likely make it more difficult to manage a household, such as marrying young, poverty and/or joblessness, low levels of education, and bringing children into a marriage. Other factors might be indicative of orientations that are associated with divorce, such as being in a second or later marriage and coming from a family without continuously married parents (Amato 2010).

Explorations of the reported causes of marriage dissolution tend to be more straightforward than explorations of predictors, as they can be done retrospectively and do not require complicated prediction models. In four studies conducted in the U.S. over the past two decades, the four factors that are present in the top ten of all lists were relationship issues (such as growing apart), infidelity, financial problems, and drug abuse (Scott et al. 2013; Hawkins et al. 2012; Amato and Previti 2003; Johnson et al. 2001). However, the reporting of frequencies tells us only the sensitivity of such factors (using the parlance of clinical health) (Lalkhen and McCluskey 2008). That is, it reveals only what proportion of divorces include such factors—it does not relate to specificity, or the likelihood of divorce occurring given that a particular risk factor is present. Thus, when comparing changes through time or among populations, differences might arise due to changes in frequencies with which these risk factors arise, as well as the impact they have on the likelihood of divorce.

The literature exploring retrospective reports of causes includes a much broader range of cultural diversity, which highlights the shared human patterns as well as the culture-specific problems faced by couples in different populations. For example, in three studies of Muslim-majority Arabic and Persian populations, relationship problems were also among the most common problems in all three studies, while infidelity was much rarer (Rehim et al. 2020; Cohen and Savaya 2003; Barikani et al. 2012). Additionally, unlike in the U.S., problems with extended families were a major cause for divorce in each population. A review of the cross-cultural record also reveals both shared notions of risks to marriage as well as features that would likely be foreign to Western newlyweds—while adultery was the most commonly cited acceptable reason for divorce across cultures, sterility was the second most common (Betzig 1989).

1.1.2. Child Outcomes of Divorce

A substantial body of research has focused on the impacts of marital dissolution on the wellbeing of children (Amato 2010; Raley and Sweeney 2020). Reviews of the literature reveal robust effects on a number of outcomes, including increased problem behavior, poorer emotional wellbeing, and increased problems in adulthood. However, recent research suggests an attenuation of the effect-sizes commonly reported in the twentieth century, as researchers have more effectively controlled for the socio-environmental factors that often precede divorce, and which also negatively impact child outcomes (Amato 2010). In fact, researchers have found that the divorce event itself has a more negative impact on children coming from low-conflict and more well-to-do families (Booth and Amato 2001; Ryan et al. 2015; Raley and Sweeney 2020).

1.1.3. Adult Outcomes of Divorce

Divorce is strongly associated with negative outcomes for adults in Western populations, although there are numerous contextual factors that mediate the effect (Raley and Sweeney 2020). U.S. women continue to suffer disproportionately higher financial costs from divorce, although women's increased participation in the labor force means that these differences have been diminishing through time (Tamborini et al. 2015). In addition to loss of income, divorced women experience higher risk of poverty and a loss of housing (Hogendoorn et al. 2020; Dewilde 2008). Remarriage increases women's financial standing, but women remarry at lower rates than men. Increasing age decreases the likelihood of remarriage in women, although the effect of children is less consistent (McNamee et al. 2014). While some research suggests that potential husbands might be more reluctant to marry women with children, divorced mothers might be more motivated to find a partner, canceling the effect (Buckle et al. 1996).

Much of the focus of research on the costs of divorce is on the financial and quality-of-life costs to women, but for some measures, it appears that men in Western populations bear the cost disproportionately. Men tend to report lower immediate subjective wellbeing and greater feelings of loneliness, although such differences disappear as individuals adapt (Dykstra and Fokkema 2007; Leopold 2018). Men also appear to suffer from greater reductions in physical health and even higher mortality after divorce than women do (Sbarra et al. 2011; Leopold 2018).

1.1.4. Who Initiates Divorce

Determining each partner's relative contribution to the decision to divorce is not always simple. As a respondent told one of the authors in a separate study, "I was the one who divorced my wife; when I returned from being away, she was living with another man, so I left her". The two most common approaches to determining who initiated divorce are linking it to who legally filed for divorce or to ask who most wanted the divorce. Both approaches reveal the same robust effect in Western populations: women are the initiators in about two-thirds of heterosexual divorces (e.g., see Sayer et al. 2011; Brinig and Allen 2000, and citations within). When comparing men and women's responses to who most wanted divorce, there is a tendency for individuals to be more likely to report that they themselves wanted the divorce compared to the partner's response (Amato and Previti 2003). However, even with such a bias, men are still more likely to report that it was their partners who wanted the divorce.

Although the pattern of women being more likely to divorce is robust among Western countries, the effect appears to attenuate with time in the marriage (Buckle et al. 1996). The presence of children tends to reduce risk of divorce overall, but does not exhibit a consistent effect on who initiates divorce, although the current literature is limited to studies involving samples with low fertility (Sayer et al. 2011; Hewitt 2009; Kalmijn and Poortman 2006).

The reasons why women are more likely to initiate divorce are poorly understood. The effect is counterintuitive, for, as described above, women often experience greater financial costs to divorce, are often more invested in children's wellbeing, and have a lower likelihood of repartnering following divorce (Leopold 2018). Some argue that it is this very disadvantage in bargaining leverage within marriages that might lead women to more often suffer from relationship imbalances that ultimately become intolerable (Brinig and Allen 2000). Indeed, women appear more likely to divorce when unhappy in a marriage, and after divorce they tend to report higher subjective wellbeing (Leopold 2018; Amato 2014; Guven et al. 2012).

1.2. Marriage and Divorce in a Behavioral Ecology Perspective

Researchers have developed a number of theoretical models to make sense of the marriage and divorce patterns described above. Here, we explore a behavioral ecology approach, which in many ways resembles the Beckerian and Social Exchange models in the sociology, economics, and family studies traditions (Becker et al. 1977; Karney and Bradbury 1995). As in Beckerian models, behavioral ecologists treat decisions to enter or leave relationships as cost/benefit assessments, and often take into account the benefits of specialization and divisions of labor (Kaplan et al. 2000; Winking and Gurven 2011; Alger et al. 2020). As withSocial Exchange models, behavioral ecologists have treated divorce as a breakdown of cooperative arrangements between self-interested agents (Gurven et al. 2009; Buckle et al. 1996). The primary difference is that, in the behavioral ecology approach, the utility being optimized and the currency being exchanged are predicted to fall along those dimensions that are (or were) most closely related to evolutionary fitness.

Behavioral ecologists approach the exploration of behavioral variation (e.g., why some couples divorce and some do not) as a question of competing demands—competing demands within individuals (e.g., to find a good reproductive partner, to find food, to raise children, etc.), and among individuals (e.g., competition for partners or resources). The fundamental assumption is that those strategies that optimize the balancing of those demands would be selected and increase in their representation. To understand the factors that motivate divorce in humans, we must first explore the hypotheses as to why marriage was seemingly advantageous over other reproductive strategies in human evolutionary history. This, however, requires defining marriage.

1.2.1. Defining Marriage and Divorce

As with many aspects of human behavior, marital patterns are extremely variable across and within populations. However, there are clearly boundaries to this variance—for instance, no culture has ever been documented that exhibits mating patterns similar to those of chimpanzees, bonobos, or orangutans, etc. “Marriage” thus remains a useful descriptor of the reproductive and romantic practices in cultures around the world. A working definition has nevertheless proven challenging (Bell 1997; Gough 1959; Murdock 1949; Coontz 2006; Westermarck 1936; Royal Anthropological Institute of Great Britain and Ireland 1951). Proposed definitions tend to include any combination of four elements: marriage tends to be associated with (1) some form of sexual preference and restriction (Bell 1997; Murdock 1949), (2) economic cooperation (Murdock 1949), (3) social acknowledgment of the relationship (Westermarck 1936), and (4) the social acknowledgment that children produced within marriage differ somehow from those produced outside it (Royal Anthropological Institute of Great Britain and Ireland 1951; Gough 1959).

In this review, we are primarily interested in the first two of these elements, as they are largely prerequisites for the more culturally embedded other two. Sexual preference and restriction are practices that are often culturally enforced, but even in the absence of such norms, they also organically develop by humans’ capacity for romantic attachment. The capacity to establish long-term psychological attachments to reproductive partners, i.e., pair-bonding, is something that is not evident in all species, and is thus likely the result of an evolutionary trajectory that has played out many times in many different species (Young 2003). There exists a substantial body of literature exploring the proximate endocrinological mechanisms that drive such behavior in animals and humans (Fernandez-Duque et al. 2009; Gettler et al. 2011; Insel 2010). Similarly, across pair-bonded animal species, there is considerable variation in the degree to which members of a pair-bond cooperate in their contributions toward shared fertility. Additionally, again, the capacity for parental concern among mammalian males does not exist in all species, has well-studied endocrinological correlates, and likely represents the outcome of specific selective histories (Gettler et al. 2011; Geary and Flinn 2001; Wynne-Edwards and Reburn 2000).

We, therefore, define marriage simply—a long-term exclusive or semi-exclusive sexual relationship, often resulting in reproduction, which includes high levels of economic cooperation. Note that here, we do not differentiate between relationships that are culturally legitimized through the formal rituals often associated with marriage, and those which develop more informally. Indeed, in many societies, there exists no distinction (e.g., Hill and Hurtado 1996). Divorce, therefore, is simply defined as the dissolution of such a relationship.

1.2.2. Evolution of Marriage

Most attempts to explain the evolution of humans' unusual capacities for romantic attachment and biparental concern have focused on the remarkable costliness of human offspring (Lovejoy 1981; Lancaster and Lancaster 1983; Winking 2006). Human infants are born cognitively and physically altricial and present a great encumbrance to lactating mothers (Hurtado et al. 1992). Furthermore, despite being weaned early compared to other primates, they remain net consumers for a longer portion of their lifespans (Kaplan et al. 2000). Finally, as women resume reproduction long before previous children are nutritionally independent, families often include multiple offspring of varying levels of dependence (Bogin 1997). Thus, compared to other primates, human children require a higher level of investment, they require it for a longer period of time, and there are more of them. As the well of need to be filled grew, so too would the returns to sticking around and providing paternal investment.

As paternal investment proved ever more lucrative, those strategies that facilitated it might have also been selected. Thus, men and women who were oriented more towards long-term reproductive relationships might have experienced higher reproductive success, as such a strategy would facilitate paternal investment by allowing for the possibility of extended father–offspring interaction and increased paternity confidence. Through time, these unusual characteristics of human reproduction likely coevolved. As paternal care became more available, pathways opened for offspring to evolve greater dependence, further enhancing the returns to marriage, and so on (Winking 2006).

Many researchers have been critical of this "paternal provisioning model", however, noting that paternal investment is quite variable cross-culturally, and often not that impactful (Hawkes 1993; Bleige Bird et al. 2001; Sear and Mace 2008; Coxworth et al. 2015). Many have offered alternative models that focus more on the dynamics of the competitive markets for partners. For instance, men might have been selected to be more oriented toward long-term relationships as the emergence of menopause resulted in more men to be in the reproductive market than women (Coxworth et al. 2015), or as weaponry reduced the variation in men's competitive abilities (Chapais 2011), or as women's preferences shifted toward male providers as offspring need increased (Gavrilets 2012).

Although not all models position biparental care as the impetus for the selection of a long-term orientation, once long-term relationships were established, most suggest that the selection for paternal provisioning would have been stronger. Therefore, while there is some variability, there is also a fair degree of agreement among the models regarding the current motivations for entering into marriage—continually returning to the romantic market is costly, parenting needy children is easier with a partner with whom one is economically cooperating, and romantic attachment and parental concern motivate this entire process.

1.2.3. Why Divorce?

From a behavioral ecology perspective, divorce should be more likely to occur when at least one partner perceives the benefits of leaving a marriage to be higher than remaining. Furthermore, the benefits of leaving and staying are expected to be aligned with those that previously impacted fitness as described in the section above. Such a shift in perception can occur within a marriage for a number of reasons (Snopkowski 2016). Many approaches that explore this process in the human and animal literature relate to the potential for errors in partner selection (Johnston and Ryder 1987; Choudhury 1995; Snopkowski 2016). Theselection process is a classic Optimal Stopping Problem, in which a selection must be made before all available options are known (similar to choosing a house or even a parking space) (Dombrovsky and Perrin 1994). It is also a coordination problem, as each seeker must find a partner who believes that the seeker is that partner's best option as well.Given these constraints, individuals might come to realize that their selection was not optimal as they learn more about their partner or as better alternatives become available (Conroy-Beam et al. 2019).

Many unexpected realizations relate to partnercharacteristics and behaviors. While some of these, such asmutual incompatibility, might be experienced equally by men and women, some are experienced asymmetrically. For instance, men experience the asymmetric risk of cuckoldry (Scelza et al. 2020), and thus might be more responsive to cues of sexual infidelity than are women (see Scelza 2021 for an illustration of the substantial degree of cultural variation regarding infidelity). Women, however, often enter into unions with an asymmetric risk of abuse due to sexual dimorphism in body size, as well as patriarchal norms (Apostolou et al. 2019). Furthermore, for women, a major benefit of marriage is the sharing of the costs of fertility(Winking 2006; Geary 2000). This is particularly evident when comparing the human system to that of other primate species that live in large multi-male, multi-female groups, such as chimpanzees and many baboon species. Among these primates, males' expendable energy is largely squandered in costly male–male competition while females are fully responsible for parental care. Thus, women might be more sensitive their partner's lack of willingness or ability to invest.

Other factors that alter the relative benefits and costs of divorce are external to individual characteristics and behaviors. For instance, divorcesoften become more costly through time as the number of children who might experience a negative impact increases. While most of the divorce literature has focused on child outcomes that do not directly relate to fitness (e.g., academic performance), a number of studies in the behavioral ecology tradition have revealed the negative impacts of parental loss on child survival and adult fertility (Winking et al. 2011; Sear and Mace 2008; Scelza 2010).The cost of divorce might also changein relation to the availability and quality of alternative options. For instance, repartnering might become easier as one's status on the marriage market improves (e.g., due to increased social status) (Gurven et al. 2009). Kin residence patterns might shift to offer a new alternative living situation for a discontented spouse (Snopkowski 2016).

Ultimately, individuals must weigh countless factorsregarding their partners, themselves, their children, their alternatives, and much more, when deciding whether to divorce or to remain in a marriage. We extend the logic of this section to the construction of hypotheses below, but first we describe the cultural context in which they are examined.

1.3. Study Population: The Mayangna/Miskito Horticulturalists of Nicaragua

A major limitation of the existing literature is its focus on the U.S. and other Western populations. A number of findings that are robust through time and across such cultures, such as the tendency for women to be more likely to initiate divorce, might represent patterns common to humans' peculiar mating, reproductive, and parenting systems. However, they might also be artifacts of the shared cultural dimensions that define Western populations. While a growing literature already exists exploring divorce in non-Western populations, we contribute here by offering the first in-depth exploration of divorce among a small-scale population.

There is no single defining feature of small-scale populations, and they represent a diverse array of individual cultures. However, compared to industrialized, state-level populations, they share a number of distinctions. Population centers tend to be much smaller and organized around kinship systems. Much of the food is directly produced by consumers. Families tend to be defined by earlier and higher fertility rates, and the division of labor tends to be more strictly defined between men and women (Winking et al. 2018). While small-scale populations should not be romanticized as perfect analogs of humans' ancestral past, they nevertheless occupy a space among the dimensions of cultural variation that is distinct from that of nation-state populations—a space that has long been overlooked by cross-cultural research in the social sciences.

As described below, in many ways the Mayangna/Miskito population represents an ideal population to shed light on the robustness of reported trends. While this community exhibits many of the features described above that starkly differentiate it from the U.S. and other similar populations, they also share with these populations a number of cultural norms surrounding marriage—individuals are relatively free to choose their own partners, divorce is fairly common, and there is no major stigma attached to it.

1.3.1. History and Structure

Research took place in a pair of nearby villages consisting of a combined population of approximately 450 Mayangna and Miskito individuals. The Mayangna and Miskito are closely related Indigenous populations that reside in eastern Nicaragua. The Miskito are much larger as a population and politically ascendant compared to the Mayangna, and the Miskito language is the lingua franca in the region. Intermarriage is common, and the two groups share a sense of Indigenous identity that differentiates them from the larger Nicaraguan population. Among the two communities taking part in the current study, members of each culture reside in both villages, although the larger village (approximately 350 individuals) is culturally Mayangna, and the smaller (approximately 100 individuals) is culturally Miskito.

Miskito and Mayangna villages tend to include populations in the high tens to low thousands. Within these villages, nuclear family households are clustered along lines of kinship. Married couples exhibit an uxorilocal residence bias and tend to live within or near the household of the wife early in marriage (Koster et al. 2019). Residence rules are informal, however, and couples occasionally choose to reside near the man's kin.

These populations have a centuries-long interaction with colonizing populations. The British occupied much of the eastern coast of Central America, and numerous English loan words are present in both languages. The transmission of language, technology, norms, etc., from the greater Nicaraguan national culture has been the dominant force for some time. Today, all children attend a local school, where they learn Spanish among other subjects. All community members belong to the Catholic faith or one of the protestant sects that have proselytized in the region. Increasingly, more impactful technology has been more and more common, including chain saws, outboard motors, and solar panels. Unlike other villages a few hours travel away, however, cell phone reception is still not possible.

1.3.2. Marriage and Family

The nuclear family is the primary unit of social and economic organization (Koster 2018). In the early to mid-teens for women, and in the mid-to late teens for men, individuals begin experimenting with relationships. Parents will often make their opinions known, but even young adults enjoy a fair degree of autonomy in choosing their partners. There is a clear expectation that sexual activity should be limited to long-term relationships, but single motherhood is not uncommon and is not strongly stigmatized (McSweeney 2002; Koster 2011). Some of these early relationships continue on into adulthood, resulting in reports of very young ages for age at marriage. However, as most marriages are not marked by a ceremony, such scenarios would be more similar to a U.S. couple marrying after dating in high school. There are some distinctions from high school romances, though, as it is more common for these relationships to continue on into adulthood, there is typically no elaborate ceremony to mark such a relationship "becoming" a marriage, and if the relationship continues for a number of years, it is common for the first children to be born while the mother is still in her teens. Most failed marriages in this population result from these early relationships, and it is sometimes difficult to discern between a short-lived marriage and a failed long-term courtship. Some marriages are consecrated in later years by a visiting priest. This marks the relationship as more concrete and more likely to endure, although this does not seem to be viewed as a requirement for a longterm marriage (for the present study, the year the relationship began is used to mark the beginning of the marriage).

Within the household, the sexual division of labor is much sharper than that exhibited in modern Western populations (Koster et al. 2013). As a horticultural population, men are responsible for heavy labor in family agricultural fields, as well as hunting, fishing, and most wage-earning activities. Women are responsible for most childcare and domestic tasks, such as cooking and washing clothes. However, husbands and wives can often be found working cooperatively in agricultural and domestic work, and it is clear that many couples share a great affinity for one another.

Parenthood begins much earlier compared to Western contexts, and fertility remains high throughout adulthood. First birth is common in the late teens for both men and women, and completed fertility exceeds seven children (Winking and Koster 2015). Additionally, although contraception use is increasing and ideal family sizes are decreasing, young adults still report a desire for more than five children (Kurten 2019).

Divorce can be initiated by either party, and usually involves one or both partners leaving the residential home and returning to kin. Children from the marriage most often stay with the mother, but occasionally will be raised by the grandparents, and rarely by the father. Step-parentage is thus not uncommon and is primarily a step-father/step-child relationship. Most divorces occur in the first years of a marriage, making the process simpler, particularly if no children were born. When marriages end after many years, some couples seek mediation from local or family leaders to divide the resources, such as livestock, that accumulate over time, and fathers will often contribute money for the education and wellbeing of children remaining with the mother. Divorced mothers will usually move back to their parents' or another relative's house—female-led households are very rare.

1.4. Research Questions and Hypotheses

Here, we explore three research questions. The first is how frequently and when does divorce occur in this population? To do this we construct the survival curve of marriage (the proportion remaining intact). To explore when divorces occur, we will test demographic predictors of marital dissolution. Given that increasing the wellbeing of children is a benefit shared by both men and women, we hypothesize that couples will be less likely to divorce as they have more children, independent of length of the marriage, as more children would be exposed to the negative impacts of divorce (H1). Although previous research in other populations reveals no consistent effect of family size on divorce, the range of family sizes in this Mayangna/Miskito sizes in this study is substantially larger thanthose in prior research. Furthermore, as marriage also offers a solution to avoiding the cost of having to find another partner, we also hypothesize that younger individuals will be more likely to divorce, independent of the length of marriage, as they have a greater opportunity to find a new partner (H2) (we acknowledge that this is analytically the same as the hypothesis that those who marry at a younger age are more likely to divorce).

The second research question is what are the causes of divorce? We will explore reported causes for previous divorces as well as responses to hypothetical threats to one's marriage to test if they align with the predictions of the behavioral ecology approach. Specifically, we will test if men are more likely to divorce upon discovery of infidelity (H3), and if women are more likely to divorce due to a lack of investment (H4) or abuse (H5).

The last research question is who initiates divorce and how is this related to the costs of divorce? In U.S. samples, women are consistently more frequent initiators of divorce despite incurring greater long-term financial costs following divorce. We explore whether the Mayangna exhibit the same pattern—that women are more likely to initiate divorce than men (H6), and that this effect is attenuated as the relative costs for women increase compared to those of men as women's age and number of children increase (H7). We examine costliness of divorce through participants' reports of whom they believe divorce to be more costly for (for men or women) and why this is so, and through time until remarriage. We predict that a strong majority of both men and women will report that it is women who suffer more from divorce (H8), and that women will remarry at a slower rate (H9).

2. Materials and Methods

2.1. Marriage and Divorce Interviews

In the summer of 2016, the authors visited the two communities and held community-wide meetings to describe the nature of the research, the methods that would be incorporated, and the compensation given. We allowed time for discussion and answered all questions. Individuals were given a number of days (depending on the schedule) to make their decision whether to participate. Participants were also read the consent information sheet prior each individual interview. This research was approved by the Texas A&M IRB (Protocol IRB2014-0249D).

The interviews were conducted by JWand a local translator over the course of four weeks (the interview script is available in the Supplemental Materials). All individuals who were currently or had been previously married were invited to participate. Some took place in a central location, while others took place on the participants' porches, depending on what they thought would be more convenient. Prior to the Marriage and Divorce interview, JWconducted an Investment Model Scale interview for a related study (Winking et al. 2018). The entire process would take approximately 20 to 30 min, and the participants were compensated with approximately a fifth of a daily wage (approximately USD 2.00).

2.2. Reproductive History Interviews

As part of broader demographic surveys in 2005, 2013, and 2016, reproductive histories were elicited using conventional methods (Beall and Leslie 2014). In general, birthdates for children born after 1990 are reasonably well-documented and typically accompanied by birth certificates provided by the government. For previous generations, when informants expressed uncertainty about the timing of births, estimates were inferred by inquiring about same-aged cohorts, considering relative birth order among siblings, and inquiring about the timing of births in relation to important historical events, such as the onset of the Contra War in 1982.

2.3. Calculation of Years of Marriage

As mentioned above, whether or not early and/or short-lived relationships should be considered marriages is not always clear. Individuals were not given criteria and were allowed to define marriage for themselves. For the analyses in the present study, only those that were reported to last more than six months were included. As marital histories were recorded in both the Marriage and Divorce Interview as well as the Reproductive History Interview, we were able to assess the internal reliability of their responses. For the marriages of individuals who participated in both interviews, 160 of the 190 marriages (84%) were reported in both interviews, nine (5%) were included in only the Marriage and Divorce Interviews, and 21 (11%) were recorded in only the Reproductive History Interviews. An additional 30 marriages were reported in the Marriage and Divorce Interviews by people who did not participate in the Reproductive History Interviews. Only those individuals who took part in the Marriage and Divorce Interviews are included in the present study (except for analyses of first marriage and first birth, for which all resident individuals are included).

If estimates of the years of marriage beginnings and endings were available from the two datasets and/or from the husband and wife, and the estimates differed, the average was used (rounding up). This was constrained by the rules that marriages had to begin at least as early as the year of birth of the first child, and they could not end earlier than one year prior to the year of birth of the last child. On occasion, estimates were adjusted due to assessments of confidence—for instance, if an individual reported that they were unsure, but their spouse made no such admission.

2.4. Analysis

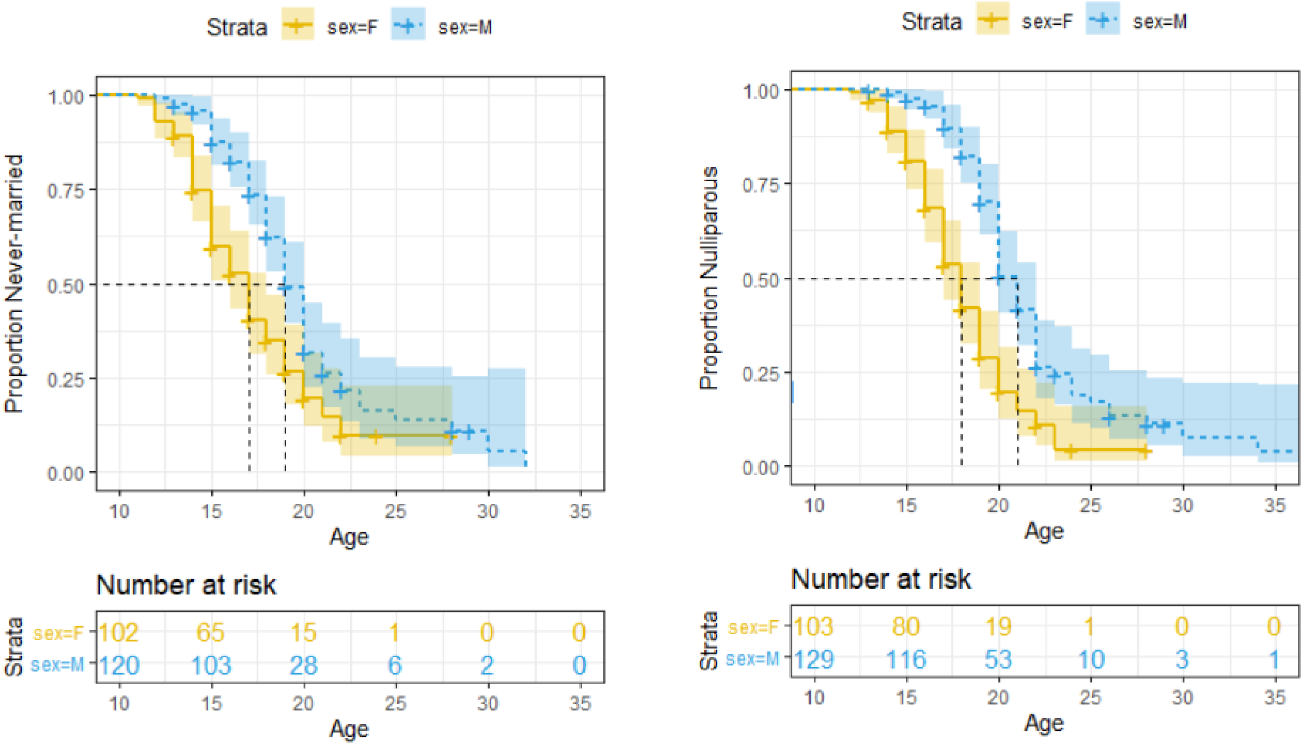
Due to the varied nature of the hypotheses and data, a number of analytical strategies are employed. All analyses were conducted in R and the script is available in the Supplemental Materials. For most tests of hypotheses, we use Bayesian regression using the BRM function in the BRMS package. This is employed with a discrete-time events history approach which models the annual likelihood of divorce (or remarriage). Along with relevant fixed effects variables (both time-varying and non-time-varying), we include appropriate random effects controls depending on the nature of the hypothesis, which can include a categorical identifier for the marital dyad, as well as crossed random effects for husbands' and wives' identifiers.

3. Results

3.1. Community Ages of First Marriage and First Birth

Median ages of first marriage and first birth were calculated using the full Reproductive History Dataset (including all individuals age 12 and over), as the Marriage and Divorce dataset does not include unmarried individuals. The Reproductive History Dataset is derived from the reproductive histories of 146 individuals who were present in the community during 2013 or 2016 data collection. This resulted in a dataset which included life history data (years of birth, marriage, reproduction, and death) for 422 individuals.

A Kaplan–Meier survival analysis reveals that the median age of first marriage in this community was 17 for women (n = 102), ranging from 12 to 22, and 19 for men (n = 120), ranging from 12 to 32 (Figure 1a). While some men and women in their twenties had yet to marry, by age thirty, all women (n = 38) and all but one man (n = 41) had married at least once. It should be noted here that the low ages in these ranges are due to a multitude of factors. Many of the younger ages stem from marriages reported from older individuals, for which age estimates are less precise. Additionally, the notion of "marriage", as described in the previous section, often includes relationships that would be more akin to those characterizing a youthful boyfriend/girlfriend relationship in Western cultures. However, they do differ in their formal social acknowledgment as well as the general expectation that they could lead to life-long partnerships. The median age of first birth was 18 for women (n = 103), ranging from 12 to 23, and 21 for men (n = 124), ranging from 14 to 34 (Figure 1b). Again, all women (n = 38) and all but two men (n = 46) had had a child by age 30.



(**a**) (**b**)

Figure 1. Kaplan–Meier plots of community-level first marriage (**a**) and first birth (**b**).

3.2. *Timing and Predictors of Divorce*

The Marriage and Divorce Dataset includes adults who were present and had been married at least once in 2016.This includes 56 women and 53 men who reported on 175 marriages (Table 1). A Kaplan–Meier survival analysis reveals a median length of a marriage of four years, although this is largely due to high divorce risk in the first (25.7%) and second year of marriage (15.3% of remaining) (Figure 2). Of those couples who make it past the median four years, the survival analysis suggests that 72.2% stay married. No divorce occurred after twenty years of marriage. The survival analysis results in an estimate of approximately two thirds of marriages ending in divorce. Similarly, of the marriages that began more than 20 years prior to data collection, 62.9% (*n* = 81) had ended in divorce.

Table 1. Marriage and divorce sample characteristics.

	N	Mean	St. Dev	Range
Individuals				
Women				
Age	56	32.61	12.27	18–72
Number of marriages	56	1.69	1.13	1–5
Men				
Age	53	38.43	13.84	19–76
Number of marriages	53	2.30	1.13	1–8
Marriages				
Length (All)	175	7.37	9.51	1–58
Length (Ongoing)	63	15.00	11.88	1–58
Length (Ended in Death)	4	8.50	9.26	1–20
Length (Ended in Divorce)	108	2.88	2.89	1–20

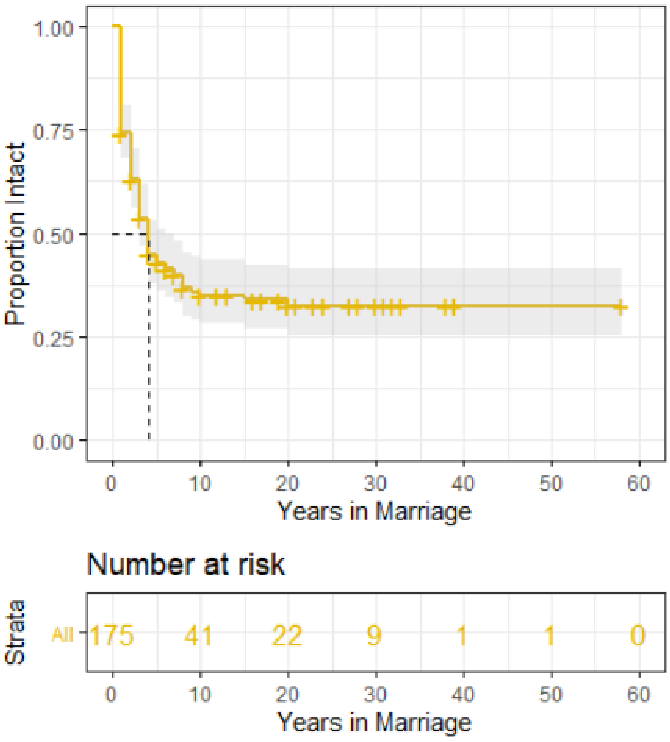


Figure 2. Kaplan–Meier plot of marriage "survival".

The results of a discrete-time event history analysis exploring predictors of divorce are described in Table 2. We used a Bayesian mixed logit model to evaluate the likelihood of divorce on a year-by-year basis (for the first 20 years), and included a marital identifier as a varying intercept, as well as non-time-varying fixed effects ("Husband Age of Marriage" and "Wife Age of Marriage") and time-varying fixed effects ("Year in Marriage" and "Number of Dependents"). The risk of divorce declines through time in a marriage (β = −0.11). Even after controlling for this effect, the number of dependents (as a time-varying variable) is a significant negative predictor of divorce (β = −0.22), in support of H1. Because years in marriage and age are collinear through time—and both are reasonable correlates of risk of divorce—we use husband's and wife's age at marriage as a measure for age that is independent of years in marriage. Neither the husband's age at marriage (β = −0.01) nor the wife's age at marriage (β = −0.02) are predictive of the risk of divorce, and thus H2 is not supported. The overall conclusions hold even when we remove marriages that begin in youth (when either partner is <18 years old) (Supplementary Materials, Table S1).

Table 2. Discrete-time event history analysis of risk of divorce using Bayesian logistic regression. Reported coefficients are posterior means.

	B	**95% CI**
Intercept	−0.52	(−2.06, 1.06)
Husband Age at Marriage	−0.01	(−0.06, 0.04)
Wife Age at Marriage	−0.02	(−0.10, 0.04)
Number of Dependents	−0.22	(−0.4, −0.05)
Year in Marriage	−0.11	(−0.25, 0.05)

n = 1077 risk years, 164 marriages. Marriage ID included as random effect.

3.3. Causes of Divorce

When participants were asked for the major causes for past divorces, they rarely offered reasons that negatively implicated their own actions. Only five out of 109 responses included a self-incriminating cause, meaning that comments primarily reflected what men and women found as divorceable behaviors or traits in their partners. The causes fall into four broad categories, as tabulated by one of the authors (JW) (Table 3), including (1) problems with partner behavior (such as a lack of respect, abuse, drug use, laziness), (2) infidelity and jealousy, (3) circumstances (such as challenges with in-laws, the war, or disagreements about where to live), and (4) one partner wishing to not be in the marriage and/or to be married to someone else. Men more frequently mentioned issues of infidelity and jealousy (35.8% of divorces, $n = 67$) than women (14.3%, $n = 42$, Fisher exact, $p = 0.01$), whereas women more frequently mentioned behavioral problems (38.1%, $n = 42$) than men (17.9%, $n = 67$, Fisher exact, $p = 0.025$). Looking at more specific categories, we find that men more frequently cited their partner's infidelity (women: 4.8%, $n = 42$; men: 20.9%, $n = 67$; Fisher exact, $p < 0.025$) in support of H3, whereas women more frequently cited abuse (women: 14.3%, $n = 42$; men: 0.0%, $n = 67$; Fisher exact, $p = 0.003$), in support of H4, as well as drug use (women: 11.9%, $n = 42$; men: 1.5%; $n = 67$, Fisher exact, $p = 0.031$), and laziness (women: 9.5%, $n = 42$; men: 0.0%, $n = 67$, Fisher exact, $p = 0.020$).

Table 3. Reported causes for past divorces.

Cause of Divorce	Women	Men	*p* (Fisher Exact)
Partner behavior	16 (38.1%)	12 (17.9)	0.025
No respect/don't get along	10 (23.8)	11 (16.4)	0.455
Partner abuse	6 (14.3)	0 (0.0)	0.003
Partner alcohol/drug abuse	5 (11.9)	1 (1.5)	0.030
Partner laziness	4 (9.5)	0 (0.0)	0.020
Infidelity & Jealousy	6 (14.3%)	24 (35.8)	0.016
Partner infidelity	2 (4.8)	14 (20.9)	0.025
Own infidelity	0 (0.0)	4 (6.0)	0.158
Partner jealousy	4 (9.5)	8 (11.9)	0.764
Circumstance	7 (16.7)	13 (19.4)	0.803
Location disagreement	6 (14.3)	4 (6.0)	0.179
Don't get along with in-laws	1 (2.4)	3 (4.5)	1.00
War	0 (0.0)	6 (9.0)	0.080
Not wanting marriage	7 (16.7)	13 (19.4)	0.803
Partner left to marry other	2 (4.8)	2 (3.0)	0.638
Partner wanted someone else/didn't want current marriage	5 (7.1)	10 (14.9)	0.779

Similar gender effects were revealed when participants were asked how likely they would be to seek divorce given eight hypothetical scenarios (Table 4). Men more frequently reported they would pursue divorce for all scenarios except abuse. The three highest ranked scenarios for men were partner infidelity (76.2% saying they would likely divorce), partner alcoholism (75.6%), and not being able to get along (66.7%). For women, the top three were partner alcoholism (56.1%), partner laziness (56.1%), and partner abuse (54.4%). Men and women were in agreement that having problems with in-laws, partner sterility, and not being in love were the scenarios least likely to motivate them to divorce. Overall, the hypothesis that men would be more focused on infidelity than women (H3), is supported, as is the hypothesis that abuse would be a more salient factor for women (H5). While no women directly referenced men's levels of investment (H4), their disproportionate focus on laziness provides tentative support to the hypothesis.

Table 4. Percentage reporting they would likely divorce in different scenarios.

	Women		**Men**	
Rank	**Scenario**	**% Likely to Divorce**	**Scenario**	**% Likely to Divorce**
1	Partner alcoholism	59.6%	Partner infidelity	76.2%
2	Partner lazy	56.1	Partner alcoholism	75.6
3	Partner abusive	54.4	Don't get along	66.7
4	Don't get along	52.6	Partner lazy	59.5
5	Partner infidelity	32.8	Partner abusive	47.6
6	Don't get along with in-laws	31.6	Don't get along with in-laws	42.9
7	Partner sterile	29.8	Partner sterile	35.7
8	Not in love	28.3	Not in love	30.6

3.4. Initiators of Divorce

When asked who more strongly desired each divorce—the wife, the husband, or both equally—the pattern that emerged from participant responses mirrored that reported for large Western populations. Both men and women more frequently reported that a divorce was desired more by the wife than by the husband, and women reported they themselves wanted a divorce slightly more often than men, which supports H7 (Table 5). However, the proportions that men and women assigned to each category were not significantly different ($n = 94$, Fisher exact, $p = 0.344$). Of the cases in which one partner was reported to have wanted the divorce more ($n = 79$, 84% of all cases), women were reported to want it more in 59.5% of the divorces, and men in 40.5% of the divorces (testing against an evenly split distribution, $n = 79$, $\chi^2 = 2.848$, $p = 0.091$). Only onedivorce was recorded by both the previous husband and wife—they both agreed that the husband wanted the divorce more.

Table 5. Divorces that were wanted more by husbands, wives, and both equally.

	Wife Wanted More	**Husband Wanted More**	**Both Wanted Equally**
Female respondents	19 (54%)	13 (37)	3 (9)
Male respondents	28 (47)	19 (32)	12 (20)

In a Bayesian mixed-effects logistic regression, with each divorce as the unit of analysis, and respective Husband and Wife identifiers included as crossed random effects, the number of children present at the time of divorce is negatively associated with the likelihood of the woman being the one who most wanted the divorce, although Year in Marriage and individual age exhibit no effects, partially supporting H7 (Table 6). For divorces that occur without children, over two-thirds of respondents reported that the wife wanted the divorce more (Figure 3). However, this proportion drops to less than a third for those that occur when the couple has three or more children.

Table 6. Bayesian logistic regression of likelihood a divorce was most wanted by the wife. Reported coefficients are posterior means.

	B	**95% CI**
Intercept	1.23	(−0.68, 3.22)
Wife's Age at Divorce	−0.03	(−0.13, 0.06)
Number of Dependents	−0.31	(−0.60, −0.04)

$n = 90$ divorces, Husband ID and Wife ID included as crossed random effects.

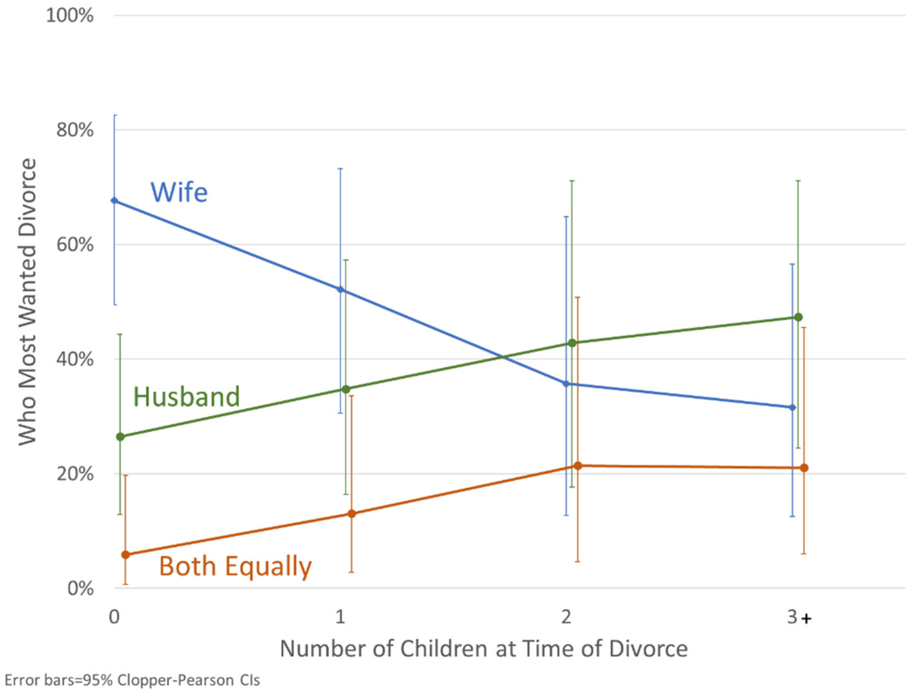


Figure 3. Proportion of Divorces Most Wanted by the Wife, Husband, or Both by Number of Children.

3.5. Costs of Divorce

In support of H8, there was general agreement in this community that divorce is more costly for women than for men. When asked if divorce tended to be more difficult for women or for men, 74.6% of women (n = 59) and 47.8% of men (n = 46) reported that it was more difficult for women. Only 3.4% of women and 10.9% of men said it was more difficult for men (the remainder said it was equally difficult for both men and women). When asked why divorce was difficult for women, the most commonly discussed topics related to the difficulty of raising and providing for children, who most often stay with the mother. Children were mentioned in 52.9% of responses (n = 85), and an increased burden or lack of needs (e.g., clothes, food, and money) was mentioned in 30.1% of responses. For instance, one woman explained, "All of the work is left to her—she has to care for the children, maintain the clothes—it's all left to her". Indeed, participants reported that following divorces involving children, the children stayed with the mother after 78.0% (n = 59) of divorces, and responsibilities were somehow shared with the father in an additional 5.1% of the cases. Fathers became the sole caretakers following only 6.8% of such divorces. Grandparents became the primary caretakers for 10.2% of the cases, but in all but one, it was the maternal grandparents who cared for the children.

The most commonly mentioned problems afflicting men after divorces were seemingly less dire, supporting the opinion that women suffer more from divorce. These challenges included not having a spouse to perform the domestic tasks that are often the responsibility of wives, such as cooking and washing clothes (mentioned in 30.1% of comments, n = 73), and the fact that men often miss their children (31.5% of comments). One man related, "When he's alone, he's worried about his family, and he has to wash his own clothes and cook his own food".

The results of a discrete events history analysis provide tentative support for H9—that divorce is more costly for women, at least regarding the length of time to remarriage (Table 7). Surprisingly, the number of dependents was associated with a slight increase in the likelihood of remarriage in years after divorce. Furthermore, there were no discernible interaction effects between gender and age or gender and number of dependents (Supplementary Materials, Table S2).

Table 7. Discrete-time event history analysis of risk of remarriage using Bayesian logistic regression. Reported coefficients are posterior means.

	B	**95% CI**
Intercept	−1.16	(−2.38, −0.07)
Gender = Woman	0.49	(−0.11, 1.07)
Age	−0.01	(−0.06, 0.05)
Number of Dependents	0.15	(−0.01, 0.30)
Other Partner Wanted	−0.40	(−0.94, 0.14)

n = 335 risk years, 53 individuals. Individual ID included as random effect.

4. Discussion

We set out to document the timing, predictors, causes, initiators, and outcomes of divorce among a near-natural fertility Mayangna/Miskito community. We show that this population exhibits an early initiation of marriage and reproduction, with median times ranging from the late teens to the early twenties, and universal participation. By the age of thirty, nearly all individuals have married and reproduced at least once.

Universal marriage and reproduction is a common feature of populations characterized by natural fertility and subsistence-level economies. These populations exhibit far less variation in life history schedules and economic paths compared to wealthier, industrialized populations. This naturally leads to marriage functioning differently and being conceptualized differently (Coontz 2006). For instance, in the Investment Model Scale (Rusbult 1980)—a research instrument designed to measure one's commitment to a relationship—the suggested alternatives to a romantic relationship are listed as "dating another, spending time with friends or on my own, etc.". When translating this scale into Mayangna, local research assistants agreed that the more salient alternatives in this community were to "live with another partner, live with your parents, or live alone", (Winking et al. 2018). Romantic relationships are not seen primarily as a means to improve the quality of one's leisure time or even to establish a meaningful emotional connection. They represent an inevitable step in the unfolding of life and are necessary to build a family and to share the economic tasks that keep a household functioning. This does not mean that strong connections and romantic love are not important for building these relationships, but they are not the sine qua non of a successful marriage. In fact, out of eight possible reasons to divorce a partner, "not being in love" was rated the least important factor by both men and women (Table 4).

To further explore patterns of divorce in this community, we applied a behavioral ecology theoretical approach to produce nine hypotheses regarding the predictors, causes, initiators, and outcomes of divorce in this population, all but one of which received at least tentative support (Table 8). In this approach, we explored the different models offered in the literature regarding the evolutionary functions of marriage. We then identified the purported functions common to the different models, namely, the avoiding of costly searching for romantic/reproductive partners, and the benefits of biparental investment in the wellbeing of shared children.

We found that the number of children in a marriage was indeed negatively associated with the likelihood of a marriage ending in divorce. In the previous literature, such effects were inconsistent and complex—young children often serve as a buffer against divorce, but older children do not (Hewitt 2009). This could be an artifact of self-selection, however, as more committed couples might be more likely to decide to have children. Furthermore, previous research involved low-fertility populations with little variation in the number of children within and across marriages. In the present study, by the median length of marriage, four years, 84.2% (n = 81) of couples had at least one dependent. By year 10, all had reproduced save a small number of couples who were unable to have children, with an average of 5.0 dependents per couple (n = 40). Thus, the test here is a clearer examination of the impact of children, as the potential for self-selection effects are likely diminished. The buffering effect of children is likely not an artifact of more committed couples being more likely to decide to have children, as virtually all couples are deciding to do so. Furthermore, we are able to examine the impact of children along a much larger range of variation in the number of offspring.

Table 8. Hypotheses and results.

Hypothesis	Result
H1. *Marriages will be less likely to end in divorce when there are more dependent children in the household, controlling for the length of marriage.*	Supported
H2. *Marriages will be more likely to end in divorce when individuals are younger.*	Not supported
H3. *Men will be more likely to divorce due to partner infidelity.*	Supported
H4. *Women will be more likely to divorce due to a lack of partner investment.*	Tentatively supported Women were more likely to divorce due to partner "laziness".
H5. *Women will be more likely to divorce due to partner abuse.*	Supported
H6. *Women are more likely to initiate divorce.*	Supported
H7. *Women's greater likelihood to initiate divorce will be mitigated as women age and the number of children increases.*	Tentatively supported Women's likelihood of initiating divorce decreases with the number of children but not age.
H8. *Participants will report that women suffer more from divorce.*	Supported
H9. *The time to remarriage will be longer for divorced women than divorced men.*	Tentatively supported The effect was in the predicted direction, but weak.

Younger individuals were predicted to be more likely to divorce due to lower costs of re-entering the marriage market—at younger ages, there are more age-appropriate partners available for marriage, and for women, youth itself often makes one more competitive on the market (Buss 1989). However, we did not find any such association. This is contrary to the robust effect reported in existing literature, in which the effect is interpreted as the negative impact of marrying young (Raley and Sweeney 2020). That is to say, after controlling for years in marriage (a very salient determinant of divorce risk), age and age at marriage become the same variable. Thus, it appears here that individuals are no more likely to divorce at younger ages and/or when they marry younger.

For the other hypotheses, we examined how men and women experience the benefits of marriage differently. If, as argued in evolutionary models of human marriage, marriage facilitates biparental investment by increasing paternity confidence, then men might be more sensitive to partner infidelity. This is indeed what we found, both in the reported causes for past divorces, and in hypothetical reasons for divorcing. Similarly, the predictions that women would be disproportionately focused on partner investments and abuse were supported.

The final series of predictions were founded upon previous research: that women were more frequent initiators of divorces, and that they suffered greater negative consequences from marriage (Sayer et al. 2011; Tamborini et al. 2015). Indeed, we find that women in this community experience greater negative consequences from divorce, and despite this, they continue to more frequently initiate divorce. Similar to studies involving Western populations, there was a slight tendency for women to be less likely to remarry following divorce, although age was not a significant factor. Those with more children were actually slightly *more* likely to remarry. In the existing literature, the impacts of children on rates of remarriage are mixed, and, as was argued in the introduction, this positive trend might reflect a more active motivation to more quickly find a partner among single parents. Overall, this study suggests that the pattern of women incurring greater costs from divorce but still being more likely to initiate divorce is not an artifact of industrialized, Western culture, but can also occur in a near-natural fertility population, where the decision to divorce is open to both men and women and divorce is not heavily stigmatized. Naturally, this presents a quandary.

Evolutionary models of marriage suggest that, all things equal, the greatest cost of marital dissolution to women would be the loss of investment toward children. This could be mediated by remarriage, but higher numbers of children can also hinder remarriage. As predicted, results suggest that, as the number of children increases in the marriage, the proportion of divorces initiated by women declines, such that men become more likely to initiate divorce once there are at least two children in the family.

Conclusions

As with Beckerian and Social Exchange models, which have long been used to interpret patterns of divorce in Western populations, the behavioral ecology approach employs a cost–benefit method. However, the behavioral ecology approach contributes by anchoring these models to theoretically motivated currencies—namely the wellbeing of children, the avoidance of the costs of re-entering the marriage market, and the reproductive and interpersonal challenges unique to either men or women. Here, we tested nine hypotheses derived from the logic of behavioral ecology and report support for all but one of them, illustrating the utility of such an approach. This study also highlights the importance of expanding the cross-cultural record to include small-scale populations, which have long been overlooked in the social science literature. This is particularly important for research questions that directly relate to topics such as reproduction and family—two dimensions which exhibit patterns of variation across small-scale populations that are largely absent in Western populations. Lastly, the expansion of cross-cultural breadth highlights the cultural embeddedness of marriage and divorce by revealing the extent of cultural diversity inherent to the institution of marriage. However, it also reveals the boundaries of that variation, outlining the space that defines this uniquely human phenomenon.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/socsci10060212/s1, Marriage and Divorce Interview, Table S1: Discrete-time Event History Analysis of Risk of Divorce for Couples over 18 Years of Age Using Bayesian Logistic Regression. Reported coefficients are posterior means, accompanied by 95% confidence intervals from the posterior distribution, Table S2: Discrete-time Event History Analysis of Risk of Remarriage Using Bayesian Logistic Regression including interaction effects for Gender*Age and Gender*Number of Dependents.

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Article

Non-Parental Investment in Children and Child Outcomes after Parental Death or Divorce in a Patrilocal Society

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Abstract: Children rely on support from parental helpers (alloparents), perhaps especially in high-needs contexts. Considerable evidence indicates that closer relatives and maternal relatives are the most likely to provide this care, as inclusive fitness theory suggests, but whether this is equally true across different family types and in culturally patrilocal societies requires investigation. This structured interview study (N = 208 respondents with 323 dependent children) focuses on who helps raise children in rural Bangladesh after the father's or mother's death, or divorce, in comparison to families with both parents present or the father temporarily a migrant laborer. Family types differed in where and with whom children resided, who served as their primary and secondary caregivers, and who provided material support, but mother's kin played a major role, and were the primary providers of material resources from outside the child's household in all family types. Despite the patrilineal ideology, only one-quarter of children of divorce lived with the father or his family, and even after the death of the mother, only 59% remained with father or other paternal kin. Household income varied by family type and was a strong predictor of child height and weight. The children of deceased mothers moved between successive caregivers especially frequently, and were uniquely likely to have no schooling. The typology of Bangladeshi society as patrilocal obscures the extent to which matrilateral family support children's well-being.

Keywords: alloparents; grandmother; death of a parent; divorce; Bangladesh; family laterality; childcare; kinship; human behavioral ecology; mother's brother

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1. Introduction

While many studies have focused on the effects of losing either a mother or a father on child outcomes, few have compared intact (two-parent and father away for migrant labor), mother-deceased, father-deceased, and divorced families in a single study. Substantial numbers of Bangladeshi children are being raised in each of these five family types, which are judged more or less approvingly or pejoratively by the larger society. By utilizing human behavioral ecology (HBE), the importance of the ecological conditions (post-marital residence patterns and family type) and cultural variation in parenting allows for more refined and focused hypotheses and interpretations of the data. By the inclusion of all five family types, attention is drawn to how family disruption type affects children, and it is anticipated that these may be mediated by differences in the contributions of alloparents (non-parental caregivers).

1.1. Theoretical Foundation

Human beings have been called "cooperative breeders" because parents rely heavily on alloparental support in the form of both direct childcare and material investments (Hrdy 2009, p. 30). Alloparents are usually relatives, presumably because only kin gain indirect fitness from costly contributions (Emlen 1995). But which relatives provide alloparental investment, under what circumstances, and with what effects on children? These questions have inspired considerable discussion (Davis and Daly 1997; Emlen 1995; Hrdy

2009). Common hypotheses are that closer relatives and mother's relatives will invest more than distal and paternal kin because of differential indirect fitness payoffs, and hence will promote better outcomes for children (Hrdy 2009; Konner 2010; Perry and Daly 2017). These evolution-minded hypotheses provide broad direction when considering universal patterns of alloparental caregiving, are open to empirical testing, and have garnered support in various societies (Daly and Perry 2017). HBE entails a focus on variation " … within and between populations, as the result of adaptive adjustment of parenting behavior to particular ecological conditions (phenotypic plasticity), as well as cultural variation in parenting behavior (which may or may not be adaptive)" (Sear 2016, p. 98). The purpose of this research is to understand the association between social environment in rural Bangladesh and alloparental caregiving.

1.2. *Alloparental Caregiving*

Alloparental care and investment vary substantially across cultures (Gibson and Mace 2005; Hrdy 2009; Konner 2010). In a review of hunter-gatherer practices, for example, Konner (2005) notes that direct allomaternal care ranges from almost none in the Ache (Hill and Hurtado 1996) to a very high level in the Efe where 18-week-olds spend 60% of their time in physical contact with people other than their mothers (Ivey 2000). Factors that apparently influence alloparental caregiving include demographic variables (Hewlett 1991; Hewlett and Lamb 2005; Turke 1988), changing subsistence patterns (Hewlett and Lamb 2005; Hirasawa 2005; Perry 2017a; Valeggia 2009) and other ecological variables (Hames 1988; Hill and Hurtado 1996; Hurtado et al. 1992; Starkweather 2017).

Alloparental contributions become crucial after parental death or divorce, and who steps forward to provide alloparental care may vary depending on the reasons for the parent's absence. In some situations, extended families reduce or terminate their involvement with the child (Biblarz and Gottainer 2000; Drew and Smith 1999; Westphal et al. 2015), a phenomenon that has been insufficiently studied outside of Western democracies (Lawson et al. 2017; Shenk et al. 2013). Comparing alloparental assistance in normative two-parent families vs. those in which parents are absent for different reasons (mother's or father's death or parental divorce) is important for understanding how and why children's needs are, or are not, being met.

A substantial body of research has focused on alloparental assistance to intact mother-father families residing neolocally (that is, apart from either spouse's family of origin), especially in Western democracies (Coall and Hertwig 2010; Tanskanen and Danielsbacka 2018). In general, the presence of maternal grandmothers is associated with positive child outcomes, which is also true in modernizing societies (Huber and Breedlove 2007; Nenko et al. 2020; Sear and Mace 2008; Strassmann and Garrard 2011), and may be especially important for children in non-intact families. Modernizing in this context means " … to encapsulate any of the various processes by which self-sufficient, subsistence-based, small-scale (i.e., "traditional") societies transition away from low-intensity and relatively localized means of living" (Mattison and Sear 2016, p. 337).

In modernizing societies, post-marital residence is often patrilocal (i.e., the bride moves to her husband's family; Murdock and Wilson 1972; Korotayev 2003), which constrains children's access to matrilateral kin (Munro et al. 2015). Studies of alloparenting in normatively patrilocal societies indicate that although father's kin play a substantial role, which is unsurprising given their proximity and the cultural emphasis on patrilineage that usually accompanies patrilocality, mother's kin also remain heavily involved (Mulder 2007; Gibson and Mace 2005; Huber and Breedlove 2007; Judd 1989; Perry 2017a; Daly and Perry 2017; Scelza 2011; Scelza and Bird 2008). Little of this research has explicitly contrasted intact versus non-intact families. More research in normatively patrilocal societies, in which a very large proportion of the world's children now reside, is needed.

In modernizing societies, the contributions that would customarily have come from a missing mother or father may or may not be provided by others, with important consequences for child development and well-being. Even in the Western democracies, children of divorce and partial or full orphans suffer deficits in education, and in mental and physical health (Amato and Anthony 2014; Cerel et al. 2000; Gertler et al. 2004; Raley and Sweeney 2020; Wallerstein and Rosenthal 2013), and in low-income nations, they are at risk for poor physical development, health, and educational outcomes, and higher mortality (Lawson et al. 2017; Mwangome et al. 2012; Ronsmans et al. 2010; Sands et al. 2017; Shenk et al. 2013). Does the availability and participation of particular alloparents mitigate these negative outcomes?

1.3. Study Context

The Bangladeshi population is approximately 90% Muslim and 8.5% Hindu, with the remaining population being Christian, Buddhist and other small minority groups (Bangladesh Bureau of Statistics 2014). It is estimated that 1.8% of the population is "indigenous", representing 54 groups with approximately 80% of those identified as indigenous living in the Chittagong Hill Tracts (IWGIA 2021), a significant distance from Matlab. There is a small population of Shodagor that live in the Matlab area (the site of this research), consisting of fewer than 200 people and although they are culturally different from the dominant population, they identify as Muslim, are Bangla speaking, and are not considered indigenous (Starkweather 2017).

Matlab, Bangladesh, with a population of approximately 230,000, is an excellent setting for investigating alloparental investment in a patrilocal society. Substantial research has been conducted there for over 50 years, under the auspices of the International Centre for Diarrhoeal Disease Research, Bangladesh (icddr,b). Predominantly rural and approximately 90% Muslim and 10% Hindu, Matlab continues to be described as normatively patrilocal, with extended families occupying joint family compounds, or *baris*, in which a senior couple resides with their sons, daughters-in-law, and grandchildren. Women are expected to observe *purdah* (their seclusion, with chaperoning in their public appearances) beginning before puberty (Amin 1998; Cain et al. 1979; Feldman and McCarthy 1983; Jahan 1973; Lata et al. 2021; Rao 2012). These accounts suggest that married women have little contact with their families of origin and rely on their in-laws for support, but there are grounds for thinking this an overstatement, most notably because married women often return to their natal homes to give birth and may stay for many months (Edhborgh et al. 2015; Perry 2017b).

According to icddr,b census data, most children reside in families with both parents present or with the father absent as a migrant laborer. However, many other children have lost one or both parents to death or divorce (icddr,b 2015), permitting comparisons across living arrangements with respect to who helps and how children fare in the various forms of parental absence. The present study focuses on who provides primary care and alloparental assistance (their relationship to the child, including family laterality, and whether they provide direct care or material support) in intact and non-intact families, as well as on associated child outcomes (height, weight, and educational attainment). Five family types are distinguished: both parents present, migrant labor families where the father works elsewhere, and those in which the focal children's mother is deceased, father is deceased, or parents are divorced.

Perry (2017a) has described alloparental caregiving and its consequences in intact Matlab families. Despite obstacles, mothers derived substantial alloparental assistance from their natal families, and made considerable effort to maintain these relationships (Perry 2017b). Most mothers of young children dwelt in their in-laws' *baris*, but over 40% did not (12% lived matrilocally and 35% neolocally); maternal grandmothers provided more childcare than expected on the basis of *bari* co-residence, and paternal grandmothers provided less; and material investments in children from outside the immediate household came primarily from maternal relatives, especially mothers' brothers (Perry 2017a), in keeping with a widespread matrilateral bias in alloparental investment (Perry and Daly 2017). Here, I extend the analysis to include non-intact families, and assess whether this matrilateral bias is seen in these higher-needs circumstances as well.

In Bangladesh, the co-residing married couple is normative, but father absence due to migrant labor evokes no negative reaction (Bhuiya et al. 2005; Rahman 2010) and is instead viewed positively due to its association with higher income (Shenk et al. 2013; Schoen 2019). Having a parent absent due to death or divorce, by contrast, is viewed negatively (Alam et al. 2000; Munro et al. 2015; Rahman et al. 2013). Women are commonly blamed for causing divorce (icddr,b 2015; Munro et al. 2015), which is characterized as the most "detestable" of allowable situations (Bangladesh Laws 2016), and widows interviewed for this study reported that they were often blamed even for their husbands' deaths. Widows and divorcées are seen as burdens on extended family and may be treated with outright hostility (Jahan 1973; Lewis 1993; Munro et al. 2015), leaving them and their children vulnerable.

Divorced or widowed men may also be stigmatized, but to a lesser degree than women (Alam et al. 2000; Amin 1998; Rahman et al. 2013), which reflects both double standards (Amin 1998; Feldman and McCarthy 1983) and men's ability to maintain their wage earning role and avoid becoming financial burdens, which have not typically been options for rural widows and divorcées (Jahan 1973; Lewis 1993).

1.4. Hypotheses

Negative attitudes toward widows, widowers and divorcées may affect whether alloparental caregivers come forward, and if so who. I hypothesize that, in general, secondary caregivers will vary by family type. This leads to additional hypotheses addressing the ways in which family type will be associated with alloparental support. Children of divorce may be especially disadvantaged in this regard, because of the stigma associated with divorce. Alternatively, children whose mothers have died may be uniquely disadvantaged because maternal death (1) takes away their most important caregiver (Hrdy 2009; Konner 2010; Strassmann 2011), and (2) breaks links with maternal relatives.

When fathers cannot provide for the needs of their children, it is normative that the father's male kin should provide for his wife and child(ren) (Amin 1998; Feldman and McCarthy 1983; Gardner and Ahmed 2006; Indra and Buchignani 1997; Munro et al. 2015), which would result in mother's family providing less alloparental aid than father's family after parental death or divorce. An alternative hypothesis, however, based on the importance of nepotism and mother's family in evolutionary interpretations of alloparenting (Perry and Daly 2017), is that matrilateral kin, especially maternal grandmothers, will be more involved than father's kin and will buffer the effects of parental death or divorce. In a patrilocal society, comparing children in intact families to those with a parent absent due to divorce or death can illuminate effects of culture and nepotism on alloparental investment and the subsequent effects on children. This more nuanced understanding of alloparental care has relevance for developing theory about alloparental caregiving and human nepotism, as well as for policy and applied work.

2. Methods

2.1. Rationale for Interview Methodology

Prior anthropological research on alloparenting has used two methods, each of which has strengths and weaknesses. One entails demographic analyses of large census-based and historical databases (Beise 2005; Sear and Mace 2008, 2009; Voland and Beise 2005) which permit robust estimates of the correlates of child mortality and other outcomes (Clarke and Low 2001), but seldom provide evidence on actual behavior. Thus, an apparent "grandmother effect", for example, may or may not have anything to do with alloparenting (Nettle 2012; Perry 2017a; Strassmann and Garrard 2011). The second approach entails intensive observation (Crittenden and Marlowe 2008; Meehan 2005; Nettle 2012), which provides direct evidence on the magnitude of alloparenting, but is necessarily constrained by limited sample sizes and statistical power. This study uses an intermediate approach, namely the collection of interview data specifically targeting alloparental contributions, supplemented by census-based evidence on family histories, plus direct anthropometric measurements of the dependent children.

2.2. Sampling Strategy

Matlab was chosen as the field site because of its patrilocal and patrilineal social structure, high-quality census data, and 50-year history of research. The icddr,b has been collecting information on every household in Matlab since 1964, recording each birth, death, in-migration, out-migration, marriage, and divorce, at frequent intervals (every two months at the time of this research). The resultant database permits researchers to draw random samples of various types from across the jurisdiction. For the present study, icddr,b staff initially drew five random samples, each consisting of 100 families, representing the five family types: "two parents present", "father migrant laborer", "mother deceased", "father deceased", and "divorced". These situations sometimes resulted in children having non-parental primary caregivers, with the remaining parent not co-residing with the child. These were important scenarios to track, because change in primary caregiver from parent to alloparent was one area of interest in this study. Selection criteria included that there be one or more living children less than 13 years old in order to ensure they were dependent on parental caregiving and resources. It would be extremely unlikely that children of these ages would be married or engage in paid labor. The primary caregiver had to be at least 19.

Twelve open-ended interviews (2 or 3 from each family type) were initially conducted with the help of a local research assistant/translator, eliciting respondents' experiences, expectations, and conceptions of local norms concerning childcare and alloparental assistance. Insights derived from these interviews informed the development of the structured interview, which provided the data presented here. The open-ended interviews were not analyzed systematically, but along with field notes made during the structured interviews, they provide additional ethnographic detail.

Available primary caregivers from the five random samples were then approached for interview, with as many structured interviews completed as was possible within the time available, March through May 2014. Interviewees were not forewarned of the researcher's visit (which would not generally have been possible), but were simply approached at their residence after the researcher had travelled to the locale provided by the icddr,b database.

One hundred and ninety respondents participated in the structured interviews. Because eighteen respondents had children in more than one family type, there were a total of 208 cases (where a "case" refers to a sibling group in the same family circumstance): 65 two-parent families, 53 migrant labor families, 30 mother-deceased families, 32 father-deceased families, and 28 divorce families. Information was obtained on all children under the age of 13 for whom the respondent was responsible, making a total of 323 dependent children in the structured interview database.

2.3. Interview Content

The structured interviews consisted of standardized questions and required approximately an hour to complete. Data from the census books in the icddr,b Matlab field office were combined with the structured interview data to supplement information on child residence and primary caregiver changes, and to validate birth dates and other interview data. Questions elicited basic demographic information, family socioeconomic status, co-*bari* and co-household residence, who served as childcare and resource providers, and education level of parents and children. For the analyses presented here, crucial questions included the following:

Whose *bari* is this (i.e., that in which the interviewee and children resided)?
What is your relationship to the children you are raising?
Who is their most common caregiver (other than you)?
Are there people who give your family gifts, payments for school, clothing, payments for medical expenses, etc.?

Follow-up questions detailed the resources provided, who provided them, and the recipients.

Interviewees were asked to estimate their household income in Bangladeshi Taka per month (see Perry 2017a). "Adjusted household income" was then computed by dividing by the square root of the number of household residents, a standard method for adjusting household income because costs do not increase linearly with family size (Johnson et al. 2005). *Bari* residence was categorized as "paternal" if the *bari* belonged to the child's father's kin, "maternal" if it belonged to the mother's kin, and "neolocal" if it belonged to relatives of neither or had been established by the couple themselves.

Finally, data were collected on child outcomes. The height and weight of each dependent child available at the time of interview were measured using a tape measure and scale. Height-for-age and weight-for-height were then converted to age- and sex-specific standard scores, according to World Health Organization norms (WHO 2015), and it is these standardized scores that are analyzed here. Children who are 2 standard deviations below the world mean for weight-for-age or height-for-height are considered wasted (Victora et al. 2008) or stunted, and are at higher risk for many negative physical and developmental outcomes (de Onis et al. 2012a, 2012b). A final outcome measure, applicable only to children 6 years of age or older, was educational attainment: the difference between the actual grade level and the normative grade for a child of that age.

This study's focus on non-parental caregiving, including children not in the primary care of a parent, raises the questions of adoption, fosterage, custody and guardianship. These terms have significant cultural complexity because of their legal meanings and connection to religious rules in Bangladesh (Khyum Tithila 2020). For instance, under Bangladeshi family law, Muslims cannot legally adopt a child, but they could become a legal guardian or gain custody of a child, with clear restrictions on the child being eligible for inheritance. Hindus can legally adopt a son, but not a daughter, and an adoptive son has equal right to inheritance as a son by birth (Government of the People's Republic of Bangladesh 2013). Alternatively, Muslim or Hindu adults can obtain custody of a child without adopting or fostering a child (Guardians and Wards Act 1890). All of these terms are typically assumed to focus on children unrelated to primary caregivers. In situations where extended family are the primary caregiver of a child, no respondents reported legal changes in response to changes in the child's caregiver, and legal services would have been beyond the financial capacity of essentially all families in this study. When families report changes in primary caregiver to a family member, they would not involve legal changes. Legal adoption could have occurred with the children who were reported to be "adopted" out of the area, but none of the families specifically identified this arrangement and it is likely that they were not using the term as a legal term, but as a description of a permanent move of a child to an un-related primary caregiver family.

2.4. Representativeness of the Samples

The initial five 100-family samples were randomly selected, and should have been representative of those five family types. Which families were approached for interview entailed no systematic choice criteria other than attempting to distribute the interviews throughout the study area in order to include families living both close to villages and in more remote areas. Degrees of remoteness are difficult to define in this area because ease of access to residences varies by season, with some *baris* being hard to reach in the dry season being far more accessible by boat in the wet season, whereas other *baris* where they are more accessible in the dry season, because of proximity to roads. The best approximation that the local research assistants could identify was village versus non-village residence. Only two potential respondents turned down the request for interview, so refusals should not have biased the results. Two interviews had to be ended early and a few respondents did not answer all questions, accounting for the occasional "unknown" responses in the data presented.

Interviewees representing the five family types were not always members of the original five random samples for several reasons. First, it was discovered only after interviews began that although the "divorce" sample was intended to capture children of divorced parents, it had been drawn such that many were actually intact two-parent or father migrant laborer families in which the mother had had an earlier, brief, childless marriage. Moreover, whereas mothers in intact families were almost always found at home, primary caregivers in the three non-intact family types were not. Thus, if the researcher travelled to a rural *bari* only to discover that the targeted interviewee was not at home, or had moved, another family in the same *bari* was substituted. This type of substitution is an accepted methodology (e.g., Fraser Schoen 2014) and is unlikely to have introduced bias, because families within *baris* are apt to share family and neighborhood attributes. Finally, the circumstances of some targeted interviewees had changed such that they belonged to a different family type than when the sample was drawn (e.g., if the husband in a "two-parent" family had recently departed to be a migrant laborer). Others met the criteria for two groups (e.g., a woman caring for a stepchild and her own child of the present union, or a grandmother caring for her deceased daughter's infant and a dependent child of her own); when such women (n = 18) provided answers about both children (or sets of children) under their care, the relevant responses were then recorded separately under the two relevant family types. Whether any of these complications compromised the representativeness of the final five samples cannot be determined.

2.5. Analytic Strategy

Descriptive data (frequencies and percentages) are reported in Table 1 and Figures 1 and 2. Two types of analysis are then presented to assess the significance of differences among the five family types: (1) simple univariate between-group comparisons using Fisher Exact tests, χ^2 tests and ANOVA (with Scheffé post hoc comparisons), as appropriate, and (2) multivariate regressions to assess between-group contrasts in child height, weight, and education, net of the potential confounding effects of between-group differences in child age, child sex, household size, and adjusted household income.

Household income was adjusted for household size because the cost of additional family members does not increase in a linear manner. Household income could be a pathway by which living arrangements influence child well-being, so regressions were completed with adjusted income both included and omitted. The inclusion or exclusion of income did not affect the impacts of other variables in any analyses. Results for the regressions, which include adjusted household income are shown, because they have the higher R^2.

Because many children had siblings who are also in the dataset, there is a risk that the data within sibling sets will not be independent. There are, however, only 1.7 dependent children per respondent, on average, and with such small group sizes, Clarke (2008) and McNeish (2014) recommend a non-clustered regression to avoid overestimating the group-level variance components. Only non-clustered regression results are therefore presented, but additional analyses, producing nearly identical results, were conducted using a method (STATA's "vce" command) that clusters children into sibling groups.

2.6. Ethics Approvals

This "minimal risk" human participant study was approved in three ethics review processes: the home institution, the hosting NGO and its associated university in Bangladesh. The Institutional Review Board at the University of Missouri approved the ethics application in January 2014 (Project #1208454), the icddr,b's Research Review Committee approved the ethics application in February 2014 (PR14018), and the Ethics Review Board at the National University of Bangladesh approved the ethics application in March 2014 (PR14018).

3. Results

3.1. Attributes of the Five Family Types

Children of non-intact families lived in poorer homes, on average, than children of intact marriages. The mean adjusted household income of migrant labor families was 85K BTK, significantly higher than that of every other family type (ANOVA and Scheffé pairwise tests). For two-parent families, the mean was 58K BTK, for mother-deceased 46K BTK, divorced 34K BTK, and widowed 33K BTK. Because of substantial within-group variability, however, there were no significant pairwise differences among these latter four family types.

Child's age differed significantly across the family types ($F_{4,308} = 12.16$, $p < 0.0001$). Of note is the fact that children of divorce were younger (mean 6.7 years) than those of widows (9.4 years) or deceased mothers (8.5 years), partly because children were younger at the time of parental divorce or estrangement (mean 2.8 years) than at the time of a parent's death (mean age 4.2 years in both father-deceased and mother-deceased groups). A child of divorce was also much more likely to be an only child: 19 of 31 for whom the information was available (61%) had no full siblings, compared to just 5% of the children of widows and 19% of those with deceased mothers ($p < 0.0001$ by χ^2 test).

There were no statistically significant differences in child sex ratio across family types, although intact families had a slight preponderance of boys (57% male), and non-intact families a slight preponderance of girls (47% male). Children of widows had 2.6 full siblings on average (range 0–7), those of deceased mothers had 1.4 (range 0–5), and children of divorce 0.8 (range 0–5). Sibling sets are relatively infrequent in the data for disrupted families, however, for three reasons: siblings of focal children were often older than the inclusion criterion, were often dispersed across households, and were sometimes deceased. Thus, the 41 children of widows represent 32 sibling sets, the 44 children of deceased mothers represent 30, and the 32 children of divorce represent 28. Sixteen children had one or more deceased siblings, with no significant differences across family types, but two widows stood out by having had three and four children die, respectively, after their husbands' deaths.

3.2. Primary Caregivers

Table 1 presents, in part, the total number of children and their gender. In part A, *bari* types are summarized. The numbers of children in each family type and their primary caregivers' relationships to them are provided in part B. Children of intact marriages were almost invariably cared for by their mothers, as were 85% of the children of widows.

Among children of divorce, 50% were in the care of their mothers, and another 25% had been left with maternal grandmothers when their mothers remarried or moved to the city as wage laborers. The remaining 25% dwelt with father's family. There was no evident tendency for custody after divorce to differ according to children's sex or age at the time of divorce: the 24 in maternal family care consisted of 14 girls and 10 boys, with a mean age at divorce of 2.6 years, whereas the 8 in paternal family care were 5 girls and 3 boys with a mean age at divorce of 2.8 years. Fifty percent of the children of divorce and 15% of the children of widows were being cared for by someone other than their mothers, compared to 3% of children in intact families. Both non-intact family types differ significantly from intact families in this regard ($p < 0.01$, Fisher Exact Tests).

Children of deceased mothers were cared for by the widest array of relatives, with stepmothers the most common primary caregiver category (Table 1). In addition to the 15 children of deceased mothers and the 2 children of divorce who were in the care of stepmothers at the time of interview, several others had dwelt with stepmothers temporarily and had moved to grandmaternal care after the stepmother produced a child of the new marriage.

Table 1. Descriptive statistics of the sample by the five family types.

	Two Parents Present		**Father Migrant Laborer**		**Father Deceased**		**Mother Deceased**		**Parents Divorced**	
Total n of children	105		100		41		44		32	
	N	%	N	%	N	%	N	%	N	%
Male children	60	57	56	56	22	54	19	43	13	41
A. Bari residence of child										
Patrilocal	51	48	47	47	20	49	23	52	8	25
Matrilocal	9	9	23	23	2	5	8	18	18	56
Neolocal	44	42	27	27	14	34	7	16	6	19
Madrasa [1]	1	1	2	2	5	12	0	0	0	0
Adopted out	0	0	0	0	0	0	5	11	0	0
Unknown	0	0	1	1	0	0	1	2	0	0
B. Frequencies at which different relatives served as primary caregivers										
Mother	103	98	96	96	35	85	0	0	16	50
Father	0	0	2	2	0	0	1	2	0	0
Older sister	0	0	0	0	0	0	3	7	0	0
Maternal grandmother	1	1	0	0	1	2	8	18	8	25
Mother's sister	0	0	0	0	0	0	1	2	0	0
Paternal grandmother	0	0	0	0	0	0	7	16	4	13
Father's sister	0	0	0	0	0	0	1	2	1	3
Father's brother's wife	0	0	0	0	0	0	2	5	1	3
Stepmother	0	0	0	0	0	0	15	34	2	6
Madrasa [1]	1	1	2	2	5	12	1	2	0	0
Adopted out	0	0	0	0	0	0	5	11	0	0
C. Frequencies of nomination as child's secondary caregiver, by laterality and family type										
Paternal relative [2]	50	48	45	45	14	34	20	45	9	28
Maternal relative [3]	12	11	27	27	3	7	8	18	19	59
Sibling or sibling's wife	25	24	20	20	17	42	4	9	2	6
Non-relative	13	12	5	5	3	7	6	14	0	0
No-one	3	3	0	0	0	0	0	0	0	0
Not known	2	2	3	3	4	10	6	14	2	6
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Child age (years) [4]	5.99	0.34	5.91	0.38	9.41	0.32	8.47	0.41	6.58	0.63
Adjusted household income (1000s of taka) [5]	58.24	5.39	85.37	7.23	34.94	5.06	47.34	5.28	35.84	4.68

[1] *Madrasas* are residential religious schools. The two *madrasa*-dwelling children in the father migrant laborer group were siblings whose father taught at the *madrasa* that they attended, outside the Matlab area; this family considered the paternal *bari* to be their home and the *madrasa* a temporary residence for schooling only. [2] Paternal cases include 11 in which the father was the secondary caregiver: 7 in the two-parents group and 4 in the mother-deceased group. [3] Maternal cases include two in which the mother was the secondary caregiver: one in the two-parents group and one in the divorce group. [4] Child age differs significantly across the five groups: $F_{4,316} = 12.39$, $p < 0.0001$. [5] Adjusted household income differs significantly across the five groups: $F_{4,293} = 9.14$, $p < 0.0001$. According to Scheffé post hoc pairwise comparisons, migrant labor families had higher incomes ($p < 0.02$) than each of the other four groups, and there were no other significant differences.

3.3. Secondary Caregivers

Interviewees were asked to identify each child's "most common caregiver" other than the primary caregiver (hereafter referred to as the secondary caregiver). Section C of Table 1 summarizes their responses. The paternal grandmother was named as secondary caregiver 71 times and the maternal grandmother 45, but these frequencies were notably different across the family types. For 93 of the 205 children of intact marriages (45%), a grandmother was the secondary caregiver (60 paternal, 33 maternal), but this was true for only 23 of the 118 children of disrupted marriages (19%; 11 paternal, 12 maternal); $\chi^2{}_{1\,\mathrm{df}} = 20.7$, $p < 0.001$.

Surprisingly, none of the 35 children in the primary care of their widowed mothers had the maternal grandmother as secondary caregiver. This reflects the fact that widows, unlike divorcées, rarely returned to the natal *bari* (Table 1, Section A). If we compare children of widows to those of divorcées with respect to *bari* residence (paternal, maternal, or neolocal), the difference is highly significant ($\chi^2{}_{2\,\mathrm{df}} = 21.0$, $p < 0.0001$).

Why did widows and their children often remain in the *bari* of the deceased husband/father? A partial answer is that the widows were significantly older (mean age 41.2 years) than the divorcées (35.1 years; $p = 0.002$ by t-test) and relatively unlikely to have mothers to whom they *could* return; 41% of widows reportedly had deceased mothers, versus 7% of divorcées (although it must be noted that for children of divorce, interviewed caregivers from the father's family did not always know whether the child's maternal grandmother was alive). Perhaps more important, interviewees maintained that remaining in the patrilocal *bari* was necessary to protect their children's entitlements to inheritance from paternal kin, despite the disadvantage of scant support from their late husband's relatives.

3.4. Material Assistance

In addition to the child's secondary caregiver, interviewees were also asked who, other than members of the immediate household, provided material support such as food, clothing, and school fees or other financial assistance. Immediate household refers to the individual house within a *bari* in which the child resided. These were reportedly the property of the father residing in the household or his male heirs if he was deceased. Access to and control of the house within a *bari* is discussed further in the discussion. Strikingly, within every family type, mother's relatives were the most frequently named contributors (Figure 1) and the majority of those helpful maternal relatives were mothers' brothers. The prevalence of assistance from mother's family cannot be attributed to proximity; in fact, children more often dwelt in close proximity to father's kin than to mother's in all family types except for divorce families (Table 1, Section A), and the ratio of mother's kin to father's kin as resource providers (Figure 1) exceeds the ratio of maternal over paternal *bari* residence (Table 1, Section A) within each family type.

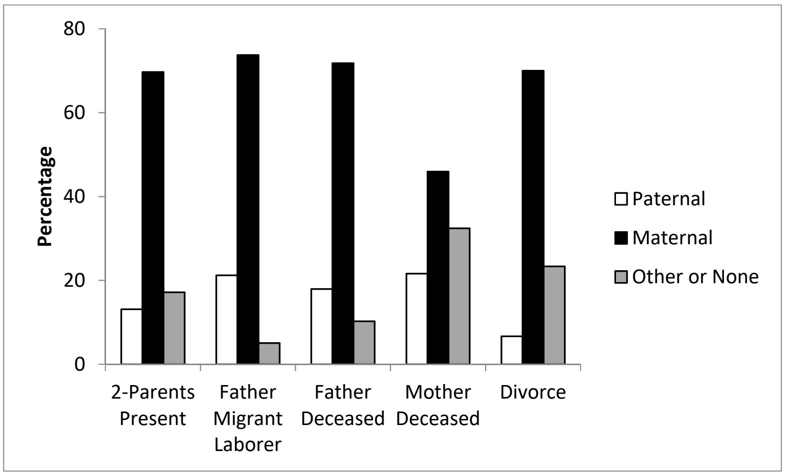

Figure 1. Percentage of paternal kin, maternal kin, and others who were nominated as a child's primary material resource provider (other than household members), by family type.

3.5. Attributes and Experiences of Children in Non-Intact Families

An important consequence of parental death or divorce is that children often change primary caregivers, sometimes repeatedly. Figure 2 portrays the numbers of primary caregivers that the children of non-intact marriages had experienced by the time of interview. (The number of moves between caregivers or households was often greater, as motherless children in particular moved back and forth between two caregivers.) Most children of widows experienced continuity of maternal care, and of residence as well. The experiences of children in the other two disrupted family situations were very different. Children of divorce either ceased to be cared for by their mothers (Table 1, Section B) or moved with their mothers to a different *bari* and a new social milieu. Children of deceased mothers experienced the most disruption, with primary care by a grandmother or stepmother often serving only as a stop gap. Each of these three groups differs significantly from the other two in the numbers of caregivers ($p < 0.001$ by Scheffé tests). Placing children with anyone other than extended family was rare, but five infants were adopted out at the death of their mothers, and a further five children whose mothers were poor widows were living in *madrasas* (see Table 1, Section A); with one exception, these children were not available to be measured. In the two-parent and migrant labor families, 98% and 96% respectively had only the mother as a primary caregiver, and no child had more than two.

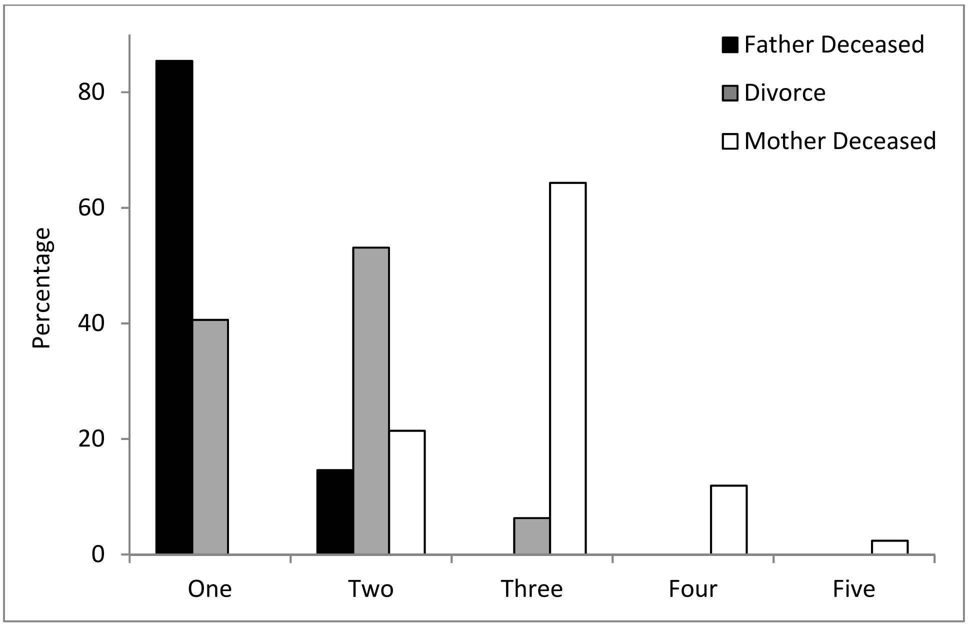

Figure 2. Percentage distribution of the number of primary caregivers that a child had experienced, by non-intact family type.

3.6. Maintenance of Contact with the Child's Maternal and Paternal Relatives

When marriages are disrupted by death or divorce, children may lose contact with kin. In the present study, the maintenance of contact with grandparents, aunts and uncles was assessed by asking primary caregivers how often they visited each such relative who dwelt elsewhere than in the same *bari*. For purposes of analysis, contact with maternal or paternal relatives other than the primary caregiver was considered to be ongoing if such a relative co-resided with the child in the same household or *bari*, had been visited by the interviewed primary caregiver within the past year, or was named as either the secondary caregiver or the primary provider of material resources. Figure 3 presents the percentages of children who maintained contact with maternal and paternal family.

Since widows tended to remain in their marital homes, often in the paternal *bari*, while deriving material assistance from natal kin, especially their brothers, it is unsurprising that children of widows usually maintained contact with kin of both parents; even those living neolocally usually maintained contact with both maternal and paternal family. By contrast, almost two-thirds of the children of divorce and of deceased mothers had lost contact with one side. Eight of 32 children of divorce dwelt in the paternal *bari* and thus maintained contact with paternal relatives; 4 of those 8 were no longer in contact with maternal kin. Paternal family contact had ceased for 12 of 18 children of divorce living in the maternal *bari* and for 5 of 6 living neolocally. In sum, 17 of 24 (71%) children of divorce not residing patrilocally had lost contact with paternal relatives, whereas just 4 of 14 (29%) not residing matrilocally had lost contact with maternal relatives (2-tailed $p = 0.02$, by Fisher Exact Test). Results for children of deceased mothers were similar, except that neolocal residence predicted ongoing contact with both sides.

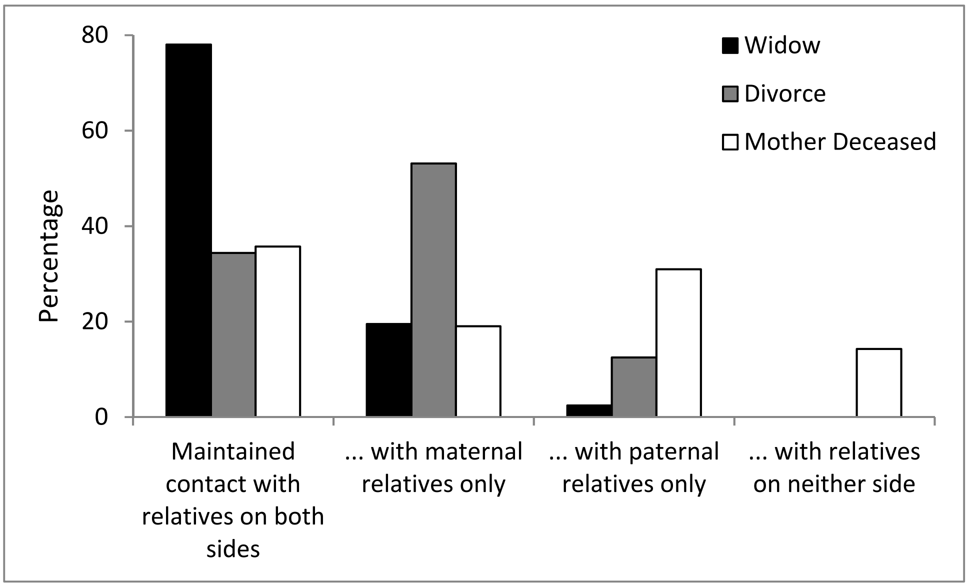

Figure 3. Maintenance of contact with maternal and paternal relatives in non-intact families.

3.7. Child Well-Being

Matlab's children are short and underweight (icddr,b 2015; Perry 2017a). Table 2 presents the WHO-normed standard mean heights-for-age and weights-for-height of children in the five family types. (WHO norms are available for height up to 120 cm tall and weight only up to the age of 10 years.) In regards to height-for-age, with the exception of the mother-deceased group, children in non-intact families did not appear to fare worse than those in intact families. For weight-for-height, children in non-intact families appeared to fare marginally worse than intact families, although this was not significant. In terms of the net effects of household income, there were no statistically significant pairwise differences among family types in residual heights and weights (Scheffé tests of pairwise comparisons from ANOVA; all $p > 0.3$). There were no significant differences between the sexes.

Table 2. Mean child height-for-age and weight-for-height, expressed as WHO-normed standard scores (see text), by family type.

	Two Parents Present	**Father Migrant Laborer**	**Father Deceased**	**Mother Deceased**	**Divorced**
Height-for-age	−1.3 (0.1, 72)	−1.3 (0.2, 59)	−1.2 (0.2, 29)	−1.7 (0.3, 18)	−1.3 (0.2, 20)
Weight-for-height	−0.7 (0.2, 51)	−0.7 (0.2, 37)	−1.3 (0.3, 7)	−1.1 (0.4, 9)	−0.9 (0.2, 13)

Standard error of the mean and number of measured children in each group are in parentheses.

A further outcome measure is child education: the difference between years of completed education and expected education for age. Children of intact marriages were on average 1.3 years behind in school, children of divorce 1.6, children of widows 1.9, and children of deceased mothers 2.8. Of course, the older a child, the farther behind one can be, so in order to compare between family types, child age must be controlled. Net of the effect of age, children of deceased mothers were significantly farther behind than all other family types except for children of divorce (ANOVA and Scheffé pairwise tests, conducted on age-controlled residuals), mainly because they were exceptionally likely to be kept out of school altogether: 42% of children over 7 years of age with deceased mothers had no education at all (Figure 4).

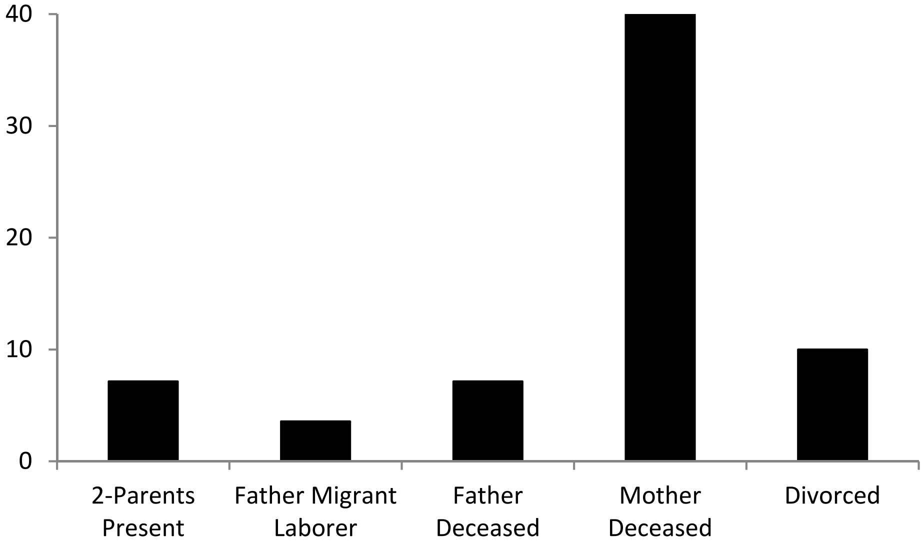

Figure 4. Percentage of school age children with no schooling, by family type.

In addition to family type, other variables that might affect child outcomes include the child's age and sex, the total number of household residents, and household income. Table 3 presents the results of multiple regressions conducted to assess the simultaneous impacts of these variables in conjunction with family type. As noted in the Methods, these analyses were conducted using both a non-clustered regression and one that clusters the children into sibling groups, with minimal differences in results. Only the non-clustered results are presented, following the recommendations of Clarke (2008) and McNeish (2014). The clustered and non-clustered methods yield identical coefficients and r-squared values, but different standard errors. The only difference in the identification of significant predictors was that a negative effect of having a deceased father on child height was significant ($p = 0.05$) in the clustered analysis, but not in the non-clustered analysis ($p = 0.07$).

Household income had a strong positive effect on height-for-age and weight-for-height, but not on educational attainment. In addition, children's weight-for-height was negatively affected by the total number of persons in the home. Children in divorced and father-deceased families suffered no substantial negative effects with income controlled. Children of deceased mothers, by contrast, had significantly less education than those in intact families. (Shortfalls in educational attainment were strongly affected by age, but this "effect" is trivial since the maximum possible shortfall increases with age.) It is noteworthy that there were no significant sex differences in any of the outcome measures, nor any sex by income effects in additional regressions (not shown).

At the suggestion of a reviewer, regressions were also run with adjusted household income removed, with no change to what results were and were not significant. There was a substantial increase in R^2 with the inclusion of adjusted household income, so this is the regression presented. Adjusted Household Income is the key factor in height-for-age and weight-for-height for the three non-intact family types.

Table 3. Multiple regression models predicting child height-for-age, weight-for-height and education on the basis of age, sex, family type, and household attributes.

	Height (SDs from WHO Norm for Child Age and Sex)				**Weight (SDs from WHO Norm for Child Height and Sex)**				**Education (Departure, in Years, from Norm for Age)**			
N children	193				116				125			
R^2 (Nagelkerke)	0.139				0.155				0.396			
F (model)	4.07				2.71				10.46			
p	<0.001				0.013				<0.001			
Predictor	**β**	**95% CI**	**t**	***p***	**β**	**95% CI**	**t**	***p***	**β**	**95% CI**	**t**	***p***
Child age (years)	−0.022	−0.078, 0.033	−0.80	0.424	**−0.115**	**−0.220, −0.010**	**−2.17**	**0.032**	**−0.387**	**−0.504, −0.271**	**−6.58**	**0.000**
Female child (ref: male)	−0.186	−0.514, 0.143	−1.12	0.266	0.059	−0.505, 0.388	0.26	0.794	0.155	−0.265, 0.575	0.73	0.467
N persons in household	−0.003	−0.101, 0.095	−0.05	0.956	**−0.174**	**−0.316, −0.033**	**−2.45**	**0.016**	−0.006	−0.133, 0.121	−0.09	0.925
Adjusted household income	**0.074**	**0.043, 0.106**	**4.70**	**0.000**	**0.057**	**0.016, 0.100**	**2.71**	**0.008**	0.034	−0.013, 0.814	1.45	0.150
Mother deceased [1]	−0.254	−0.829, 0.322	−0.87	0.386	−0.122	−0.973, 0.729	−0.28	0.777	**−1.18**	**−1.75, −0.610**	**−4.10**	**0.000**
Father deceased (widow) [1]	0.462	−0.040, 0.965	1.82	0.071	0.043	−0.1.02, 0.932	0.09	0.930	−0.256	−0.804, 0.292	−0.92	0.358
Parents divorced [1]	0.447	−0.116, 1.01	1.57	0.119	0.100	−0.626, 0.827	0.27	0.785	−0.203	−0.945, 0.539	−0.54	0.589

Bolded data indicate the results are statistically significant. [1] Reference group is all intact (two-parent and migrant labor) families. The comparison group for the three non-intact family dummies is all intact families (two parents present and father migrant laborer).

Additional regressions were run with the addition of a "Father Absent" dummy. This was not a significant predictor of any outcome variable, the coefficients were small, and including this additional dummy had no notable impact on magnitude (and none on sign or significance) of any other predictor variable.

4. Discussion

Maternal family are important alloparental investors in normatively patrilocal rural Bangladesh (Perry 2017a). The present report shows that their role becomes even larger after parental death or divorce. Maternal kin appear to be more committed to the maintenance of contact with and investment in children after marital disruption than their paternal counterparts (Figures 1 and 4).

There is a history in anthropology of typologizing entire cultures (Murdock and Wilson 1972), but there is also a parallel history of efforts to describe and understand the variation within cultures (Fortes 1969). According to this study, the typological description of Bangladesh as a patrilocal society is a half-truth: a little over half of two-parent, migrant labor, father-deceased, and mother-deceased families resided patrilocally. This is fewer than summary statements about Bengali culture imply, nor could one infer from the literature that most children of divorce reside matrilocally or neolocally.

The overarching hypothesis that alloparental support will vary by family type was supported in regards to both direct care and resource provisioning. This initial hypothesis led to two sets of alternative hypotheses. One concerns the laterality of alloparents; would patrilateral relatives help more, in keeping with cultural expectations, or would the matrilateral bias found in most societies predominate? The latter hypothesis gains more support from the data, especially with respect to material investments that are relatively unconstrained by proximity. The second set of alternatives concerned whether children of divorce or maternal death would have the greater negative impact on child well-being. The data indicate that maternal death imposes greater costs on children, perhaps because maternal relatives are able to buffer the negative effects of divorce.

In historical studies based on parish records and similar sources, whether a grandmother co-resides or is even alive has often been treated, implicitly or explicitly, as a proxy for alloparental caregiving (e.g., Clarke and Low 2001; Lahdenperä et al. 2004; Voland and Beise 2005). In the study reported here, however, patrilocal residence was no guarantee of assistance from paternal relatives, especially for widowed mothers who often remained socially isolated in the family compounds of their late husbands. Despite having the highest proportion of patrilocal residence of any family type, widows had to rely more than any other group on nuclear family (their older children and their sons' wives). In open-ended interviews, widows explained that they remained in the patrilocal *bari* to have somewhere to live and to protect their sons' patrimony. One widow, for example, reported that she stayed for the sake of her son even though her in-laws gave her nothing but a little rice in exchange for cleaning their houses. The only secondary childcare she received occurred each weekend when she visited her mother and brother, who also provided her with clothing, household supplies, and food. Her own mother had taken over caring for her eldest daughter, and her brother paid for her son's schooling. The data (Table 1) suggest that this case was not exceptional. It is striking that widows and their children received so little help from the children's patrilateral relatives, despite cultural expectations that hold the patrilineage responsible (Jahan 1973; Cain et al. 1979; Hossain 2003).

The children of widows exhibited no conspicuous deficits in this study; indeed, their height-for-age was above average (Table 2). Direct childcare needs were being met within the household by older siblings and sisters-in-law, and material needs were being provided by matrilateral family. These supports apparently offset the lack of support from paternal family, protecting children of widows from negative growth effects. In this study, as in others (Case and Ardington 2006; Foster and Williamson 2000; Sear and Mace 2008), the death of a mother is more clearly detrimental to children than the death of a father or parental divorce, notwithstanding the greater emphasis on father absence in much of the policy literature (Amato and Gilbreth 1999; Foster and Williamson 2000; Sarkadi et al. 2008).

Material support does not require proximity, and is therefore relatively unconstrained by *bari* residence. In all five family types, material support was provided mainly by mother's relatives, particularly mother's brothers, despite a purported cultural norm that the husband's family is primarily responsible (Cain et al. 1979; Feldman and McCarthy 1983; Hossain 2003; Jahan 1973). It has been noted previously that there are especially close emotional relationships between women and their brothers, and between maternal uncles and their nieces and nephews (Kenner et al. 2008), but there may be an additional reason why a woman's natal family is willing to help her. Women are legally entitled to a half share of what their brothers would inherit from their fathers, but most women leave the property with their brothers, hoping that they will provide help when needed (Scalise 2009). This is reminiscent of avuncular relationships in patrilineal African societies in which men provide their sisters' sons with food and land based on need, not inheritance (Goody 1959).

The situation for divorced women and their children was quite different. Children of divorce had the highest proportion of matrilocal residence, because their mothers frequently returned to the natal *bari*. Even children who remained with their fathers often lived neolocally, making patrilocality less frequent after divorce than in any other family type. Mothers who took the children when marriages ended were at the mercy of natal family to take them in (Bangladesh Laws 2016; Hossain 2003). Divorce is not only shameful, but also excludes women (and often their children) from any inheritance or support from the husband's patriline (Hossain 2003). Children of divorce had little access to patrilateral family or their support, because they were least likely to co-reside in the paternal *bari* (Table 1, Section A and Figure 1). The few divorced men who retained their children relied on new wives (stepmothers), unrelated friends, or patrilateral relatives for childcare. Divorce was not, in general, a fate of older women; rather, interviewees reported that divorce typically followed an estrangement while the wife was in her teens or twenties, had produced a single child or none, and had dwelt only briefly, if at all, in the marital home.

A young divorcée might return with her child, or more rarely, her children, to her natal *bari*, whereupon she was expected to remarry and leave any children with the maternal grandmother. If she could not remarry or the family could not afford to care for her and her child, she might leave to work in Dhaka or Chittagong and send remittances to help support her child. This was a shameful option, which women tried to avoid (Feldman and McCarthy 1983; Rao 2012). In every case in which a child of divorce dwelt matrilocally but was not in the mother's care, the mother had either remarried or moved to the city for work.

In this study, children of divorce, like those of widows, fared surprisingly well (Table 2), but this may reflect a selection bias. Divorced women who emigrate with their children typically end up in urban slums, where they suffer deficits in nutrition, health, and growth (Hassan and Ahmad 1991; Kamruzzaman and Hakim 2016). Divorced and deserted women constitute a higher proportion of the mothers in urban slums than in the Matlab population (Afsar 2003; Rabby 2015), suggesting that those who remain may be a minority with better-than-average social support, while more desperate divorcées emigrate to seek work. Moreover, even in Matlab, there is evidence that children of divorce have incurred excess mortality, at least until recently (Alam et al. 2001).

Children of deceased mothers had the most varied experience with respect to residence, caregivers, and resource providers. Infants whose mothers died were apt to be adopted out; these were the only adoptions in this dataset (although census records for families that were not interviewed included rare cases in which a poor widow or divorcée gave up a child for adoption). Approximately one-third of the children of deceased mothers were in the care of stepmothers at the time of interview (Table 1, Section B), but there was evidence that these step-relationships were often temporary. After divorce, a father might keep his child and quickly remarry, with the stepmother becoming the primary caregiver, but once the stepmother had her own child, it was common for the stepchild to out-migrate or move to the primary care of a grandmother. One-third of children with deceased mothers were in the care of grandmothers, some paternal, some maternal, and even when maternal kin were not providing direct care, they were still the leading providers of material support, implying that despite the mother's death, a committed relationship with her children was often maintained.

Child outcome data from the present study are too few to establish clear effects of marital disruption or the various remedies that families adopt to deal with it, but further study is clearly warranted. It was notable that there were no significant differences in WHO standardized height and weight scores by gender, because Bangladesh is a place where girls could be more behind due to greater discrimination against girls than other places sampled by the WHO normative sample. Household income was a strong predictor of children's growth, and those of deceased mothers stood out as especially short and underweight (in comparison to children of widows and divorcées), as well as being educationally deprived. This may not be entirely due to low income (Table 3. These children were often cared for by stepmothers (Table 1, Section B), who constitute a risk factor for child neglect and maltreatment in many societies (Daly and Wilson 2008) and are certainly seen as such in Matlab, where interviewees alleged that stepparents discriminate against and abuse stepchildren. Two stepmothers had been expelled from mother-deceased homes for stepchild maltreatment, and a widower who was his daughter's primary caregiver declared that he would not remarry because he would not expose his daughter to a stepmother.

In traditional societies, children typically survive best in the care of their birth mothers (Hrdy 2009; Konner 2010; Strassmann 2011). This is largely due to deprivation of breastfeeding (Roy 2000; Ronsmans et al. 2010; Mwangome et al. 2012), but elevated mortality and morbidity after the mother's death are sometimes found even among weaned children, including in Bangladesh (Ronsmans et al. 2010). What the present data suggest is that children of deceased mothers may suffer from reduced care more generally, as their situations are precarious and unstable (Table 2). Repeated changes of primary caregiver may be analogous to placement instability in foster placements in industrialized and post-industrial countries, where such instability is associated with (but not necessarily causal to) negative outcomes including poor mental and physical health, homelessness, involvement in the criminal justice system, poor relationships in adulthood, poor educational attainment, and high unemployment (Ryan and Testa 2005; Rubin et al. 2007; Perry et al. 2014; Raley and Sweeney 2020 for review).

Research on effects of family structure in modernizing societies tends to show that children with a parent absent due to death or divorce fare relatively poorly, although effect sizes are typically small and the problems exhibited by children of divorce were often present prior to the divorce and related to the degree of family problems before the break-up (Amato and Anthony 2014; Amato and Keith 1991; Kelly 2000). Those children who manifest fewer negative effects from divorce or parental death are those who were exposed to better family functioning prior to the event and had more social and material supports available to them after it (Amato and Anthony 2014; Hope and Hodge 2016; Raley and Sweeney 2020).

Widows and divorcées are stigmatized in Bangladesh, and so to a lesser degree are widowers. As anticipated, caregivers in these non-intact family types lack the alloparental support available to intact families. It is striking that mother-deceased or divorced families had lower incomes than intact families, but were nevertheless more likely to report that "no-one" outside the family provided material assistance.

Whether the particular primary and secondary caregivers and material investors in non-intact families affect child outcomes requires further investigation. Do the children in non-intact families suffer deficits when cared for by stepmothers, for example? Numbers of children in each non-intact family type in the present study are too few to resolve such questions (Pedhazur 1997). It may be that the involvement of matrilateral kin in non-intact families is buffering against negative effects, particularly when they are not competing for resources (Sheppard and Sear 2016).

In view of the prevailing negative attitudes toward divorced and widowed women, it remains surprising that their children were not obviously faring worse than those in intact families. As noted earlier, a selection bias as a result of differential emigration may be largely responsible, but insofar as children of disrupted marriages really fare no worse than others, this could be a result of several developments and associated cultural changes in Bangladesh over the past 40 years. Opportunities for poor and landless families have increased due to greater access to wage and migrant labor, even for some women (Rabby 2015), as well as to less restrictive interpretations of purdah, increased education for girls, reduced child and maternal mortality, increased life spans, and lower completed fertility (Blunch and Das 2014; icddr,b 2015). These changes may have resulted in extended family being able to provide more alloparental care and material investment than in the past, improving child outcomes in non-intact families. Further research may elucidate the power of these potential practices to buffer children from negative outcomes.

In any event, it seems clear that the typological characterization of Bangladeshi society as patrilineal and patrilocal has obscured the extent to which matrilateral family connections support children's survival and well-being, especially in high-needs circumstances.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

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Article

Mother's Partnership Status and Allomothering Networks in the United Kingdom and United States

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Abstract: In high-income, low-fertility (HILF) settings, the mother's partner is a key provider of childcare. However, it is not clear how mothers without partners draw on other sources of support to raise children. This paper reports the findings from a survey of 1532 women in the United Kingdom and the United States, in which women described who provided childcare for a focal child and how frequently they did so. We use multivariate Bayesian regression models to explore the drivers of support from partners, maternal kin, and other allomothers, as well as the potential impact of allomothering on women's fertility. Relative to mothers who are in a stable first marriage or cohabitation, mothers who are unpartnered rely more heavily on fewer maternal kin, use more paid help, and have networks which include more non-kin helpers. Repartnered mothers received less help from their partners in the UK and less help from maternal kin in both countries, which US mothers compensated for by relying on other helpers. While repartnered mothers had higher age-adjusted fertility than women in a first partnership, allomaternal support was not clearly related to the mother's fertility. These findings demonstrates the importance of partners but also of allomothering more broadly in HILF settings.

Keywords: cooperative breeding; behavioral ecology; pair-bonding; fertility; social support; paternal investment; evolutionary demography

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1. Introduction

Compared to our closest primate relatives, human life history is unique in that it features an extended period of development and dependency (Bogin 1997; Hill and Kaplan 1999). During this time, human children require high amounts of care to survive and to learn the skills they need to thrive in adulthood. The demands of childcare and food acquisition for a mother and her children represent too much work for one mother to perform alone, particularly if she has multiple dependent children (Kramer 2010). Therefore, two key characteristics of human life history are that mothers receive a substantial amount of support for childrearing from allomothers and that the source of this support varies in response to socioecological conditions (Hill and Kaplan 1999). Allomothering (literally "other mothering") is so crucial to the human story that humans are often classified as cooperative breeders; that is, we *require* the help of nonmaternal individuals to successfully reproduce (Hrdy 2009; Kramer 2010). Cooperative breeding, moreover, may have been a key driver behind the demographic success of humans by allowing mothers to have more surviving offspring at closer intervals than they would have without the support of allomothers (Kramer 2010, 2019).

In Western, educated, industrialized, rich, and democratic (WEIRD Henrich et al. (2010)) settings, the economically-independent nuclear family type is widely regarded as the traditional family type (Sear 2021). However, anthropological and evolutionary research demonstrates that this view is not accurate. Mothers across nonindustrialized societies obtain considerable support with childcare as well as food production from a range of extra-household individuals (Hewlett and Lamb 2005; Meehan 2009; Meehan et al. 2013; Ivey 2000; Crittenden and Marlowe 2008). Kin, and especially close kin, typically provide more childcare help than do non-kin (Ivey 2000; Crittenden and Marlowe 2008; Meehan et al. 2014), likely because helping closely related mothers and their children can increase inclusive fitness (Hamilton 1964). Despite an emphasis on biparental care in WEIRD societies, i.e., from mothers and fathers together, paternal investment in childcare cross-culturally is facultative and varies with social and ecological conditions (Geary 2000; Meehan 2005). For example, in three agrarian societies in Belize, Kenya, and Samoa included in the Standard Cross Cultural Sample, fathers were not observed holding their children at all (Marlowe 2000). On the other end of the spectrum, Aka fathers, a foraging group from central Africa, are well known for their high level of investment in childcare and spend up to nearly half of their days within arm's reach of their infants (Hewlett 1993). Just as level of parenting by fathers vary across societies, so do the impact of paternal care on children's health. In nonindustrialized settings, paternal presence or absence is only sometimes associated with child outcomes (Sear and Mace 2008; Sear and Coall 2011) in contrast to other allomaternal support which typically positively predicts both children's health (Sear and Coall 2011) and maternal fertility (Sear and Coall 2011; Snopkowski and Sear 2016).

Processes of industrialization and modernization, however, have deeply shifted the relationship between mothers and their help networks. The increased mobility associated with industrialization and urbanization has physically dispersed kin networks (Zelinsky 1971; Newson et al. 2005; Emmott and Page 2019). Mothers often have fewer kin from whom to draw physical support, and thus, they may rely more upon non-kin for support (Newson et al. 2005; Sear and Coall 2011). The reduction in kin help with childcare may raise the financial and perceived costs of childcare, leading to hesitancy to have more children and the choice to invest more into each offspring, perhaps contributing to reductions in fertility associated with demographic transitions (Turke 1989; Kaplan et al. 2002; Newson et al. 2005; Sear and Coall 2011). Even in contemporary, less-kin-dense settings, kin continue to play an important role in childrearing. In modern high-income, low-fertility (HILF) nations, investments by kin, especially maternal kin, are generally are associated with more favorable educational and psychological child outcomes, although there is some variation in the magnitude of these associations (Sear and Coall 2011; Sadruddin et al. 2019; Sear 2021). In HILF settings, relationships between kin support and fertility are more variable, and different types of support from kin have been linked to both positive (Mathews and Sear 2013a, 2013b; Schaffnit and Sear 2017a) and negative (Sear and Coall 2011; Schaffnit and Sear 2014, 2017a) relationships with fertility outcomes, which may reflect that some mothers in these settings use childcare help to return to work rather than to have more children.

Alongside, and perhaps because of, the reduction in kin networks that occurred with industrialization, mothers increasingly rely upon their partners for help with childcare (Sear and Coall 2011; Emmott 2015; Pailhé et al. 2021). Paternal investment in children in HILF countries is consistently associated with better educational, behavioral, and psychological wellbeing outcomes for children (Harris et al. 1998; Flouri and Buchanan 2004; Nettle 2008; Jeynes 2014; Emmott and Mace 2020), though such findings may be confounded by socioeconomic position. Due to the importance of fathers and father figures in child outcomes, there is a rich body of anthropological, demographic, and sociological research on the drivers of paternal investment in HILF countries. Fathers tend to invest more in childcare if they are of higher socioeconomic position (Nettle 2008), if they have strong religious and/or traditional values (Wilcox 2002; Lynn et al. 2016), if they live with the child (Anderson 2000; Lancaster and Kaplan 2000), and if the child is a boy rather than a girl (Lundberg 2005; Nettle 2008), for example.

Although the nuclear family is regarded as the traditional family type in HILF countries, divorce and remarriage have become increasingly common over the last 50 years (Murphy 2008; Furstenberg et al. 2020, but see also Sussman 1959). This has driven research on how absentee fathers and stepfathers vary in their investments in children relative to biological fathers living with their children. Parental separation or ceasing to live with a child reduces the biological father's physical and monetary investment in his child (Anderson 2000; Lancaster and Kaplan 2000; Pashos et al. 2016) and reduces paternal kin contact with the child (Jappens and Bavel 2016), resulting in a reduction or loss of these key sources of support for mothers. Nevertheless, some research suggests that the reduction of paternal investment after parental separation depends on context; nonresident fathers in the US, for example, have lower rates of contact and provide less financial support to their children than nonresident fathers in the UK (Clarke et al. 1998).

Faced with a loss in support, mothers who separate from their partners may turn to their kin to compensate for lost partner and paternal kin support (Schaffnit and Sear 2017a). A separated woman may remarry, after which her allomothering network may expand to include her new partner and his network, and/or she may lose the support of her former partner's kin. The patterns and drivers of step-paternal investment in children is a topic of keen interest to many social scientists. New partners may invest in a mother's children with a previous partner as a form of mating effort (Anderson 2000; Lancaster and Kaplan 2000). While many stepfathers care for their partner's previous children, stepfathers tend to invest less intensively in stepchildren than in their biological children (Cooksey and Fondell 1996; Lancaster and Kaplan 2000; Lawson and Mace 2009; Emmot and Mace 2014), and stepfathers' kin are also less likely to invest in stepchildren than they would in biological descendants (Coall et al. 2014; Gray and Brogdon 2017; Steinbach and Silverstein 2019). Therefore, repartnered mothers may experience shifts in their alloparental networks, which could conceivably include expansion of the network if both her previous partner and her new partner remain invested in childcare, or alternatively could include greater reliance on nonpartner sources of support if the new partner does not compensate for the reduction of investment from the previous partner.

Although divorce and remarriage are considered a relatively new phenomenon in WEIRD settings, serial monogamy is considered the most common form of mating systems across human societies (Schacht and Kramer 2019). In WEIRD settings, divorce and remarriage are considered departures from traditional family norms and have been on the rise in the last 50 years, when in fact divorce or widowhood and remarriage (or repartnering) appear to be a common feature of human mating and kinship systems. What is perhaps unique about divorce and remarriage in HILF countries is that, due to the nuclearization of the family, the loss of a partner is potentially also the loss of a significant source of childcare. Understanding how women navigate these pressures in HILF settings may help to shed light on dynamics in both contemporary HILF settings as well as other contemporary and past societies.

Currently, women in HILF countries frequently underachieve their fertility intentions (Morgan and Rackin 2010; Sear et al. 2016; Beaujouan and Berghammer 2019). Because humans are cooperative breeders, understanding how mothers' support networks anticipate their reproductive outcomes is essential for identifying the conditions necessary to allow women to fulfil their reproductive goals. In this study, we analyze newly collected survey data from the United Kingdom and the United States to understand the structure of mothers' support networks and how these affect her fertility outcomes. Given the known importance of partners in childrearing in HILF contexts and the increasing prevalence of reconstituted and alternative families in HILF countries (Furstenberg et al. 2020), we specifically consider how women's partnership statuses (either marriage or cohabitation) are associated with patterns of support and fertility preferences. We investigate patterns in both the UK and the US to illustrate that HILF societies are not monolithic (Stulp et al.

2016). Although the UK and the US are socioculturally similar countries, variations in government support for individuals and families means that the socioecologies in these countries vary, and this could impact parental investment strategies and family relationships (Clarke et al. 1998).

Throughout these analyses, we evaluate the following five predictions. Based on research that finds that stepfathers invest less in childcare (e.g., Cooksey and Fondell 1996; Lancaster and Kaplan 2000; Lawson and Mace 2009; Emmot and Mace 2014), we predict that second partners provide less childcare than first partners to a woman's children (P1). Given that mothers are flexible in whom they seek childcare from (Sear and Coall 2011), we predict that maternal kin invest more in childcare when mothers are unpartnered or repartnered than when mothers are partnered (P2), and that other (nonpartner or maternal kin) helpers may also provide more help to unpartnered and repartnered mothers (P3). Because having multiple partners is known to increase fertility (Balbo et al. 2013), we predict that repartnered mothers have higher fertility than unpartnered or partnered mothers (P4). Lastly, because the cooperative breeding hypothesis suggests that childcare increases women's fertility (Kramer 2010, 2019), we predict that the level of help received is also associated with mothers' fertility (P5). Although we make no specific predictions about differences between the study countries, we anticipate that socioecological pressures and corresponding behaviors may vary between them, and therefore analyze them separately. This analysis is, to our knowledge, the first to document the impact of partnership status on the composition and level of investment of allomothers in a woman's network.

2. Results

The data used to test predictions consist of responses to questionnaires collected through the Prolific online survey participant recruitment platform in August 2020. A total of 919 UK and 609 US women with children under 5 years of age answered questions about themselves, their families, and who helped them care for a focal child under the age of 5 years. Women were categorized as partnered if they indicated they were married or cohabitating with a partner and the current partner was the biological father of all of her children; repartnered if they were married or cohabitating with a partner and at least one of her children's biological father was not her current partner; and unpartnered if she was not currently married or cohabitating with a partner. For further details on the survey, see Section 4 and the Supplementary Materials.

The descriptive statistics for the variables included in the models are presented in Table 1. In the countries combined, focal children received care from an average of 1.82 people besides the mother, and 1.09 people besides the mother and her partner. Children of partnered and repartnered mothers received similar levels of allomothering (mean score of 133 tasks per month for both groups), while children of unpartnered women received less (mean score of 80 tasks per month).

Table 1. Participant characteristics by country of residence and partnership status. See materials and methods for details on calculating age-adjusted fertility and level of alloparental support.

	UK			**US**		
	Partnered (*N* = 768)	**Unpartnered (*N* = 82)**	**Repartnered (*N* = 69)**	**Partnered (*N* = 468)**	**Unpartnered (*N* = 78)**	**Repartnered (*N* = 63)**
Age						
Mean (SD)	33.3 (5.07)	32.0 (6.23)	33.6 (5.99)	31.1 (4.77)	31.0 (6.81)	33.5 (5.91)
Number of births						
Mean (SD)	1.59 (0.753)	1.62 (0.911)	2.61 (1.34)	1.69 (0.819)	1.96 (1.24)	2.63 (1.22)
Age-adjusted fertility						
Mean (SD)	−0.185 (0.716)	−0.0871 (0.854)	0.816 (1.28)	0.0321 (0.780)	0.305 (1.15)	0.845 (1.13)
Intent to have another child within two years						
No	473 (61.6%)	60 (73.2%)	53 (76.8%)	234 (50.0%)	60 (76.9%)	48 (76.2%)
Yes	295 (38.4%)	22 (26.8%)	16 (23.2%)	234 (50.0%)	18 (23.1%)	15 (23.8%)
Total number of births desired						
Mean (SD)	2.37 (0.882)	2.57 (1.10)	3.30 (1.47)	2.84 (1.18)	2.90 (1.37)	3.35 (1.38)
Receipt of any childcare help from partner						
No	127 (16.5%)	82 (100%)	18 (26.1%)	96 (20.5%)	78 (100%)	13 (20.6%)
Yes	641 (83.5%)	0 (0%)	51 (73.9%)	372 (79.5%)	0 (0%)	50 (79.4%)
Number of maternal kin allomothers						
Mean (SD)	1.24 (0.883)	0.317 (0.494)	1.14 (0.912)	1.10 (0.779)	0.359 (0.738)	1.32 (0.964)
Number of other allomothers						
Mean (SD)	0.518 (0.995)	0.549 (0.688)	0.551 (0.948)	0.449 (0.793)	0.808 (0.981)	0.619 (1.07)
Total amount of childcare help						
Mean (SD)	136 (77.6)	65.8 (63.7)	127 (88.2)	127 (78.4)	94.5 (87.2)	139 (80.0)
Amount of childcare help—partner						
Mean (SD)	101 (52.8)	0 (0)	87.6 (58.9)	93.1 (55.9)	0 (0)	93.7 (56.5)
Amount of childcare help—maternal kin						
Mean (SD)	20.0 (37.5)	40.0 (54.7)	17.2 (33.2)	15.3 (38.0)	51.4 (62.2)	11.3 (29.2)
Amount of childcare help—other helpers						
Mean (SD)	15.0 (35.6)	25.8 (40.3)	22.1 (48.3)	18.9 (42.6)	43.1 (69.3)	34.0 (66.3)
Number of maternal kin residing nearby						
Mean (SD)	2.82 (2.34)	3.68 (2.36)	3.51 (2.51)	2.22 (2.31)	3.22 (1.92)	2.44 (2.35)
Number of partner’s kin residing nearby						
Mean (SD)	2.68 (2.34)	0 (0)	2.71 (2.39)	2.19 (2.29)	0 (0)	2.32 (2.15)
Age of focal child						
Mean (SD)	2.68 (1.28)	2.88 (1.21)	2.65 (1.27)	2.72 (1.34)	3.04 (1.13)	2.90 (1.24)
Hours spent in paid care weekly						
Mean (SD)	11.9 (12.8)	11.6 (12.2)	8.61 (12.5)	9.88 (14.3)	12.2 (15.9)	7.39 (14.1)
Missing	0 (0%)	0 (0%)	0 (0%)	2 (0.4%)	0 (0%)	1 (1.6%)
Number of children in home						
Mean (SD)	1.61 (0.767)	1.57 (0.770)	2.42 (1.08)	1.73 (0.855)	1.68 (0.919)	2.25 (1.19)
Mother has a religious affiliation						
No	430 (56.0%)	44 (53.7%)	40 (58.0%)	157 (33.5%)	29 (37.2%)	28 (44.4%)
Yes	338 (44.0%)	38 (46.3%)	29 (42.0%)	311 (66.5%)	49 (62.8%)	35 (55.6%)
Household income quintile						
1 (lowest)	20 (2.6%)	34 (41.5%)	1 (1.4%)	17 (3.6%)	16 (20.5%)	8 (12.7%)
2	116 (15.1%)	27 (32.9%)	25 (36.2%)	81 (17.3%)	35 (44.9%)	12 (19.0%)
3	198 (25.8%)	14 (17.1%)	21 (30.4%)	153 (32.7%)	15 (19.2%)	26 (41.3%)
4	363 (47.3%)	6 (7.3%)	19 (27.5%)	108 (23.1%)	10 (12.8%)	10 (15.9%)
5 (highest)	71 (9.2%)	1 (1.2%)	3 (4.3%)	109 (23.3%)	2 (2.6%)	7 (11.1%)

Table 1. *Cont.*

	UK			US		
	Partnered (*N* = 768)	**Unpartnered (*N* = 82)**	**Repartnered (*N* = 69)**	**Partnered (*N* = 468)**	**Unpartnered (*N* = 78)**	**Repartnered (*N* = 63)**
Mother's ethnicity						
White	684 (89.1%)	63 (76.8%)	65 (94.2%)	353 (75.4%)	45 (57.7%)	49 (77.8%)
Other or mixed	84 (10.9%)	19 (23.2%)	4 (5.8%)	115 (24.6%)	33 (42.3%)	14 (22.2%)
Mother born in country of residence						
No	115 (15.0%)	8 (9.8%)	3 (4.3%)	25 (5.3%)	4 (5.1%)	3 (4.8%)
Yes	653 (85.0%)	74 (90.2%)	66 (95.7%)	443 (94.7%)	74 (94.9%)	60 (95.2%)
Mother's educational attainment						
Primary	1 (0.1%)	2 (2.4%)	0 (0%)	3 (0.6%)	1 (1.3%)	0 (0%)
Secondary	66 (8.6%)	12 (14.6%)	13 (18.8%)	91 (19.4%)	24 (30.8%)	20 (31.7%)
Junior college	207 (27.0%)	35 (42.7%)	30 (43.5%)	56 (12.0%)	17 (21.8%)	22 (34.9%)
Undergraduate	326 (42.4%)	28 (34.1%)	21 (30.4%)	207 (44.2%)	30 (38.5%)	16 (25.4%)
Postgraduate	168 (21.9%)	5 (6.1%)	5 (7.2%)	111 (23.7%)	6 (7.7%)	5 (7.9%)
Urbanization of place of residence						
City	221 (28.8%)	30 (36.6%)	11 (15.9%)	272 (58.1%)	51 (65.4%)	31 (49.2%)
Town	366 (47.7%)	36 (43.9%)	44 (63.8%)	168 (35.9%)	23 (29.5%)	22 (34.9%)
Village	181 (23.6%)	16 (19.5%)	14 (20.3%)	28 (6.0%)	4 (5.1%)	10 (15.9%)

2.1. Partner Investment in Childcare (P1)

We firstly describe the contributions of women's partners to raising her children (P1). Of the mothers who were either partnered or repartnered, 83% in the UK and 80% in the US reported ever receiving childcare help from their partners (Table 1). Of the partners who provided help with specified childcare tasks (see materials and methods), most were very involved: the average number of tasks performed daily by partners were 4.13 out of 5 possible tasks in the UK and 3.97 out of 5 in the US. In neither country were second partners more or less likely to provide any help at all with childcare than first partners (odds ratio (OR) (95% credibility interval (CI)), UK = 0.60 [0.32, 1.14], US = 0.88 [0.43, 1.87], Table 2 and Figure 1). However, in terms of the level of support (with higher levels indicating greater instances of support provided over the course of a month, see Section 4 for details), in the US, second partners provided similar levels of help as first partners (incidence rate ratio (IRR) [95% CI] = 1.02 [0.99, 1.05]), but the same was not true in the UK, where second partners provided less help than first partners (IRR [95% CI] = 0.89 [0.87, 0.92]). Results from similar models testing alternate operationalizations of the measure of involvement (a count of care tasks provided daily and the number of days of supervision provided per month, see Section 4) were consistent with the findings presented here (Supplementary Materials). Similarly, running the models without the kin proximity variable did not significantly change the impact of being repartnered (see Section 4 for details and Supplementary Materials for results).

We also examined differences in the likelihood of partner involvement and level of partner's help with childcare help, differentiating between first partners, second partners who were caring for their biological child, and second partners who were caring for a stepchild. Results again differed between the UK and the US. In the UK, second partners were not more or less likely to provide any amount of childcare for their biological child (OR [95% CI] = 0.97 [0.47, 2.23]) but were less likely to care for their stepchild (OR [95% CI] = 0.19 [0.06, 0.59], Table 2 and Figure 1). In the US, however, there were no meaningful differences in second partners' care toward their own child (OR [95% CI] = 0.70 [0.30, 1.73] and their stepchild (OR [95% CI] = 1.54 [0.46, 7.31]). Unfortunately, sample sizes for second partners caring for stepchildren were small (16 in the UK and 18 in the US).

Table 2. Results of Bayesian regression models predicting partner involvement in the US and in the UK.

	Likelihood of Partner Involvement		**Level of Partner Involvement**		**Likelihood of Partner Involvement (Based on Relationship to Child)**	
	UK	**US**	**UK**	**US**	**UK**	**US**
	***N* = 836**	***N* = 528**	***N* = 836**	***N* = 528**	***N* = 836**	***N* = 528**
	OR **[95% CI]**	**OR** **[95% CI]**	**IRR** **[95% CI]**	**IRR** **[95% CI]**	**OR** **[95% CI]**	**OR** **[95% CI]**
Intercept	3.63 [0.70, 19.79]	0.23 [0.02, 2.11]	97.23 [91.30, 103.61]	42.67 [48.78, 46.92]	4.27 [0.80, 23.37]	0.20 [0.02, 1.82]
Partner status						
Repartnered	0.60 [0.32, 1.14]	0.88 [0.43, 1.87]	0.89 [0.87, 0.92]	1.02 [0.99, 1.05]	-	-
Partner relation to child						
Second partner and biological dad	-	-	-	-	0.97 [0.47, 2.23]	0.70 [0.30, 1.73]
Stepfather	-	-	-	-	0.19 [0.06, 0.59]	1.54 [0.46, 7.31]
Mother's age	1.01 [0.97, 1.05]	1.09 [1.04, 1.16]	1.00 [1.00, 1.00]	1.02 [1.02, 1.02]	1.00 [0.96, 1.04]	1.10 [1.04, 1.16]
Religious	0.79 [0.53, 1.16]	1.08 [0.65, 1.78]	0.96 [0.94, 0.97]	0.94 [0.92, 0.96]	0.77 [0.52, 1.15]	1.10 [0.66, 1.82]
Number of kin residing nearby	0.98 [0.93, 1.03]	1.07 [1.01, 1.14]	0.99 [0.99, 1.00]	1.01 [1.01, 1.02]	0.98 [0.93, 1.03]	1.07 [1.01, 1.14]
Focal child's age	0.92 [0.77, 1.10]	0.90 [0.74, 1.08]	0.97 [0.96, 0.97]	0.95 [0.95, 0.96]	0.94 [0.78, 1.11]	0.88 [0.73, 1.06]
Hours weekly in paid care	1.01 [0.99, 1.03]	1.02 [1.00, 1.04]	1.00 [1.00, 1.00]	1.00 [1.00, 1.00]	1.01 [0.99, 1.03]	1.02 [1.00, 1.04]
Number of children in home	0.97 [0.76, 1.25]	1.03 [0.78, 1.38]	0.99 [0.98, 1.00]	0.98 [0.97, 0.99]	0.91 [0.71, 1.17]	1.06 [0.80, 1.42]
Education	1.40 [1.13, 1.77]	1.07 [0.83, 1.38]	1.07 [1.06, 1.07]	1.06 [1.05, 1.07]	1.45 [1.16, 1.83]	1.05 [0.82, 1.37]
Nativity	1.38 [0.78, 2.40]	1.32 [0.48, 3.37]	1.11 [1.08, 1.13]	1.13 [1.08, 1.18]	1.39 [0.78, 2.43]	1.38 [0.48, 3.52]
Ethnicity	0.80 [0.44, 1.52]	0.85 [0.49, 1.46]	0.95 [0.93, 0.98]	0.96 [0.94, 0.98]	0.81 [0.45, 1.58]	0.87 [0.52, 1.50]
Household quintile	0.83 [0.66, 1.03]	0.83 [0.66, 1.05]	0.97 [0.96, 0.98]	1.00 [0.99, 1.01]	0.82 [0.65, 1.03]	0.84 [0.67, 1.07]
Urbanization	0.86 [0.65, 1.11]	1.01 [0.70, 1.46]	0.98 [0.97, 0.99]	1.03 [1.02, 1.05]	0.85 [0.65, 1.11]	1.00 [0.69, 1.44]

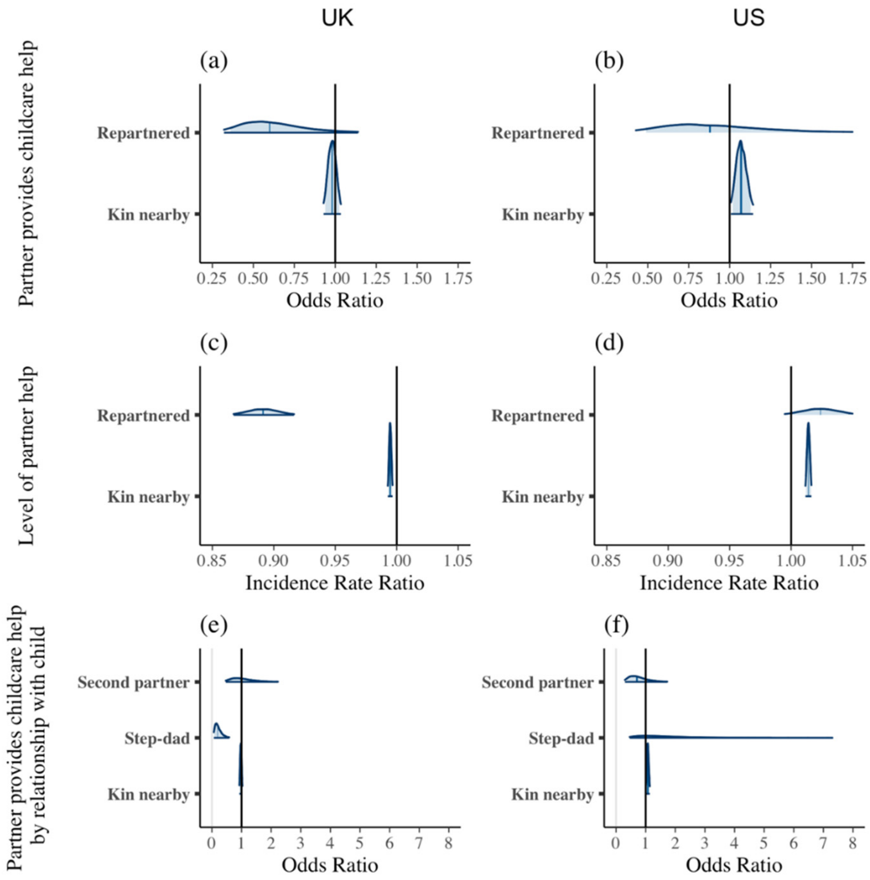

Figure 1. Plots showing the posterior distributions (95% credibility intervals) for the major predictors and control variables in the models for partner investment in each country, using the following measures: (**a**,**b**) likelihood of partner involvement in childcare; (**c**,**d**) level of childcare help from the partner; and (**e**,**f**) likelihood of providing childcare help based on partner's relationship to child. Reference category for repartnered is partnered women; reference category for women with a second partner or a step-dad (second partner caring for a step-child) is women with a first partner; kin nearby is entered as a continuous predictor.

2.2. Maternal Kin Investment in Childcare (P2)

To examine the level of involvement of maternal kin in unpartnered and repartnered mothers' allomaternal networks (P2 and P3), we built models predicting the number of maternal kin allomothers, their level of support, and the percentage of overall level of support provided by maternal kin (Table 3, Figure 2). After adjusting for level of partner help, number of maternal kin residing nearby, and sociodemographic covariates, both UK and US unpartnered mothers received help from fewer maternal kin than partnered women (IRR [95% CI], UK = 0.62 [0.38, 0.94]; US = 0.57 [0.36, 0.87]). Repartnered mothers in both the UK and the US did not differ from partnered women in the number of maternal kin from whom they received help (IRR [95% CI], UK = 0.99 [0.77, 1.26]; US = 1.04 [0.82, 1.33]). Considering the level of help received from maternal kin rather than number of helpers revealed a different pattern. In both the UK and the US, relative to partnered women, unpartnered women received a greater amount of help from maternal kin (IRR [95% CI], UK = 2.76 [2.60, 2.91]; US = 2.42 [2.29, 2.57]), and a greater percentage of their total help score came from maternal kin (Beta [95% CI], UK = 0.20 [0.13, 0.27]; US = 0.29 [0.20, 0.37]). In the US, repartnered women received less help from maternal kin (IRR [95% CI] = 0.79 [0.73, 0.85]), but in the UK, repartnered women received similar amounts of help from maternal kin as did partnered women (IRR [95% CI}: 1.02 [0.96, 1.09]). In both countries, repartnered women did not differ from partnered women in the percentage of overall help that was received from maternal kin (Beta [95% CI], UK = −0.00 [−0.06, 0.05]; US = −0.02 [−0.09, 0.05]).

Table 3. Results of Bayesian regression models predicting childcare involvement of maternal kin in the US and in the UK.

	Number of Maternal Kin Providing Childcare Help		**Level of Help from Maternal Kin**		**Percentage of Nonpartner Help Received Contributed by Maternal Kin**	
	UK	**US**	**UK**	**US**	**UK**	**US**
	N = 918	**N = 606**	**N = 918**	**N = 606**	**N = 809**	**N = 537**
	IRR [95% CI]	**IRR [95% CI]**	**IRR [95% CI]**	**IRR [95% CI]**	**Beta [95% CI]**	**Beta [95% CI]**
Intercept	0.32 [0.18, 0.57]	0.25 [0.11, 0.54]	17.74 [15.53, 20.38]	5.20 [4.38, 6.16]	0.35 [0.22, 0.49]	0.28 [0.08, 0.48]
Partner status						
Unpartnered	0.62 [0.38, 0.94]	0.57 [0.36, 0.87]	2.76 [2.60, 2.91]	2.42 [2.29, 2.57]	0.20 [0.13, 0.27]	0.29 [0.20, 0.37]
Repartnered	0.99 [0.77, 1.26]	1.04 [0.82, 1.33]	1.02 [0.96, 1.09]	0.79 [0.73, 0.86]	−0.00 [−0.06, 0.05]	−0.02 [−0.09, 0.05]
Level of partner involvement	1.01 [1.01, 1.01]	1.01 [1.00, 1.01]	1.00 [1.00, 1.00]	1.00 [1.00, 1.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
Mother's age	1.01 [1.00, 1.03]	1.02 [1.01, 1.04]	0.95 [0.95, 0.95]	0.99 [0.98, 0.99]	−0.01 [−0.01, 0.00]	0.00 [0.00, 0.00]
Religious	1.09 [0.96, 1.24]	0.99 [0.83, 1.17]	1.10 [1.07, 1.13]	0.75 [0.73, 0.78]	0.01 [−0.02, 0.04]	−0.03 [−0.08, 0.01]
Number of maternal kin residing nearby	1.02 [0.99, 1.05]	1.01 [0.98, 1.05]	1.16 [1.15, 1.17]	1.25 [1.24, 1.26]	0.02 [0.02, 0.03]	0.03 [−0.02, 0.03]
Focal child's age	1.00 [0.94, 1.06]	0.99 [0.93, 1.06]	1.10 [1.08, 1.12]	1.06 [1.04, 1.07]	0.00 [−0.01, 0.02]	0.00 [−0.02, 0.02]
Hours weekly in paid care	1.00 [0.99, 1.01]	1.00 [1.00, 1.01]	0.98 [0.98, 0.98]	1.01 [1.01, 1.01]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
Number of children in home	0.97 [0.89, 1.06]	1.10 [1.00, 1.20]	0.81 [0.79, 0.83]	0.96 [0.93, 0.98]	−0.02 [−0.04, 0.00]	−0.02 [−0.04, 0.01]
Education	1.01 [0.93, 1.09]	0.94 [0.86, 1.04]	1.19 [1.16, 1.21]	1.20 [1.17, 1.23]	0.02 [0.00, 0.04]	0.01 [−0.02, 0.03]
Nativity	1.10 [0.89, 1.36]	1.06 [0.73, 1.61]	1.36 [1.28, 1.44]	0.43 [0.41, 0.46]	0.04 [0.00, 0.09]	−0.08 [−0.18, 0.01]
Ethnicity	0.90 [0.72, 1.12]	0.96 [0.79, 1.17]	0.86 [0.81, 0.90]	1.24 [1.19, 1.30]	−0.03 [−0.08, 0.02]	0.01 [−0.04, 0.06]
Household quintile	1.02 [0.95, 1.10]	0.99 [0.91, 1.08]	1.12 [1.10, 1.14]	1.03 [1.01, 1.05]	0.02 [0.00, 0.03]	0.00 [−0.02, 0.03
Urbanization	0.95 [0.87, 1.04]	1.07 [0.94, 1.22]	0.98 [0.96, 1.00]	1.43 [1.38, 1.48]	0.00 [−0.02, 0.02]	0.03 [−0.02, 0.05]

Running the models without the kin proximity and partner help covariates increased the impact of being unpartnered but did not significantly change the impact of being repartnered (see Section 4 for more details and Supplementary Materials for results). The increased effect of being unpartnered occurred when removing the partner help covariate, suggesting that the lack of a contribution from a partner partially, but not completely, explains the impact of being unpartnered on a mother's allomaternal network. Overall, these results suggest that unpartnered women receive a larger amount of help from, and rely much more on, fewer maternal kin allomothers. Repartnered women receive somewhat less help from a similar number of maternal kin allomothers as do partnered mothers and rely on them about as much as partnered mothers do.

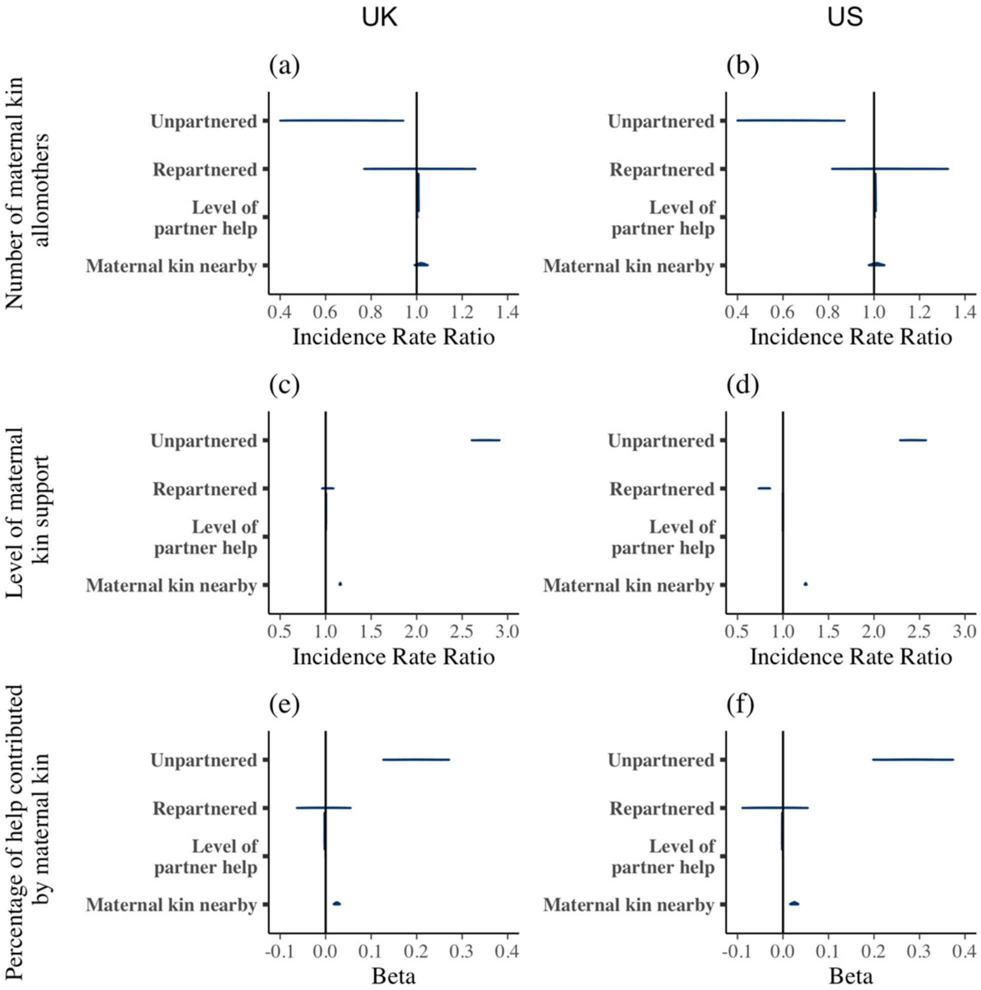

Figure 2. Plots showing the posterior distributions (95% credibility intervals) for the major predictors and control variables in the models for maternal kin allomother investment in each country, using the following measures: (**a**,**b**) number of maternal kin providing childcare; (**c**,**d**) total level of childcare help provided by maternal kin; and (**e**,**f**) percentage of total childcare help contributed by maternal kin. Reference category for unpartnered and repartnered women is partnered women; level of partner help and maternal kin nearby are entered as continuous predictors.

2.3. Other Allomother Investment in Childcare (P3)

We then considered how partnership status was related to help received from others, which comprised primarily non-kin but also the father or stepfather's kin and any sibling helpers (P2 and P3). We again built models predicting the number of other allomothers, their level of support, and the percentage of overall level of support provided by other allomothers (Table 4, Figure 3). After adjusting for level of partner help and the number of maternal kin residing nearby, unpartnered mothers in both the UK and the US received help from a greater number of other allomothers than did partnered mothers (IRR [95% CI], UK = 1.49 [0.99, 2.24]; US = 1.64 [1.11, 2.39]). Repartnered mothers in both the UK and the US did not differ from partnered women in the number of other allomothers they received help from (IRR [95% CI], UK = 1.09 [0.75, 1.52]; US = 1.31 [0.88, 1.86]). In both countries, both unpartnered (IRR [95% CI], UK = 1.94 [1.83, 2.07]; US = 1.95 [1.85, 2.06]) and repartnered women (IRR [95% CI], UK = 1.38 [1.31, 1.47]; US = 1.79 [1.70, 1.89]) received greater amounts of help from other allomothers than partnered women. However, patterns in reliance on other allomothers were inconsistent across countries. Unpartnered women relied more on other allomothers than did partnered women in the UK (Beta [95% CI] = 0.11 [0.03, 0.18], but there was no difference in reliance on other allomothers between unpartnered and partnered women in the US (Beta [95% CI] = −0.03 [−0.13, 0.06]). Similarly, repartnered women relied on other allomothers more than did partnered women in the US (Beta [95% CI] = 0.07 [−0.01, 0.15]), although the effect was unclear, but no difference in reliance on other allomothers was found in the UK (Beta [95% CI] = 0.02 [−0.04, 0.09]).

Table 4. Results of Bayesian regression models predicting childcare involvement of other (nonpartner, nonmaternal kin) allomothers and reliance on paid care in the US and in the UK.

	Number of Other Helpers Providing Childcare Help		**Level of Help from Other Helpers**		**Percentage of Nonpartner Help Received Contributed by Other Helpers**		**Number of Hours Weekly Spent in Paid Care**	
	UK	**US**	**UK**	**US**	**UK**	**US**	**UK**	**US**
	***N* = 918**	***N* = 606**	***N* = 918**	***N* = 606**	***N* = 809**	***N* = 537**	***N* = 918**	***N* = 606**
	IRR [95% CI]	**IRR [95% CI]**	**IRR [95% CI]**	**IRR [95% CI]**	**Beta [95% CI]**	**Beta [95% CI]**	**Beta [95% CI]**	**Beta [95% CI]**
Intercept	0.17 [0.07, 0.412]	0.06 [0.02, 0.17]	3.01 [2.59, 3.51]	3.79 [3.22, 4.47]	0.24 [0.11, 0.38]	0.25 [0.03, 0.48]	−18.85 [−24,85, −12.95]	−27.01 [−37.12, −17.09]
Partner status								
Unpartnered	1.49 [0.99, 2.24]	1.71 [1.18, 2.47]	1.94 [1.83, 2.07]	1.95 [1.85, 2.06]	0.11 [0.03, 0.18]	−0.03 [−0.13, 0.06]	5.34 [2.43, 8.40]	6.61 [2.69, 10.42]
Repartnered	1.09 [0.75, 1.52]	1.40 [0.96, 1.96]	1.38 [1.31, 1.47]	1.79 [1.70, 1.89]	0.02 [−0.04, 0.09]	0.07 [−0.01, 0.15]	0.49 [−2.30, 3.18]	0.11 [−3.52, 3.68]
Level of partner involvement	1.00 [1.00, 1.01]	1.00 [1.00, 1.00]	1.00 [1.00, 1.00]	1.00 [1.00, 1.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.01 [0.00, 0.03]	0.02 [0.00, 0.04]
Mother's age	1.03 [1.01, 1.05]	1.03 [1.01, 1.05]	1.05 [1.04, 1.05]	1.00 [0.99, 1.00]	0.00 [0.00, 0.01]	0.00 [−0.01, 0.00]	−0.05 [−0.20, 0.09]	0.16 [−0.06,0.38]
Religious	1.32 [1.09, 1.60]	0.93 [0.73, 1.19]	1.51 [1.46, 1.57]	0.95 [0.92, 0.99]	0.01 [−0.02, 0.04]	−0.01 [−0.06, 0.04]	−0.18 [−1.52, 1.22]	−3.67 [−5.88, −1.37]
Number of maternal kin residing nearby	1.05 [1.00, 1.09]	0.99 [0.94, 1.04]	1.06 [1.06, 1.07]	0.98 [0.98, 0.99]	−0.01 [−0.01, 0.01]	−0.01 [−0.02, 0.00]	−0.06 [−0.39, 0.26]	0.38 [−0.08, 0.86]
Focal child's age	0.95 [0.87, 1.04]	0.97 [0.88, 1.07]	0.86 [0.85, 0.88]	0.99 [0.97, 1.00]	−0.01 [−0.03, 0.00]	0.00 [−0.02, 0.02]	5.44 [4.88, 5.99]	1.92 [1.03, 2.79]
Hours weekly in paid care	1.01 [1.00, 1.01]	1.01 [1.00, 1.02]	1.01 [1.01, 1.01]	1.01 [1.00, 1.01]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	-	-
Number of children in home	0.89 [0.78, 1.01]	1.24 [1.09, 1.40]	0.97 [0.95, 0.99]	1.39 [1.37, 1.42]	0.01 [−0.01, 0.03]	0.03 [0.00, 0.05]	−0.98 [−1.90, −0.05]	−0.79 [−2.07, 0.55]
Education	0.92 [0.83, 1.03]	1.00 [0.88, 1.14]	0.95 [0.93, 0.97]	1.07 [1.05, 1.09]	−0.01 [−0.02, 0.01]	0.02 [−0.01, 0.05]	1.73 [0.92, 2.54]	2.57 [1.39, 3.81]
Nativity	1.16 [0.85, 1.59]	1.44 [0.82, 2.72]	1.36 [1.28, 1.44]	0.88 [0.82, 0.95]	0.01 [−0.04, 0.06]	0.07 [−0.03, 0.18]	−0.33 [−2.48, 1.83]	2.94 [−1.87, 7.72]
Ethnicity	0.77 [0.55, 1.06]	0.95 [0.73, 1.24]	0.88 [0.83, 0.93]	0.89 [0.86, 0.93]	0.01 [−0.04, 0.06]	−0.01 [−0.06, 0.05]	2.43 [0.21, 4.60]	2.33 [−0.13, 4.80]
Household quintile	1.02 [0.92, 1.14]	1.14 [1.01, 1.28]	1.02 [1.00, 1.04]	1.14 [1.12, 1.16]	0.00 [−0.02, 0.01]	0.02 [−0.01, 0.04]	3.18 [2.41, 3.95]	2.85 [1.74, 3.92]
Urbanization	0.90 [0.79, 1.02]	1.26 [1.04, 1.54]	0.93 [0.91, 0.95]	1.43 [1.39, 1.47]	−0.01 [−0.03, 0.01]	0.02 [−0.02, 0.06]	0.41 [−0.54, 1.36]	2.13 [0.41, 3.89]

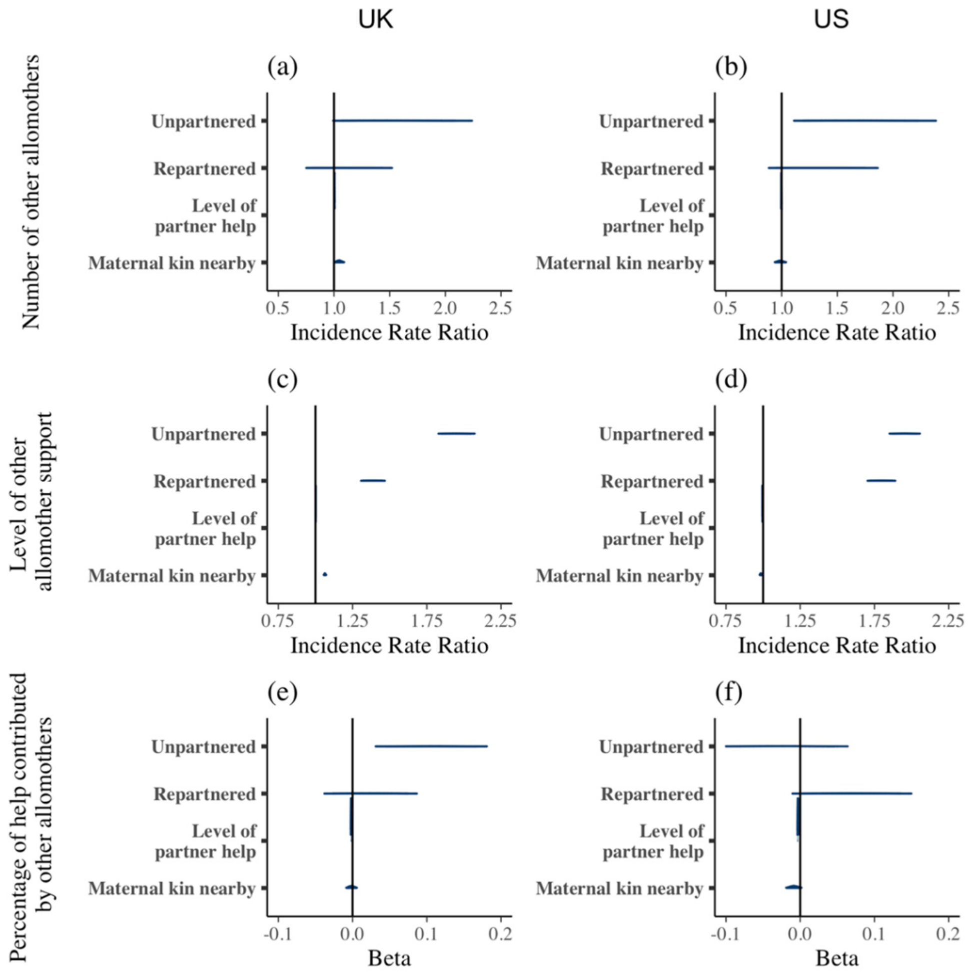

Figure 3. Plots showing the posterior distributions (95% credibility intervals) for the major predictors and control variables in the models for other allomother investment in each country, using the following measures: (**a**,**b**) number of other allomothers providing childcare; (**c**,**d**) total level of childcare help provided by other allomothers; and (**e**,**f**) percentage of total childcare help contributed by other allomothers. Reference category for unpartnered and repartnered women is partnered women; level of partner help and maternal kin nearby are entered as continuous predictors.

Running the models without the kin proximity and partner help covariates increased the impact of being unpartnered but did not significantly change the impact of being repartnered (see Section 4 for more details and Supplementary Materials for results). The increased effect of being unpartnered occurred when removing the partner help covariate, suggesting that the lack of a contribution from a partner partially, but not completely, explains the impact of being unpartnered on a mother's allomaternal network.

To account for additional sources of childcare support available in HILF countries, we also modeled the link between partnership status and paid childcare. In both the UK and US, unpartnered women used more hours of paid childcare on a weekly basis than did partnered women (Beta [95% CI], UK = 5.34 [2.43, 8.40]; US = 6.61 [2.69, 10.42], Table 4). Repartnered women did not differ from partnered women in the number of hours of paid childcare in either the UK of the US (Beta [95% CI], UK = 0.49 [−2.30, 3.18]; US = 0.11 [−3.52, 3.68]).

2.4. Partnership and Fertility (P4)

After describing support networks by women's partnership status, we considered the link between partnership and fertility. In both the UK and the US, repartnered women had higher age-adjusted fertility (Beta [95% CI], UK = 0.90 [0.71, 1.10]; US = 0.72 [0.49, 0.95],

Table 5, Figure 4). However, being unpartnered had no clear association with age-adjusted fertility in the UK (Beta [95% CI] = −0.07 [−0.27, 0.12]), while in the US unpartnered women had higher age-adjusted fertility (Beta [95% CI] = 0.27 [0.04, 0.49]). Unpartnered women were less likely to plan to have another baby within the next two years than partnered women in both countries (OR [95% CI], UK = 0.53 [0.29, 0.95]; US = 0.30 [0.16, 0.55]). Repartnered women were neither more nor less likely to plan to progress to the next birth within two years relative to partnered women (OR [95% CI], UK = 1.15 [0.56, 2.30]; US = 0.65 [0.31, 1.29]). When examining desired number of births, in both the UK and the US, neither unpartnered (IRR [95% CI], UK = 1.05 [0.89, 1.22]; US = 0.94 [0.80, 1.09]) nor repartnered (IRR [95% CI], UK = 1.08 [0.92, 1.25]; US = 0.98 [0.84, 1.15]) women seemed to differ from partnered women in fertility intentions.

Overall, unpartnered women showed somewhat higher age-adjusted fertility than partnered women in the US, and while in both countries unpartnered women were less likely to be planning a new child in the near future, they did not differ from partnered women in their total fertility desires. Repartnered women, however, had higher age-adjusted fertility relative to partnered women, although they did not differ from them in either their short- or long-term fertility intentions.

Table 5. Results of Bayesian regression models predicting fertility outcomes in the US and in the UK.

	Age-Adjusted Fertility		**Intent to Have Another Child in Next 2 Years**		**Total Number of Children Desired**	
	UK	**US**	**UK**	**US**	**UK**	**US**
	***N* = 918**	***N* = 609**	***N* = 918**	***N* = 609**	***N* = 918**	***N* = 609**
	Beta [95% CI]	**Beta [95% CI]**	**OR [95% CI]**	**OR [95% CI]**	**IRR [95% CI]**	**IRR [95% CI]**
Intercept	0.35 [0.02, 0.68]	0.52 [0.01, 1.03]	11.02 [3.19, 38.63]	6.22 [1.20, 33.98]	2.46 [1.74, 3.47]	2.72 [1.76, 4.19]
Partner status						
Unpartnered	−0.07 [−0.27, 0.12]	0.27 [0.04, 0.49]	0.53 [0.29, 0.95]	0.30 [0.16, 0.55]	1.05 [0.89, 1.22]	0.94 [0.80, 1.09]
Repartnered	0.90 [0.71, 1.10]	0.72 [0.49, 0.95]	1.15 [0.56, 2.30]	0.65 [0.31, 1.29]	1.08 [0.92, 1.25]	0.98 [0.84, 1.15]
Parity	-	-	0.31 [0.24, 0.41]	0.51 [0.39, 0.65]	1.27 [1.21, 1.32]	1.27 [1.21, 1.33]
Mother’s age	-	-	0.93 [0.89, 0.96]	0.94 [0.90, 0.98]	0.98 [0.97, 0.99]	0.98 [0.97, 0.99]
Religious	0.13 [0.03, 0.24]	0.13 [−0.02, 0.28]	1.65 [1.19, 2.27]	2.00 [1.35, 2.95]	1.06 [0.98, 1.16]	1.09 [0.99, 1.21]
Education	−0.14 [−0.20, −0.08]	−0.18 [−0.26, −0.10]	1.16 [0.96, 1.40]	1.15 [0.94, 1.41]	1.03 [0.98, 1.09]	1.01 [0.96, 1.07]
Nativity	0.09 [−0.06, 0.24]	0.27 [−0.04, 0.59]	1.21 [0.78, 1.93]	0.68 [0.29, 1.55]	1.01 [0.90, 1.15]	1.00 [0.81, 1.25]
Ethnicity	0.11 [−0.06, 0.27]	0.00 [−0.16, 0.17]	1.21 [0.78, 1.93]	1.11 [0.72, 1.67]	1.06 [0.93, 1.21]	1.08 [0.97, 1.20]
Household quintile	−0.05 [−0.11, 0.00]	0.06 [−0.01, 0.13]	1.26 [0.77, 2.05]	1.09 [0.90, 1.31]	1.00 [0.95, 1.05]	1.01 [0.96, 1.06]
Urbanization	0.01 [−0.06, 0.08]	−0.15 [−0.26, −0.03]	1.11 [0.93, 1.32]	1.16 [0.85, 1.57]	1.01 [0.96, 1.07]	0.99 [0.92, 1.07]

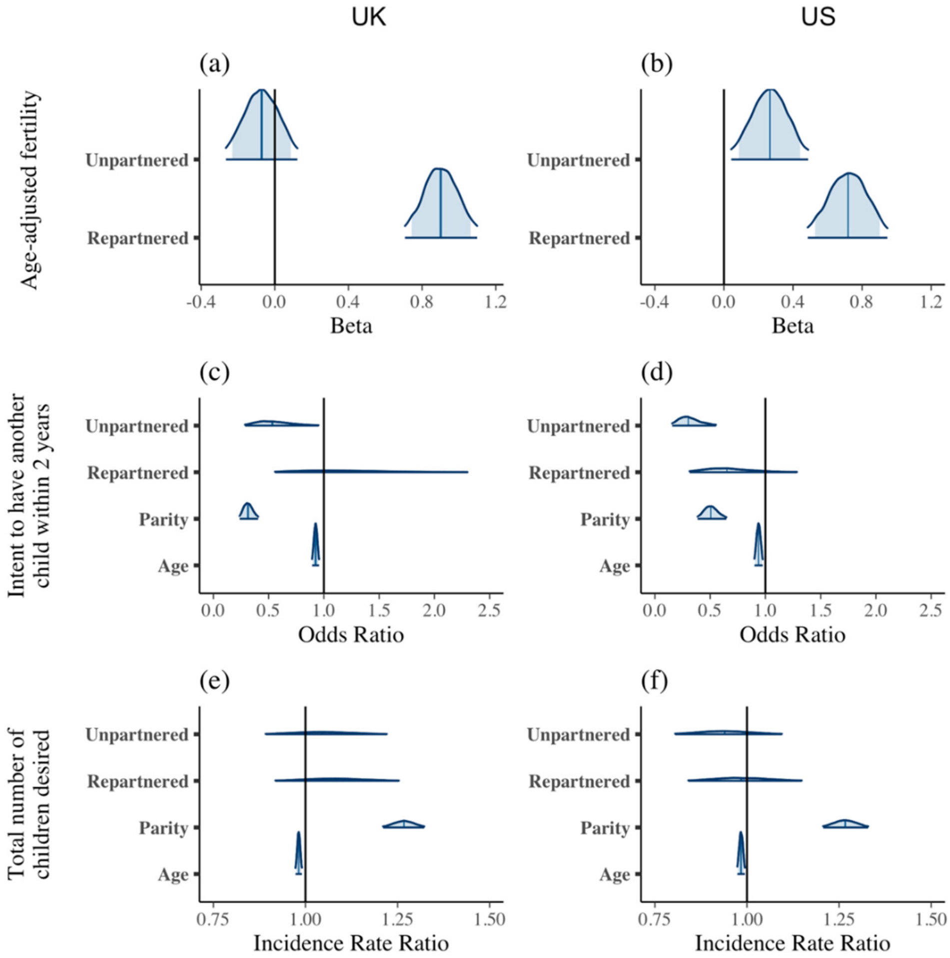

Figure 4. Plots showing the posterior distributions (95% credibility intervals) for the major predictors and control variables in the models for fertility outcomes using the following measures: (**a**,**b**) age-adjusted fertility; (**c**,**d**) intent to have another child within two years; and (**e**,**f**) total number of children desired. Reference category for unpartnered and repartnered women is partnered women; parity and age are entered as continuous predictors.

2.5. Allomothering and Fertility (P5)

Finally, we described the link between allomaternal support and fertility. The overall amount of childcare help received by the mother had no relationship with age-adjusted fertility in either the UK (Beta [95% CI] = 0.00 [0.00, 0.00], Table 6, Figure 5) or the US (Beta [95% CI] = 0.00 [0.00, 0.00]). The overall number of helpers (including the partner) did show a relationship with fertility and differed between the UK and the US. In the UK, the number of helpers was negatively associated with age-adjusted fertility (Beta [95% CI] = −0.04 [−0.08, −0.01]), while in the US, there was a slight positive relationship with age-adjusted fertility, although the effect was uncertain as the 95% credibility interval crossed zero ((Beta [95% CI] = 0.04 [−0.02, 0.10]).

Table 6. Results of Bayesian regression models predicting age-adjusted fertility in the US and in the UK.

	Age-Adjusted Fertility		**Age-Adjusted Fertility**	
	UK	**US**	**UK**	**US**
	***N* = 918**	***N* = 609**	***N* = 918**	***N* = 609**
	Beta **[95% CI]**	**Beta** **[95% CI]**	**Beta** **[95% CI]**	**Beta** **[95% CI]**
Intercept	0.42 [0.08, 0.76]	0.48 [−0.02, 0.97]]	0.41 [0.08, 0.75]	0.49 [−0.02, 0.99]]
Partner status				
Unpartnered	−0.12 [−0.32, 0.08]	0.27 [0.06, 0.49]	−0.10 [−0.30, 0.09]	0.25 [0.03, 0.48]
Repartnered	0.90 [0.70, 1.09]	0.71 [0.48, 0.94]	0.89 [0.70, 1.09]	0.71 [0.48, 0.94]
Total amount of childcare help	0.00 [0.00]	0.00 [0.00, 0.00]	-	-
Number of helpers	-	-	−0.04 [−0.08, −0.01]	0.04 [−0.02, 0.10]
Religious	0.14 [0.03, 0.24]	0.13 [−0.02, 0.28]	0.14 [0.04, 0.25]	0.13 [−0.02, 0.28]
Education	−0.14 [−0.20, −0.08]	−0.18 [−0.26, −0.10]	−0.14 [−0.20, −0.08]	−0.18 [−0.26, −0.10]
Nativity	0.11 [−0.04, 0.26]	0.28 [−0.03, 0.60]	0.12 [−0.03, 0.28]	0.27 [−0.05, 0.60]
Ethnicity	0.10 [−0.07, 0.27]	0.00 [−0.16, 0.17]	0.10 [−0.07, 0.26]	0.00 [−0.16, 0.16]
Household quintile	−0.05 [−0.11, 0.01]	0.05 [−0.02, 0.12]	−0.05 [−0.11, 0.01]	0.05 [−0.02, 0.12]
Urbanization	0.01 [−0.06, 0.08]	−0.15 [−0.26, −0.04]	0.01 [−0.06, 0.08]	−0.15 [−0.26, −0.04]

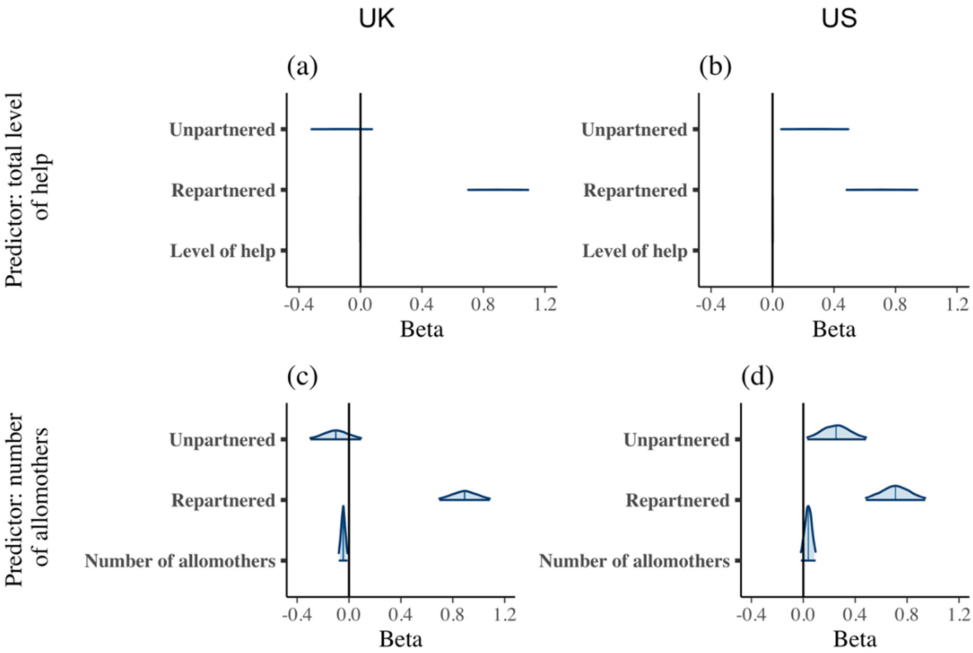

Figure 5. Plots showing the posterior distributions (95% credibility intervals) for the major predictors and control variables in the models of age-adjusted fertility as a function of: (**a**,**b**) total level of childcare help received and (**c**,**d**) total number of allomothers in the allomaternal network. Reference category for unpartnered and repartnered women is partnered women; level of help and number of allomothers are entered as continuous predictors.

3. Discussion

Our results emphasize the important contribution of partners to childcare in HILF settings and, in their absence, of maternal kin. Partners contribute nearly 75% of the nonmaternal care received by children when a mother has a partner (Figure 6). In the absence of a partner, unpartnered women rely heavily on a few high-investing maternal kin. Other helpers (the kin of the current or expartner, non-kin helpers) are also important for unpartnered mothers and contribute slightly more help for repartnered women than they do for partnered women. Even though mothers are flexible in the individuals from whom they obtain help, unpartnered women are not able to match the total level of help attained by currently partnered women. They may make up for this lower level of help by relying more heavily on paid sources of childcare. Lastly, while repartnership is associated with higher age-adjusted fertility, allomothering was not clearly associated with fertility: the number of helpers in the allomothering network was associated with fertility only in the UK, while the overall level of help was not associated with fertility in either country.

We predicted that second partners would invest less in childcare than first partners (P1). Results suggest that second partners were not less likely to be involved in childcare help in the home, but at least in the UK, they provided lower levels of help than did first partners in terms of instances of support in the past month. This was particularly the case when caring for a stepchild rather than a biological child. This pattern was not observed in the US, where levels of investments were similar for first and second partners, even when controlling for relationship to the child. It is possible that the similarity of partner investment levels between first and second partners in the US, even when differentiating between second partners caring for a biological child versus a stepchild, is due to the fact that these households include a mixture of biological and stepchildren. Studies in the US and St. Kitts have found that fathers in households with both biological children and stepchildren tend to invest similarly in both types of children, although they may feel less emotionally close to stepchildren (Cooksey and Fondell 1996; Gray and Brown 2015). Thus, if second partners caring for stepchildren in the US are living with both biological and stepchildren, there may be incentives to investing equally in both types of children. Small numbers of second partners caring for stepchildren (N = 16 in the UK and N = 18 in the US) prevent further differentiation between stepfathers caring for stepchildren in households where there are also biological children versus those where only stepchildren are present. While this could explain the similarity in partner investment in the US, it is not clear why the patterns of partner investment differ between the UK and the US. Stepfather investment in the UK is well studied from evolutionary perspectives, and studies consistently find that stepfathers tend to invest less than fathers (Lawson and Mace 2009; Emmot and Mace 2014). Our findings are consistent with this existing literature. It is possible that a greater degree of social support provided by the UK government means that the consequences of lower levels of partner investment are less important in the UK and thus that the incentives for second partner investment in childcare are not as strong as they are in the US.

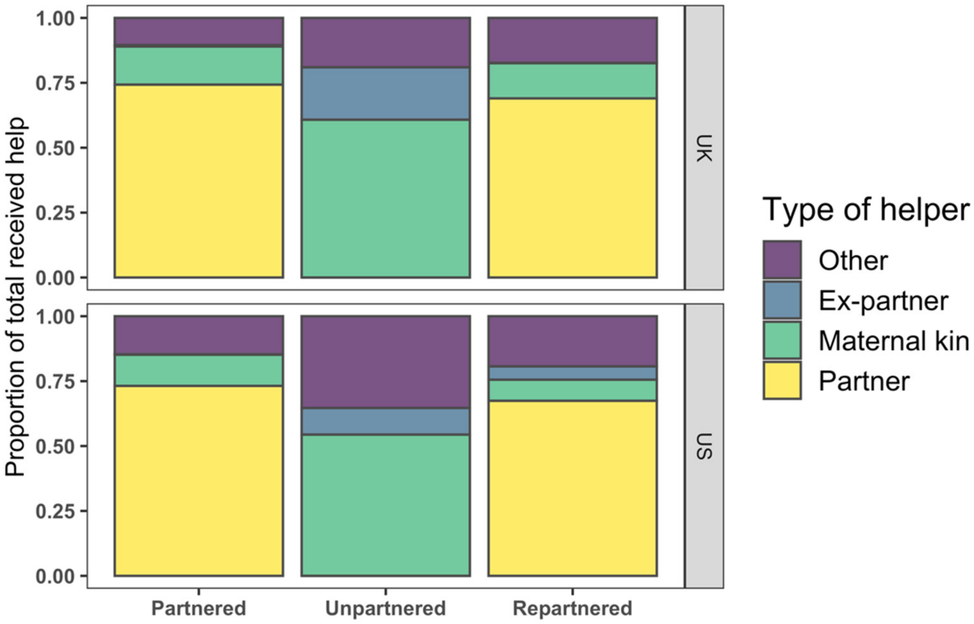

Figure 6. Proportion of total childcare help received (as a number of tasks performed over the course of a month) by type of allomother, according to partnership status of the mother, for each country separately.

We found some support for our prediction that unpartnered and repartnered women would receive more support from maternal kin (P2) and others (P3) than partnered women. Unpartnered, but not repartnered, mothers relied more heavily on maternal kin and on other helpers for childcare help than partnered women in both the UK and the US. The greater involvement of maternal kin in providing support to women following a divorce is consistent with the notion that family support is based on women's needs, and has been demonstrated elsewhere (Scelza 2011; Coall et al. 2014; Snopkowski and Sear 2015). For unpartnered mothers, the most common maternal kin allomother was the child's grandmother, and other helpers were most commonly nonrelated individuals and expartners. Allomothers who are unrelated to the mother, key helpers for unpartnered mothers, may be motivated to help with childcare if they can receive reciprocal help, childcare, or otherwise, in return (Denham 2015; Jaeggi et al. 2016; Page et al. 2019). While mothers are flexible in terms of the people from whom they seek out the help they need, the absence of the partner's help is not completely offset by relying more heavily on other helpers: the mean help score for unpartnered women is 80, while both partnered and repartnered mothers had mean help scores above 130 (Table 1), meaning that partnered and repartnered mothers receive help with an average of 50 additional tasks per month than do unpartnered women. Coresidence of helpers may explain why mothers who are unpartnered receive less overall help, despite receiving higher levels of help from both maternal kin and other helpers. Studies have found that coresidence is correlated to higher likelihood that a grandparent, step-parent, or step-grandparent provides childcare help (Baydar and Brooks-Gunn 1998; Vandell et al. 2003; Pashos et al. 2016), and higher levels of investment from the biological father (Lancaster and Kaplan 2000; Pashos et al. 2016). Further, most childcare help to single mothers comes from household members (Clarke et al. 2017). In other words, partnered and repartnered mothers can leverage more regular help from a coresident and available helper such as the partner, whereas unpartnered mothers without coresident help are not able to mobilize helpers as regularly.

Again in partial support of P2 and P3, mothers who were repartnered reported lower levels of support from maternal kin but higher levels of support from other helpers in both the UK and the US relative to partnered mothers. The lower investment from maternal kin is unexpected, because the genetic relationship between maternal kin and the mother's children from a first or second union remains the same, and inclusive fitness theory would suggest that maternal kin would show similar investment in children from first or second unions. However, the lower investments of maternal kin investment in repartnered mothers may be a response to their increased contribution during the time between partnerships. That is, maternal kin may see the mother's new partner as a source of support for her, and accordingly readjust their level of support based on their new perception of her needs. The higher level of help obtained from other helpers for repartnered mothers relative to partnered mothers may reflect an expansion of the allomothering network during the unpartnered phase to rely more heavily on reciprocal relationships with non-kin, which persists into a second partnership. Alternatively, the higher level of help from other partners for repartnered mothers may also be due to the expansion of her allomothering network to include the new partner and his kin.

Our prediction that fertility behavior and intentions would be higher among repartnered women than unpartnered or partnered women was supported, as being repartnered was clearly associated with higher fertility (P4). However, repartnership was not predictive of fertility desires as measured by intent to progress to another child within two years nor by the total of number of children desired. This suggests that although repartnered women do not state a preference for more children than other women, they do in fact achieve a higher fertility for their age. Because our sample is still in an active reproductive phase, it is possible that the higher age-adjusted fertility of repartnered women reflects an earlier schedule of reproduction (i.e., starting and completing reproduction earlier in life) rather than a higher complete fertility. However, other studies from HILF countries find that repartnering increases fertility (Balbo et al. 2013), and that remarried couples desire a child together regardless of pre-existing children (Vikat et al. 1999). While research in lower- and middle-income countries suggests that remarriage increases fertility desires (John 2018; Elleamoh and Dake 2019; Akinyemi et al. 2021), there is little recent research on the impact of repartnership on fertility desires in HILF countries. If repartnering does in fact increase completed fertility, as our data and other studies suggest, the lack of difference in stated fertility preferences could mean either that repartnered women have more children than they desire to, perhaps because men tend to state similar or higher fertility preferences than women (Sear and Coall 2011), or because women with only one partner underachieve their fertility desires, as has been documented elsewhere (Morgan and Rackin 2010; Sear et al. 2016; Beaujouan and Berghammer 2019). It is not possible to tell from our data whether the higher fertility of repartnered women is due to women who have more children being more likely to repartner upon becoming single, or because women who repartner go on to have additional children with their new partner. In the case of the former, single mothers with more children may seek to repartner, in part, because a new partner may contribute childcare or other forms of support. On the other hand, partners may be willing to perform these duties as a form of mating investment (Anderson 2000; Lancaster and Kaplan 2000), and mothers may be motivated to cement their new relationship by having a baby, both of which could result in the latter possibility (i.e., that repartnering causes more children). The latter is at least partially supported by our findings: 77% of repartnered women had at least one child with a second partner, suggesting their higher fertility was partially influenced by post-repartnering births.

Finally, we found no clear evidence for our prediction that receiving childcare help or the size of the allomothering network is positively correlated with fertility (P5). A positive relationship between help and fertility is predicted by the cooperative breeding hypothesis, but studies in less market integrated settings have found both positive (Forrester 2020) or no relationship (Kramer and Veile 2018) between allomothering and fertility outcomes. However, this does not necessarily mean that allomothering does not increase fertility in the UK or the US. We did not assess interbirth intervals in this analysis and thus cannot conclude as to whether allomothering does or does not shorten interbirth intervals, a key prediction of the cooperative breeding hypothesis in non-industrialized settings. There may also be a nonlinear relationship between allomothering and fertility that was not captured in this analysis. For example, it is possible that receiving less than a certain level of support may suppress fertility but that receipt of additional support beyond that threshold does not substantially affect fertility levels. Additionally, all of the respondents to our survey had children under the age of 5 years and were thus still in the reproductive periods of their lives; therefore, it is possible that those receiving more allomothering support may still progress to higher order births. Alternatively, the relationship between allomothering and fertility may be altered in HILF settings relative to traditional societies because of an overall lower fertility rate following the demographic transition. For example, Schaffnit and Sear (2017a, 2017b) suggested that in their analysis of data from the Netherlands and the United Kingdom, emotional support for the mother was more important than physical support in determining progression to a next birth perhaps because practical support is more likely to be needs based. Further, across HILF countries, women may use allomaternal support to return to work rather than to have another child (Sear and Coall 2011; Schaffnit and Sear 2017a). Lastly, and importantly, our study looked at cross-sectional measures of allomothering for a single focal child. It is conceivable that shifts in allomothering over time or in cumulative help over several children may reveal a clearer relationship between allomothering and fertility.

In HILF settings, paid allomothers such as babysitters and government sources of care (e.g., subsidized daycares and schools) are important sources of support for mothers (Allen 2003). Unfortunately, due to our data collection procedures we could not integrate our data on paid care with those for the allomothering network. However, analyses indicate that unpartnered mothers, who receive less total allomaternal support than either partnered or repartnered women, use a mean of about 5 and 6 more hours of paid care a week than do partnered women in the UK and the US, respectively. Our model also suggests that higher household income quintile and higher education are associated with greater use of paid care. Given that unpartnered women are actually more likely to report lower household incomes and lower levels of education, the fact that they report using more paid care suggests that they are doing so out of need for childcare help, rather than because they have the economic means to do so. It is important to note that the focal children in this study were all under the age of 5 years, meaning that none of them were yet attending primary school.

While our discussion has focused on the association of partnership status with allomothering and fertility, our models also controlled for several sociodemographic indicators that may be of interest to other researchers. Importantly, in our sample unpartnered women tended to be part of lower household income quintiles and have lower level of educational attainment relative to partnered women. These differences in socioeconomic status, combined with lower overall childcare help scores, suggest that unpartnered women may be carrying a double burden of performing a greater amount of care work while having fewer socioeconomic resources to do so.

Women in this study reported similar allomothering networks sizes as studies from low-income settings including Bangladesh (Lynch et al.) and urban Nairobi (Clarke et al. 2017). Respondents in this survey reported an average of 1.81 helpers (median = 1), and

171 of them (11%) reported receiving help from no one. Mothers in Matlab, Bangladesh, a rural agricultural region undergoing market transition and fertility decline, reported receiving childcare help from an average of 1.97 people (median = 2), with 10.5% of women receiving childcare help from no others (Lynch et al.). Mothers residing in urban slums in Nairobi received childcare help from an average of 1.4 kin helpers, with 31% receiving no help from kin at all (Clarke et al. 2017). The Nairobi study is not completely comparable to ours, since data were only collected on care provided by kin, but overall, both studies show sizes of allomothering networks that are roughly comparable to ours. Support networks in these studies are drastically different than those in forager populations where children can expect to be cared by anywhere from 5 to 20 caregivers besides their mothers (Hewlett and Lamb 2005; Meehan 2009; Meehan et al. 2013; Ivey 2000). It is possible that this difference is due to the method of data collection, which typically consists of observed interaction in foraging groups, whereas it is recalled through survey questions in our study as well as those in Bangladesh and Nairobi. However, the similarity in the size of allomaternal networks in Bangladesh and Nairobi versus the US and the UK, contexts that vary in terms of state-provided childcare options and market integration, is surprising. Emmott (2016) has suggested that a shift to agricultural subsistence strategies shifted a greater burden of childcare to mothers, and this appears to be exemplified by the Bangladeshi data. However, it could be that communal living in foraging societies and decreased market integration, rather than subsistence strategy, are the drivers behind larger allomaternal networks. Indeed, Ngandu farmers tend to have smaller allomothering networks than nearby foragers; however, infants still have access to an average of 10.9 alloparents (Meehan 2009), and Sidama infants, an agropastoralist group in Ethiopia, are documented to average 10.8 caretakers (Helfrecht et al. 2020). Quantification of allomothering networks and crosscultural exploration of the drivers affecting their size and composition merits greater study.

In this analysis, we demonstrate the key roles played by fathers and partners in contemporary families by showing that when they are available, partners provide the bulk of nonmaternal care received by children. However, we also show that mothers continue to draw on childcare help from allomothers outside of the pair-bond, particularly from their kin. As Sear (2021) has argued, the notion of the traditional family as a nuclear independent economic unit is inaccurate cross-culturally and historically. The narrative that the modern mother should be able to balance work duties with caring for their families effortlessly can be harmful. The impact of partnership on allomaternal support is of interest not only for understanding family dynamics in HILF countries but also for understanding these in any society past or present where serial monogamy exists. Applying a human behavioral ecological lens to studies on family dynamics in HILF countries helps shed light on how human reproduction responds to socioecological pressures both past and present.

4. Materials and Methods

Data from this study were collected from an online survey of women conducted in August of 2020 through Prolific, an online platform connecting researchers with participants. Due to its focus on connecting researchers and participants, ease of use, and clear rules for compensation, Prolific has been argued to achieve more naïve and diverse participant pools and yield higher data quality compared to similar platforms such as MTurk (Peer et al. 2017; Palan and Schitter 2018). Women were eligible for participating in the survey if they resided in either the UK or the US and had at least one child under the age of five at the time of survey. Mothers were asked about their residential proximity to kin, close social networks, and reproductive history, as well as questions regarding who provides them with help in taking care of a focal child. Helpers were defined as anyone providing help, including the child's biological father and/or the mother's current partner, but excluding any paid or state-provided help such as nannies, teachers, or care-aids. For each helper, the mother provided her relationship to the helper, and the frequency with which they performed several childcare tasks (daily, weekly, monthly, less than monthly, or never). Mothers were asked to provide an average number of hours weekly that the child spent in paid childcare. In all cases, we asked mothers to describe their practices prior to the onset of the COVID-19 pandemic, five or six months prior to the survey, in order to minimize the impact of closures and restrictions on our results. Mothers were compensated 1.25 GBP, or roughly 1.63 USD for completing the questionnaire, the Prolific-suggested rate for roughly 10 min of participation time. The survey and sampling strategies were approved by the University of Otago Human Ethics Committee (reference number: D20/242). A copy of the survey administered is available in the Supplementary Materials. We excluded responses where the mother indicated her first birth had occurred prior to 15 years of age (n = 4), responses where the mother failed the attention-check question (n = 159), and responses that showed low effort, for example not completing demographic questions (n = 6). After exclusions, the final sample available for analysis consisted of 1528 women, 919 from the UK, and 609 from the US.

Help provided to mothers was assessed with the following measures calculated from the responses: the number of people of each type (partners, maternal kin, and others, see below) she received help from, the frequency of help they provided (referred to as "level" of support), and the percentage of total help that was received from that type of helper. Paternal kin help could not be examined separately because the survey did not clearly differentiate between paternal and step-paternal kin; thus, these helpers are included in the category of "other helpers". The level of help was operationalized using mothers' reports of how often (daily, weekly, monthly, less than monthly, or never) each person helped with five childcare tasks (changing/washing, feeding, playing, supervising, and unspecified other tasks), which were adapted from the Avon Longitudinal Study of Parents and Children (Golding et al. 2001; Lawson and Mace 2009). These were converted to an estimate of the number of days per month each type of help was provided. We estimated that daily help with a task would be provided almost every day (score of 28 days per month); that weekly help could be provided as much as twice a week (score of 8 days per month); that monthly help could be provided up to twice a month (score of 2 days per month); and that less than monthly or never would not be provided regularly (score of 0 days per month). These scores are roughly analogous to scoring the help frequency on a scale from 1 to 5, which has been used in other analyses (Lawson and Mace 2009). The level-of-help scores were then summed across categories of helpers to create an overall support score—higher scores represented higher levels of support from allomothers. To ensure that our results were robust to our operationalization scheme, we also tested two alternative measures of support. First, we used the same scoring scheme but used only the frequency of supervision, as supervision could theoretically include instances of other types of care. Second, we tried a different operationalization scheme, categorizing a type of help as either occurring daily (1) or not (0). These alternative models are reported in the Supplementary Materials and provide substantively similar results to those presented below.

Three measures were used to assess fertility behavior: age-adjusted fertility, intent to have another child within the next two years, and total number of children desired. Age-adjusted fertility was calculated as the residual of a linear regression of number of births on age. Age-adjusted fertility, rather than raw number of births, was used as the primary measure of fertility because the average age of the respondents was in the early thirties (mean = 32.5, SD = 5.3), meaning that a substantial proportion of the study sample may not have completed their fertility.

The main predictor used in the models was partnership status. We categorized this as partnered, unpartnered, and repartnered. If women indicated that they were currently married or cohabiting with a partner, they were categorized as either partnered or repartnered, and if not, they were categorized as unpartnered. If a woman indicated that she was currently married or cohabiting with a partner and all of her children's biological fathers were her current partner, she was categorized as partnered, and otherwise she was categorized as repartnered. All analyses considered partnered women as the reference category, and effects for unpartnered and repartnered women were relative to partnered women. Models predicting likelihood and level of partner involvement were restricted to partnered and repartnered women. In analyzing partner involvement, we included one model evaluating the impact of biological relatedness to the child on likelihood of partner involvement. In this case, second partners were categorized as either biological fathers or stepfathers, and effects for these categories were relative to first partners who were also biological fathers. In all analyses, we included the following sociodemographic covariates for the mother: age, whether she indicated a religious affiliation, highest educational attainment, whether she was born in the country of residence (nativity), ethnicity (coded as white or other), household income quintile, and level of urbanization (village, town, or urban center). All models for partner, maternal kin, and other allomother investment controlled for age of the focal child, the number of hours weekly that the child spent in paid care, and the total number of children (biological or not) residing in the mother's home. Models for partner investment controlled for the number of kin residing within an hour's travel of the mother's residence. Models for maternal kin and other allomother investment controlled for the level of partner help and the number of maternal kin residing within an hour's travel from the mother's residence. Since the level of partner help and the number of maternal kin residing nearby were likely related to partnership status, we also ran the partner, maternal kin, and other allomother models without these covariates and report the results in the Supplementary Materials. In the models analyzing intent to have another child and total number of children desired, we adjusted for maternal age and parity.

Data were modeled with multivariate Bayesian regression models using the *brms* package (Bürkner 2017) in R (R Core Team 2020). Models were built with a Gaussian distribution for age-adjusted fertility, a Poisson distribution for the total number of children desired and for models estimating both the number of helpers and level of help provided to the mother, and a Bernoulli distribution for the desire to have a child within the next two years and for models examining the likelihood of partner help. These were created for the countries separately, as the US and UK are known to differ in their fertility patterns and have different levels of state-provided childcare support for families. Full model specifications are available in the Supplementary Materials, and the data and scripts used in this analysis are available on the project OSF page at: https://osf.io/zpu5f/ (accessed on 17 May 2021).

Supplementary Materials: Supplementary Materials are available online at https://www.mdpi.com/article/10.3390/socsci10050182/s1. Data and scripts are available on the project OSF page at https://osf.io/zpu5f/ (accessed on 17 May 2021).

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Article

Frail Males on the American Frontier: The Role of Environmental Harshness on Sex Ratios at Birth across a Period of Rapid Industrialization

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Abstract: While sex ratios at birth (SRB) have been shown to vary within and across populations, after over a century of research, explanations have remained elusive. A variety of ecological, demographic, economic, and social variables have been evaluated, yet their association with SRB has been equivocal. Here, in an attempt to shed light on this unresolved topic within the literature, we approach the question of what drives variation in SRB using detailed longitudinal data spanning the frontier-era to the early 20th century in a population from the US state of Utah. Using several measures of environmental harshness, we find that fewer boys are born during challenging times. However, these results hold only for the frontier-era and not into a period of rapid economic and infrastructure development. We argue that the mixed state of the literature may result from the impact and frequency of exogenous stressors being dampened due to industrialization.

Keywords: sex ratio; prenatal stress; environmental stressors

1. Introduction

The ratio of male-to-female live births (sex ratio at birth, SRB; also known as the secondary sex ratio) for humans is male-biased (~1.05), yet SRB varies considerably both across time and place (James 1987). While this pattern has been well-documented, understanding why this variation occurs has been labeled as one of the most elusive concepts in the life sciences today (Pavic 2015). One well-developed line of inquiry targets ambient stressors as drivers of SRB outcomes given that prenatal stress is expected to negatively affect developing males more so than females (Schacht et al. 2019). However, from across social science disciplines, a variety of demographic, economic, and ecological variables have been evaluated, producing mixed findings (Lydersen 2007; Ruckstuhl et al. 2010; Song 2012; Stein et al. 2004; Zhao et al. 2013). A key consideration for this ambiguity is that living conditions in industrial societies (e.g., infrastructure development) may blunt possible adverse consequences associated with exogenous shocks (e.g., drought) due to connectivity between populations facilitating the flow of resources (Scalone and Rettaroli 2015). Fertility patterns within these societies too may contribute to the mixed state of literature, whereby the demographic transition and lower fertility limit our ability to detect patterns that may be clearer in natural fertility populations (Davis 1986). It is with these critiques in mind that we examine environmental drivers of variation in SRB using detailed, longitudinal historical data (births from 1851–1919) spanning a period encompassing natural fertility conditions for a US population. Specifically, we target novel measures of environmental quality on SRB across a time period of transitioning economic development: from subsistence agriculture to rapid industrialization.

Males experience higher rates of mortality across nearly all stages of development (Andreev 2000). This bias is particularly heightened during the prenatal period (male-biased fetal losses regularly outnumber those of females by 9 to 20 percent; Ammon et al. 2012) and is argued to be driven by their need for greater metabolic investments from mothers to survive (Tamimi et al. 2003; Harrell et al. 2008). Consequently, sources of maternal and/or environmental stress are expected to negatively affect males more so than females, earning them the moniker 'frail males.' Indeed, a growing body of research shows that following ambient stressors, SRB falls below expected levels. For example, findings from historical populations indicate that the type of shock associated with male-biased fetal loss ranges widely and includes famine, temperature swings, earthquakes, volcanic eruptions, and pandemics (Helle et al. 2009; Catalano et al. 2008; Fukuda et al. 1998; Casey et al. 2019; Schacht et al. 2019).

Results from studies on contemporary populations are more mixed, however. While some researchers examining 21st century stressors, such as terrorist attacks (Bruckner et al. 2010) and economic downturns (Catalano et al. 2005), have found SRB to fall after these events (i.e., fewer boys were born), other researchers found no relationship (e.g., Lydersen 2007). As noted, the presumed mechanism driving these associations involves elevated male frailty *in utero*. Unexpected sources of prenatal stress may more acutely affect frail male fetuses, reducing the number of male births relative to female births (Bruckner et al. 2013). However, in the modern era, fertility control and declining family sizes may decrease our ability to detect an effect (Davis 1986). Son-preference may also play a role, particularly where families seek to end reproduction after producing a boy and/or sex-selective practices are employed (female-biased abortions, infanticide; Hesketh and Min 2012). An additional consideration is the role of economic development on SRB. Both the impact and frequency of ambient stressors are likely diminished in industrial societies, as market integration and economic development blunt exogenous shocks, particularly those driven by resource scarcity (Scalone and Rettaroli 2015). Moreover, nutritional profiles are expected to improve with infrastructure development (i.e., individuals will be better nourished), making the population as a whole more resilient in the face of short-term resource scarcity (Cai and Feng 2005). Accordingly, infrastructure development, which allows for a more regular distribution of goods and access to health care, may play a crucial role in moderating how environmental stressors affect SRB.

Here, we analyze a longitudinal dataset (1851–1919) from the US state of Utah that spans the frontier era to a period of rapid economic and infrastructure development. The completion of the Trans-Continental Railroad in 1869 (this event is often referred to as the Golden Spike) initiated a period of industrialization that reduced the population's reliance on subsistence agriculture by linking Utah's previously insular economy to that of the larger national economy (Powell 1994). Given that the consequences of poor local ecological productivity changed with access to external markets, we examine how indicators of exogenous stressors covary with the sex ratio at birth both before and after 1869. During Utah's frontier-era, farmers practiced a mix of dryland and irrigated farming, but in both cases, crop productivity depended heavily on rainfall (ibid). Severe droughts were documented during this period, and mortality rates followed inter-annual variation in rainfall. Therefore, for measures of ecological quality, we target historical water values for the Great Salt Lake (GSL; the largest saltwater lake in the western hemisphere) as they serve as ideal indicators of annual water availability in the area. Our GSL measures serve as gauges for ecological stress on this agrarian population, with potential impacts for SRB.

Here, we test three predictions to examine whether measures of drought vary inversely with the sex ratio at birth in Utah from 1851 to 1919.

Predictions

1. The SRB will increase with greater water availability (i.e., relatively more boys will be born in wet years).
2. GSL water metrics (as measures of local environmental quality) will be most strongly associated with SRB for populations living near the lake since those living farther away will be affected by differing and other place-specific ecological conditions.
3. The association between GSL metrics and SRB will be strongest prior to industrialization in Utah.

2. Methods

2.1. Settlement and Economic Development of Utah

The settlement by Euro-Americans of what is now the state of Utah began in 1847. Initially, Salt Lake County served as a central settlement area, with smaller populations forming to the north and south (Mineau et al. 1989). Over the next 20 years, migration rates were high, and the population grew rapidly (U.S. Bureau of the Census 1900). During this frontier period, the economy was primarily reliant on subsistence agriculture, with most households maintaining a small farm holding (Powell 1994). However, after the completion of the transcontinental railroad and the driving of the Golden Spike in 1869, industrialization rapidly began and urban populations began to grow, the manufacturing industry became established, and communities became connected through road, rail, and communication systems allowing for the rapid movement of goods, people, and news (*ibid*.). Thus, 1869 serves as a useful benchmark for the end of the frontier-era in Utah and the beginning of an industrializing state economy.

2.2. Sample and Data

We relied on SRB data from the Utah Population Database (UPDB; births pre-spike = 39,451; births post-spike = 348,421). The UPDB is one of the world's richest sources of linked population-based information for demographic, genetic, and epidemiological studies. The UPDB has supported numerous biomedical investigations in large part because of its size, inclusion of multi-generational pedigrees, and linkages to numerous data sources. The UPDB now contains data on over 11 million individuals from the late 18th century to the present. The multigenerational pedigrees representing Utah's founders and their descendants were constructed based on data provided by the Genealogical Society of Utah (GSU). Pedigrees spanning the past century have been expanded extensively based on vital records and, together with the GSU data, form the basis of the deep genealogical structure of the UPDB. This study has been approved by the University of Utah's Resource for Genetic and Epidemiologic Research and its Institutional Review Board.

To be included in our analyses, eligible individuals were those with a known sex, year of birth, and county of birth in Utah (to determine geographic proximity to GSL; see map in Figure 1). County was selected as our level for data aggregation to generate sufficient sample sizes necessary for comparisons of SRB across geographic areas. We restricted the study population to births between 1851 and 1919. Our unit of analysis is the geographic year, with one observation for each year and each geography (Salt Lake County and other Utah counties).

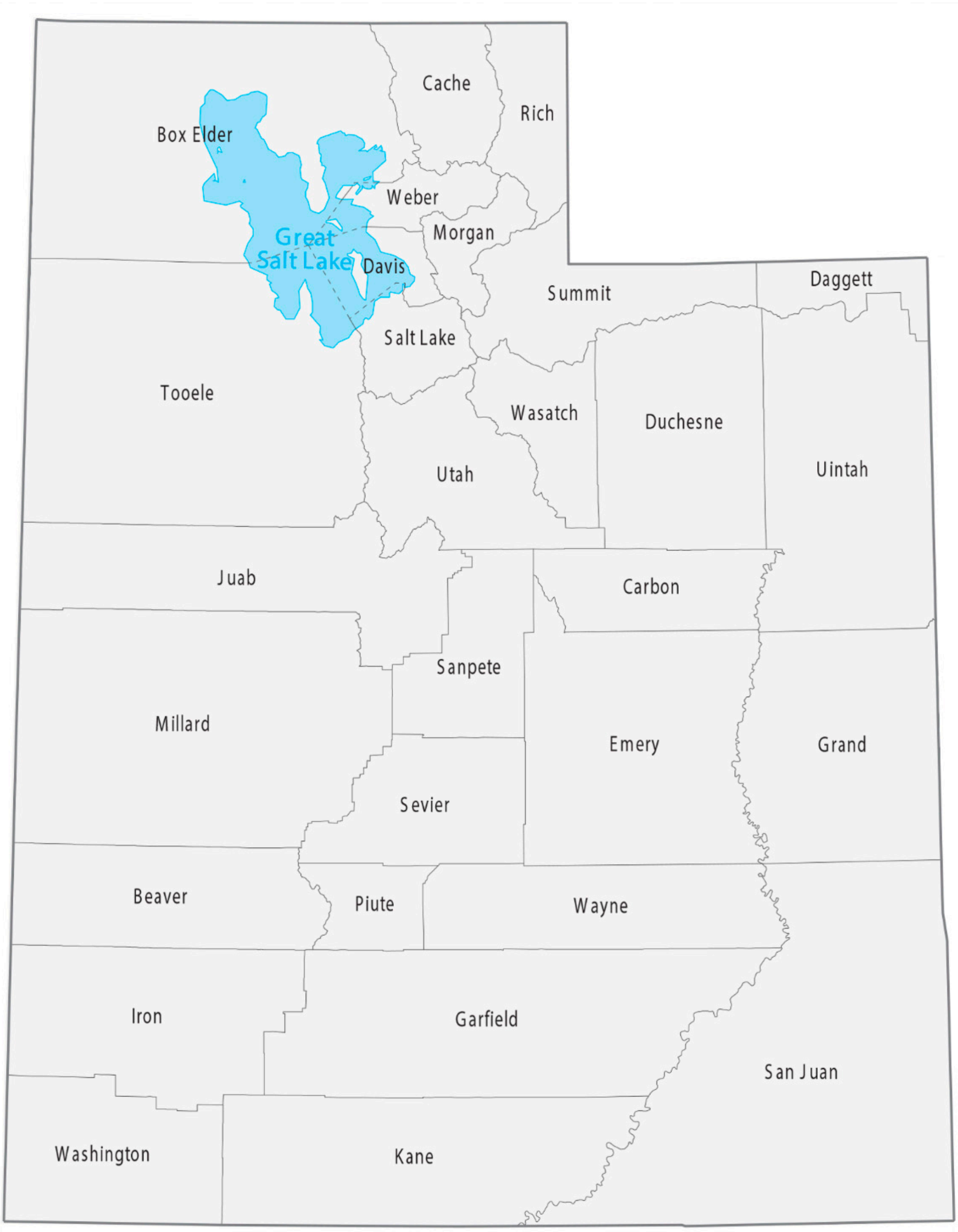

Figure 1. Map of Utah, including the Great Salt Lake (GSL) and names of counties.

Our metrics of environmental quality come from data compiled in Bowles et al. (1985). This report contains data (and associated methodologies) for four historical measures of GSL dynamics. The four variables of interest, which gauge the presence of arid conditions, include the GSL's (1) water level elevation, (2) river inflow, (3) precipitation, and (4) evaporation. These variables are reported annually (either estimated or measured directly, see below) beginning in 1851.

3. Variables

3.1. UPDB Variables

Agrarian, Natural Fertility Era (Pre-Golden Spike) is a binary indicator variable capturing the period 1869 and before (1 for 1851–1869, 0 for 1870–1919).

Salt Lake County was measured with a binary indicator variable (1 for born in Salt Lake County, 0 for born in another Utah county).

Sex Ratio at Birth is an interval-level variable determined by the number of male births divided by the number of female births. We calculated the SRB for each year and each geography (Salt Lake County or other Utah county; SRB pre-spike/Salt Lake County = 1.06; SRB pre-spike/other county = 1.04; SRB post-spike/Salt Lake County = 1.05; SRB post-spike/other county = 1.05).

3.2. Great Salt Lake Measures

We employ four measures of potential ecological hardship relevant to those living near the GSL.

Annual Peak Lake Elevation in feet, hereafter referred to as simply *elevation*.

Annual River Inflows in 1000 acre-feet, hereafter simply referred to as *river flow*. This includes the combined totals from the Bear, Weber, and Jordan Rivers.

Annual Lake Precipitation in inches, hereafter simply referred to as *inches*.

Annual Lake Freshwater Evaporation in inches, hereafter referred to simply as *evaporation*.

For the first three measures, higher values serve as indicators of better environmental conditions. The fourth, evaporation, is the only measure where a higher value indicates a worse environment. Bowles et al. (1985), used estimation methods to impute some data points that could not be directly measured, and we controlled for these with a dummy variable.

4. Analysis

First, we examined simple correlation coefficients among the four GSL measures and SRB. Second, we estimated an ordinary least squares (OLS) regression model for each GSL measurement with SRB as the outcome. The full OLS equation, with relevant interaction terms, appears below:

$$srb = \beta_0 + \beta_1 r + \beta_2 t + \beta_3 g + \beta_4 (r \times t) + \beta_5 (r \times g) + \beta_6 (t \times g) + \beta_7 (r \times t \times g) + \beta_8 f$$

where *SRB* is the interval-level sex ratio at birth, r is the relevant GSL risk factor (elevation, river inflow, precipitation, or evaporation, introduced one at a time), t (time) is the Pre-Golden Spike indicator, g (geography) is the Salt Lake County indicator, and f is a flag for data estimation by Bowles et al. (1985). The marginal effect of SRB with respect to the GSL risk factor, then, is:

$$\frac{\partial srb}{\partial r} = \beta_1 + \beta_4 t + \beta_5 g + \beta_7 t \times g$$

Since t and g are simple 0/1 binary variables, we can collect terms to develop a parsimonious two-by-two contingency table that examines the marginal effects separately. For example, to interpret the role of a particular GSL metric on SRB during the frontier (pre-spike) time period in Salt Lake County, we would add the coefficients bolded in the marginal effects table below:

	Time Period (t)	
Geography (g)	Pre-spike = 1	Post-spike = 0
Salt Lake County = 1	$\boldsymbol{\beta_1 + \beta_4 + \beta_5 + \beta_7}$	β_1
Other county = 0	$\beta_1 + \beta_4$	$\beta_1 + \beta_5$

Parameters were estimated with *PROC REG* in SAS (v9.4). Since births increased over time, we weighted each observation by the total number of births experienced. Continuous variables were centered about their grand mean to address multicollinearity and facilitate interpretation. We also apply Durbin–Watson tests and find no evidence for the presence of serial correlation.

5. Results

5.1. Descriptive

Descriptive statistics appear in Table 1. The SRB shows greater annual variability for Salt Lake County owing to a relatively smaller population size compared to Utah as a whole, though Salt Lake County was, and is, the largest county in the state (Harris 2020). This increased variability is also reflected in Figures 2 and 3, which chart SRB alongside the total births for each geography.

Table 1. Descriptive Statistics (N = 69 Years).

	Mean	SD	Min	Max
Sex Ratio at Birth				
Salt Lake County	1.06	0.07	0.89	1.23
Other Utah Counties	1.05	0.04	0.96	1.16
Great Salt Lake Measures				
Elevation [a]	4204.47	3.59	4197.60	4211.60
River Inflow [b]	2092.94	859.99	396.00	4536.00
Precipitation [c]	10.66	2.66	5.99	19.30
Evaporation [d]	4854.71	326.04	4140.00	5508.00

[a] Lake elevation (in feet). [b] River inflows from Bear, Weber, and Jordan rivers (in 1000 acre-feet). [c] Precipitation on lake (in inches). [d] Freshwater evaporation (in inches).

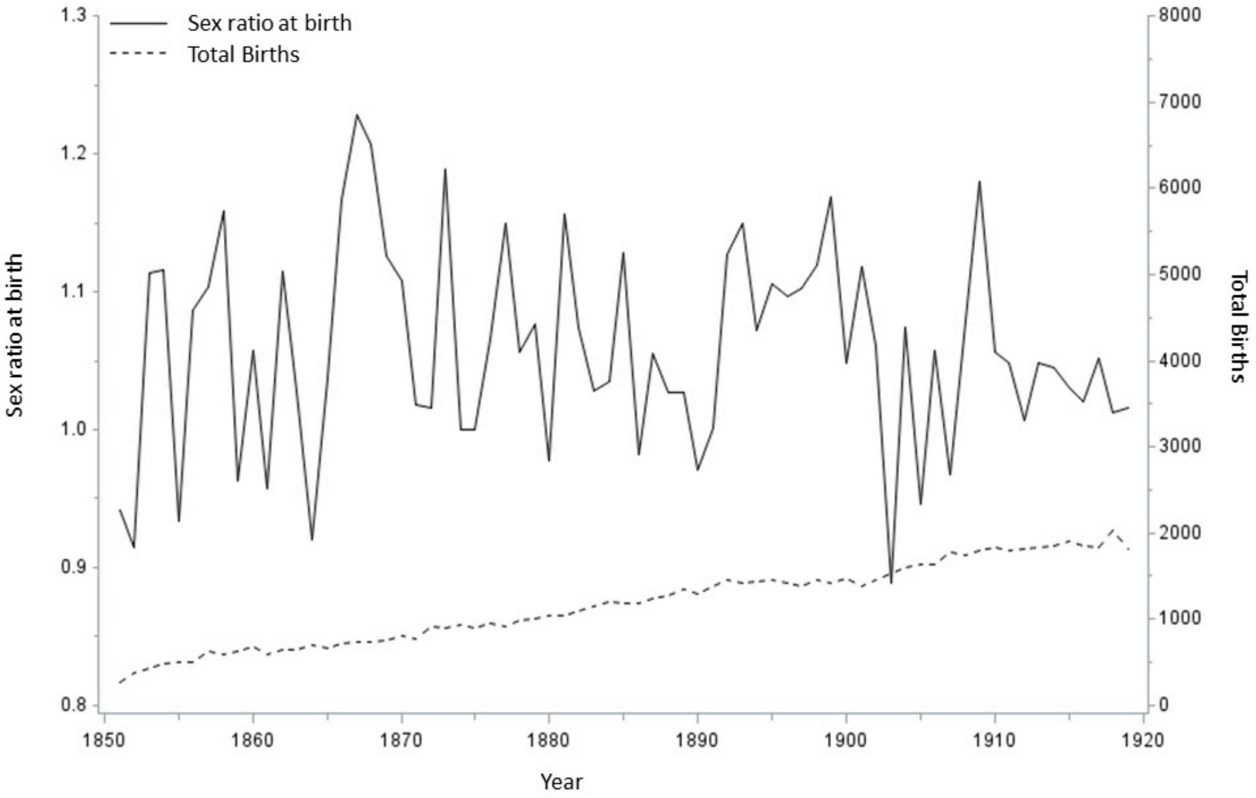

Figure 2. Sex ratio at birth and total births for Salt Lake County 1851–1919.

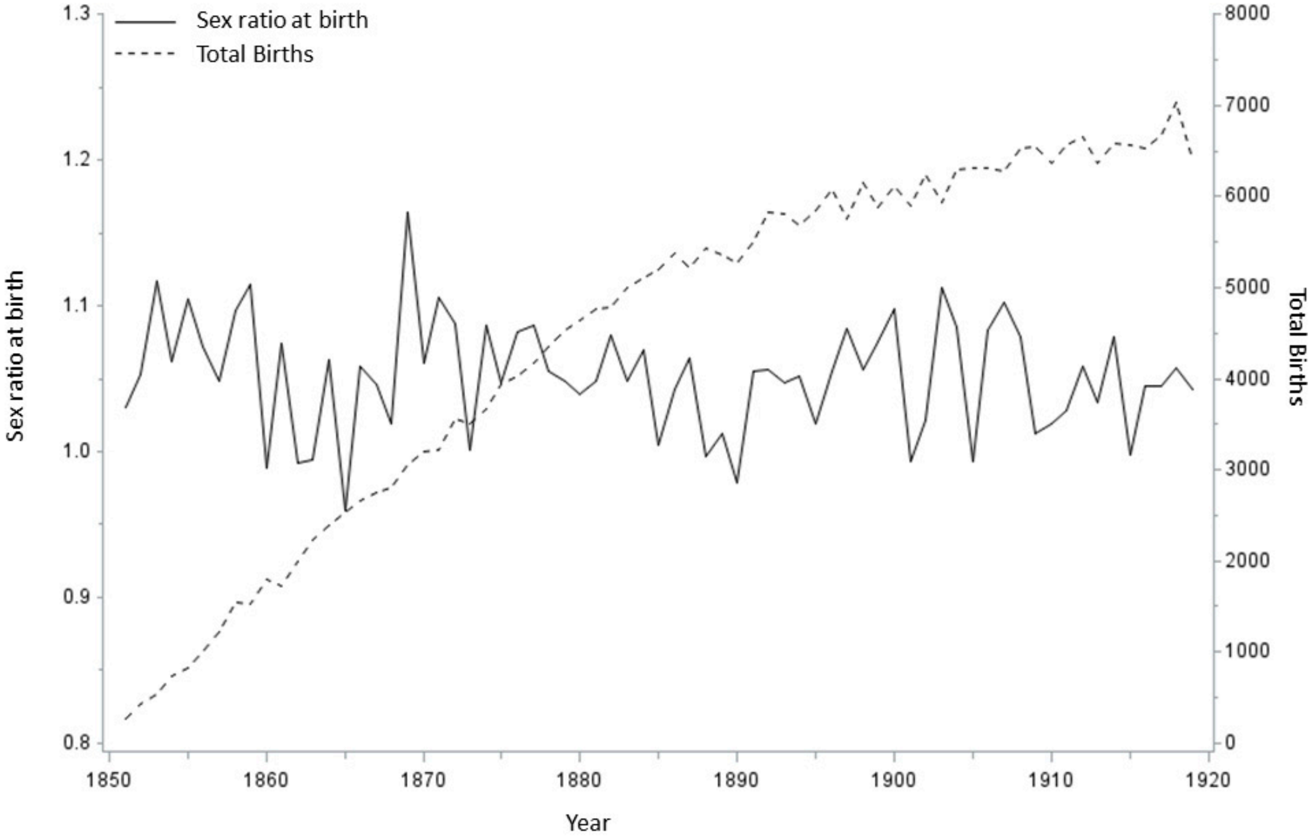

Figure 3. Sex ratio at birth and total births for other Utah counties 1851–1919.

5.2. Correlations

The correlation matrix for SRB and GSL measures is shown in Table 2. River inflows and precipitation correlate positively with each other, but negatively with evaporation. Note that river inflow's correlations with evaporation and precipitation are weak and not statistically significant but the correlation with lake elevation is. This may be because while river inflows affect the lake level, they are not affected by, for example, localized precipitation. In addition, as expected, SRB positively correlates with elevation and precipitation, but negatively with evaporation. The correlation with river inflows is positive but not statistically significant.

Table 2. Pearson correlation coefficients of sex ratio at birth with four measures of Great Salt Lake (N = 138 geographic years).

	SRB	Elevation	River Inflow	Precipitation	Evaporation
SRB [a]	1	0.18 *	0.06	0.21 *	−0.19 *
Elevation [b]	0.18 *	1	0.28 ***	0.23 **	−0.22 *
River Inflow [c]	0.06	0.28 ***	1	0.09	−0.05
Precipitation [d]	0.21 *	0.23 **	0.09	1	−0.91 ***
Evaporation [e]	−0.19 *	−0.22 *	−0.05	−0.91 ***	1

[a] SRB- Sex ratio at birth (number of live male births/number of live female births). [b] Lake elevation (in feet). [c] River inflows from the Bear, Weber, and Jordan rivers (in 1000 acre-feet). [d] Precipitation on lake (in inches). [e] Freshwater evaporation (in inches). *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

5.3. Regressions

Given our interest in the GSL's association with the SRB by time and space, we provide tabular results of the marginal effects in Table 3. For the pre-industrial period in Salt Lake County, lake elevation and precipitation vary positively with SRB—higher quality environments are associated with a relatively greater number of boys. For example, if the lake level rose by one foot during the pre-spike era, the SRB increased by ~0.026 (i.e., became more male-biased) in Salt Lake County, but there was no effect in other parts of the state. Evaporation shows a significant negative relationship with SRB in this same location and time. Outside of Salt Lake County in the pre-industrial period, those three measures show no statistically significant association with SRB. The findings for river inflows, however, show a significant negative association with SRB in the pre-spike period, but only for counties other than Salt Lake.

Table 3. Marginal effects of the relevant GSL measure on sex ratios at birth, by time and space.

Peak Lake Elevation (in feet)			**River Inflows (in 1000 acre-feet)**		
	Pre-Spike	**Post-Spike**		**Pre-Spike**	**Post-Spike**
Salt Lake County	0.02694 **	0.00192	**Salt Lake County**	0.00001	0.00001
Other county	−0.00278	0.00093	**Other county**	−0.00002 *	0.00001
Precipitation on Lake (in inches)			**Fresh-Water Lake Evaporation (in inches)**		
	Pre-Spike	**Post-Spike**		**Pre-Spike**	**Post-Spike**
Salt Lake County	0.01974 *	0.00307	**Salt Lake County**	−0.00019 **	−0.00002
Other county	0.00049	−0.00076	**Other county**	−0.00001	−0.00001

** $p < 0.01$, * $p < 0.05$.

Lastly, we apply two robustness checks to the data. For the first, we model our outcome variable as 'sex proportions' ($N_{\text{males}}/(N_{\text{males}} + N_{\text{females}})$) rather than 'sex ratios' ($N_{\text{males}}/N_{\text{females}}$) due to possible methodological issues (detailed in Wilson and Hardy 2002 and Ancona et al. 2017). However, we find these results to follow those presented above (see Supplementary Materials Table S1 and Figure S1). For the second, we model the outcome as a binary variable (male = 1) through logistic regression. The results again follow those presented above, however, precipitation is no longer significant (although it still trends positively with the probability of a boy being born; Supplementary Materials Table S2). In sum, through a variety of analytical approaches, we find that the relative number of males to females born is generally positively associated with measures of environmental quality.

6. Discussion

We examined whether ambient environmental stressors were associated with lower sex ratios at birth using historical data from the US state of Utah. Across the time period under study here (1851–1919), this population exhibited natural fertility, which arguably better approximates conditions over much of human history than do contemporary societies. Moreover, and central to our research focus here, is that economic development occurred very rapidly, allowing us to compare the role of environmental quality on SRB pre- and post-frontier era. Our central finding is that, among the Salt Lake County population, sex ratios at birth fall below expected values in years of arid conditions. This result remains robust across three of our four measures of precipitation. However, SRB values are unassociated with GSL measures during the early industrial era (i.e., post 1869) and with the broader Utah population residing farther away from the Great Salt Lake. Taken together, findings from the high-fertility, subsistence agriculture population under study here support our predictions that ambient environmental stressors will affect SRB in the local area prior to industrialization.

The strengths of our analysis include the exogenous nature of aridity conditions, which precludes the possibility of reverse causality when examining associations with the sex ratio in the synchronous year. We also use as the dependent variable sex ratios from the full population of a well-described and well-documented historical population. We know of no indication in the UDPB of bias in reporting sex of live birth, particularly given that SRB averages here match the globally expected value of ~1.05. Moreover, the specificity of our results to Salt Lake County (but not to greater Utah) indicates that results cannot arise from broader general demographic or economic factors that affected these populations equally.

The limitations include that, as with most historical records, we do not have information on fetal deaths and/or pregnancy losses. Although the presumed mechanism for sex ratio reductions during ambient stressors involves excess male fetal loss, we cannot rule out the possibility of changes in fertility behaviors in response to environmental conditions. Information on pregnancy losses, combined with monthly resolution of the date of live birth, could better assist with the identification of such mechanisms. In addition, whereas we use 1869 as the end of the frontier period in Utah, we acknowledge strong temporal variability in the extent to which Utah families participated in the industrial economy. Lastly, the Trivers–Willard hypothesis is commonly invoked when studying sex ratios at birth (Trivers and Willard 1973). Central to this hypothesis is an expectation that mothers will adjust their parental investment in sons vs. daughters given their own condition relative to other mothers in the population. However, here we have no indicators of maternal quality (e.g., SES) and so can provide no test of this hypothesis.

In conclusion, our findings indicate that greater water availability, and likely a more productive environment, is positively associated with SRB in Salt Lake County. Moreover, we show a clear relationship whereby the association disappears with geographic distance from the putative stressor. With the exception of river inflows, our measures of water availability all performed as predicted, with greater availability increasing the number of boys born relative to girls. However, these results hold only for the frontier-era and not into the period of rapid industrialization. In sum, we argue that the mixed state of the literature may result from the fact that the impact and frequency of exogenous stressors are likely dampened in industrialized societies.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/socsci10090319/s1, Figure S1: Sex radio at birth (sr) by sex proportion (propmale), Table S1: Marginal effects of the relevant GSL measure on sex proportions at birth, by time and space, Table S2: Marginal effects of the relevant GSL measure on the probability of a birth being male, by time and space.

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Institutional Review Board Statement: The research was approved by the University of Utah Institutional Review Board (IRB no. 00043524) as part of the 'Early Life Conditions, Survival, and Health: A Pedigree-Based Population Study' (PI Smith).

Informed Consent Statement: Not applicable.

Data Availability Statement: The UPDB is a unique research resource that enhances the value and furthers the advancement of research in studies linking early life circumstances to health and behavioral outcomes later in life. Special attention is given to protect individuals and their information contained within the UPDB and the organizations that contribute data while also allowing access to researchers. Accordingly, the Utah Resource for Genetic and Epidemiologic Research (RGE), established by the Executive Order of the Governor of Utah, administers access to the UPDB through a review process of all proposals using UPDB data. The protection of privacy and confidentiality of individuals repre-sented in these records has been negotiated with agreements between RGE and data contributors. Data from the UPDB are available only for approved health-related research studies and access is project-specific and granted after review and approval by an RGE oversight committee and the University of Utah's IRB. This process allows researchers with approved protocols to use the data, a process that has proven effective and successful as evidenced by hundreds of approved studies that have relied on the UPDB.

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