

Systematic Review

Residential Crowding and Mental Health in Built Residential Environments: A Systematic Review of Evidence, Environmental-Psychological Mechanisms, and Design Implications

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Abstract

Residential crowding is a widespread housing-health challenge, but floor-area and occupancy measures offer limited guidance for architectural assessment. This systematic review examined associations between residential crowding and mental-health and psychosocial outcomes, relevant environmental-psychological mechanisms, and design-oriented spatial indicators. Following PRISMA 2020, we searched four databases from inception through 3 April 2026. Seventy-six empirical studies were included; 48 formed a structured evidence matrix, and studies reporting adjusted estimates in explicit spatial units underwent additional extraction. Methodological quality was appraised using a ROBINS-E-style framework. Heterogeneity in exposure definitions, outcomes, effect metrics, and study designs precluded meta-analysis. The narrative synthesis therefore emphasized adjusted estimates, temporality, confounder control, and risk of bias rather than unweighted study counts. Greater livable area was associated with lower depression risk, higher persons-per-room ratios with greater child behavioural difficulties, and bedroom-loss-driven crowding with increased depressive symptoms. These estimates did not support a universal threshold. Privacy loss and reduced perceived control recurred most broadly. Sleep disturbance, family strain, weakened social support, and impaired sense of home were salient in particular populations and settings. The resulting Crowding-Sensitive Residential Performance Assessment integrates spatial load, regulatory capacity, and occupancy context.

Keywords: residential crowding; overcrowding; mental health; built environment; housing; privacy; perceived control; systematic review



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1. Introduction

Housing is increasingly recognized as a major social and environmental determinant of health, not merely physical shelter [1,2]. Rapid urban concentration, rising housing costs, changing households, and expanding rental and shared living have intensified pressure on residential space [3]. At the same time, homes support sleep, recovery, study, work, caregiving, and social interaction [4,5]. Residential performance must therefore encompass psychological well-being, autonomy, and everyday recovery alongside technical and physical indicators [6–8]. Residential crowding is consequential within this housing-health

agenda but remains conceptually difficult [9,10]. Classic environmental-psychology texts established crowding as a distinct field of theory and evidence [11,12]. It occurs across family dwellings, dormitories, shared and rental housing, migrant and refugee accommodation, Indigenous housing, and institutional or temporary settings [13,14]. Policies and studies usually identify crowding through persons per room or bedroom, room occupancy, dwelling size, or floor area per capita [15,16]. These measures identify spatial deprivation and compare minimum provision but do not explain different psychological responses to similar residential density [17,18]. Environmental psychology provides a crucial distinction [19]. Objective density is measurable; crowding is the experience that environmental and social demands exceed one's capacity to regulate contact, privacy, and personal space [10,20,21]. Identical occupancy or floor area may therefore be tolerable in one dwelling but stressful in another. Layout, household relationships, cultural expectations, retreat space, and control over shared facilities shape that response [22–24]. When residents cannot withdraw, manage unwanted interaction, or recover, objective density may become perceived crowding and a chronic stressor [25–27]. Privacy loss and reduced perceived control are central to this process [28,29]. Sleep disturbance, impaired restoration, weakened social support, and family strain may also transmit psychological effects [30–32].

Previous research has established important parts of this relationship. Studies of family housing have associated limited living space and high room occupancy with depression, anxiety, psychological distress, and lower subjective well-being [33,34]. Longitudinal studies likewise associate household crowding with psychological distress or reduced well-being [35,36]. Classic and recent cross-context studies also report consequences for psychological well-being or social anomie [37,38]. Housing stress and affordability have been linked to mental-health outcomes in urban populations [39,40]. Among housing-assistance recipients, housing conditions have also been examined in relation to depressive symptoms and hostile affect [41]. Cross-country evidence during the COVID-19 pandemic further indicates that the housing environment was associated with mental health [42]. Research on children and adolescents has additionally linked crowded homes with disturbed sleep, constrained study and play space, parent–child tension, and behavioural adjustment [43,44]. Broader reviews identify the physical home environment as an important context for child development [45,46]. House type and parental responsiveness help explain variation in children's outcomes [23,47]. Maternal mental health and schooling conditions provide additional child-specific pathways [48,49]. Dormitory and shared-housing studies indicate that room occupancy alone is not consistently harmful [50,51]. Perceived control, roommate relations, belonging, and communal-space quality often determine whether high density becomes psychologically burdensome. Experimental and observational dormitory studies show that social density, tripling, and environmental appraisal can produce different stress responses [52–54]. Indoor-environment quality and student-housing reviews have also been related to well-being and distress [55,56]. Residence typology, room location, and floor height shape perceived room size, socialization, or dormitory satisfaction [57–59]. Shared-housing research identifies loneliness and entrapment as context-dependent risks [60,61]. Pandemic-era shared-housing studies further identify relationship strain, crowding, and precarity [62–64]. Evidence from migrant, refugee, Indigenous, and institutional settings further shows that crowding is frequently compounded by housing instability, displacement, restricted autonomy, and social exclusion [13,65]. In urban China, migrant crowding, housing stress, and affordability form overlapping but distinguishable exposures [39,40,66]. In Arctic and First Nations settings, cultural adequacy, housing conditions, and physiological burden complicate density-based interpretations [67–69]. Prison studies similarly show that architecture, reduced space, and population density influence complaints or misconduct [70–72]. Taken together, this

literature suggests that the crowding–mental health relationship is conditional rather than uniform [18,73].

In this review, “built residential environments” denotes settings used for sustained sleeping, daily routines, social interaction, and recovery. It does not imply equivalence in tenure, residential voluntariness, governance, or design purpose. Prisons were retained only as comparative institutional settings for examining privacy regulation and perceived control under constrained occupancy. Their evidence was not used to infer effect magnitudes, thresholds, or directly transferable design prescriptions for ordinary housing.

Despite this progress, the evidence does not yet provide a sufficiently integrated explanation of residential crowding as a built-environment health problem. First, residential settings are usually examined within separate disciplinary literatures, making it difficult to distinguish common mechanisms from setting-specific conditions. Second, objective density, perceived crowding, privacy loss, reduced control, and residential dissatisfaction are often measured or interpreted interchangeably, blurring the distinction between exposure, psychological appraisal, mechanism, and outcome. Third, the evidence spans heterogeneous outcomes, from depression and anxiety to sleep, loneliness, aggression, family relations, and restoration, without a common framework explaining how these outcomes are connected. Finally, the predominance of cross-sectional studies, inconsistent control of socioeconomic and housing confounders, and limited translation from psychological mechanisms to spatial variables constrain both causal interpretation and practical design guidance.

The central question is not simply whether crowding is associated with poorer mental health. It is how and under what residential conditions objective spatial constraints become perceived crowding and psychological burden. This review addresses two questions:

RQ1. Which mental-health and psychosocial outcomes are associated with residential crowding? How do direction and consistency vary across settings and between objective and subjective measures?

RQ2. Which environmental-psychological pathways link objective density or perceived crowding to mental-health and psychosocial outcomes? Which modifiable spatial or managerial factors intensify or buffer these pathways?

To address these questions, this study conducts a systematic review with narrative synthesis. It covers family housing, student dormitories, shared and rental housing, migrant and refugee accommodation, Indigenous housing, and selected institutional residential environments. Its contribution is not limited to cataloguing outcomes. First, it separates objective spatial load, perceived crowding, environmental-psychological mechanisms, and health outcomes as distinct analytic levels. Second, it extracts adjusted findings reported in explicit architectural units, including square metres per resident, persons per room or bedroom, bedroom deficit, ceiling height, and space per resident. Third, it compares the support for privacy loss, reduced perceived control, sleep disturbance, family strain, weakened social support, and impaired sense of home across settings. Fourth, it derives the Crowding-Sensitive Residential Performance Assessment (CS-RPA) through an explicit evidence-classification procedure and an international standards crosswalk. The resulting method distinguishes core, extended, and contextual indicators and provides a reproducible minimum dataset for architectural surveys, post-occupancy evaluation, and future intervention studies.

2. Materials and Methods

2.1. Review Design and Analytic Framework

This systematic review used narrative synthesis to examine definitions and measures of residential crowding, associations with mental-health and psychosocial outcomes,

and recurring environmental-psychological mechanisms across built residential settings. Reporting followed PRISMA 2020 [74]. The protocol was not prospectively registered; information sources, search strategy, eligibility, screening, coding, quality appraisal, and synthesis procedures are therefore reported explicitly below. Meta-analysis was inappropriate because settings, populations, exposures, outcomes, designs, and effect metrics differed substantially [75], and the evidence included qualitative and mixed-methods studies. The review proceeded through identification and screening, structured coding, setting- and mechanism-based synthesis, and evidence appraisal (Figure 1). The full corpus of 76 eligible studies informed the narrative synthesis, whereas a 48-study structured evidence matrix supported computed figures, tables, and mechanism comparisons. Results from the coded subset were kept distinct from conclusions based on the full corpus. Study-direction and mechanism-frequency summaries mapped evidence distribution only; they were not interpreted as pooled effects, probabilities, or certainty ratings.

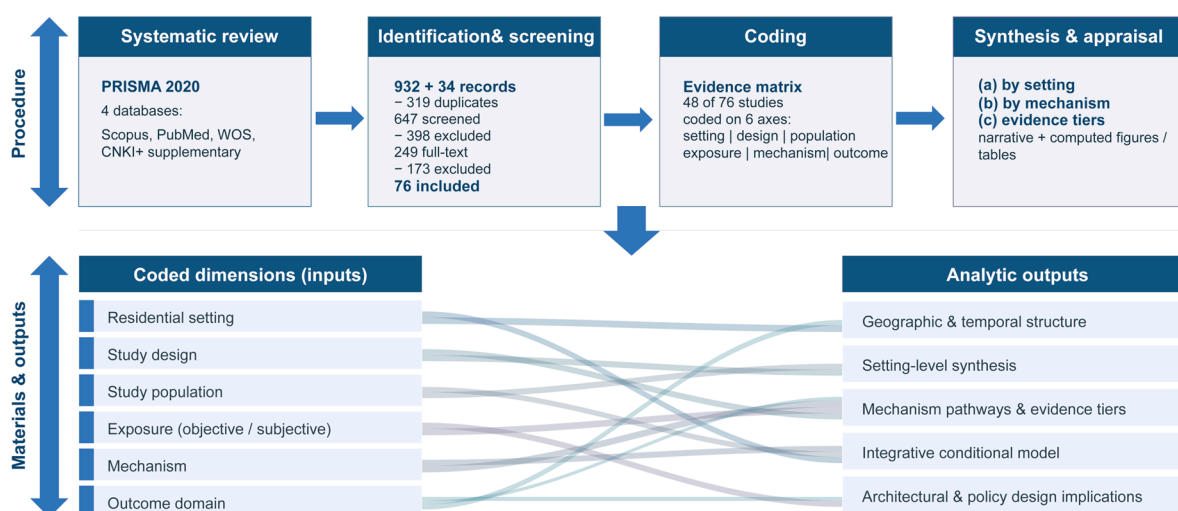


Figure 1. Review workflow and analytic framework. The upper panel summarizes the review procedure; the lower panel links the six coded study dimensions to the principal analytic outputs.

2.2. Information Sources and Search Strategy

Scopus, PubMed, Web of Science Core Collection, and the China National Knowledge Infrastructure (CNKI) were searched from database inception through 3 April 2026. Table A4 reports the exact final search date, search fields, recorded database-level restrictions, and retrieval totals. Database-specific record counts were not retained in the available search record. No lower publication-date limit was applied. The available review record indicates that no database-level language or document-type filters were applied. During eligibility screening, only full-text reports of original empirical research were retained. Reviews, editorials, theoretical papers, policy documents, and conference abstracts were excluded, as specified in Section 2.3. The search strategy combined three concept blocks covering residential crowding or density, mental-health and psychosocial outcomes, and built residential settings. The crowding block included terms relating to overcrowding, persons per room or bedroom, floor area per capita, room occupancy, perceived crowding, privacy, and spatial constraint. The outcome block included psychological distress, depression, anxiety, stress, well-being, sleep, loneliness, aggression, and social functioning. The residential-setting block included housing, dwellings, dormitories, shared housing, refugee accommodation, and prisons. English and Chinese terms, spelling variants, controlled vocabulary where available, field tags, and database-specific syntax were adapted for each source. Privacy, perceived control, and retreat-space terms were retained only when explicitly linked to residential crowding, high occupancy, insufficient residential space, or shared

living conditions. Complete reproducible search strings for all four databases are provided in Supplementary Material S1. Supplementary searching comprised backward citation searching, forward citation tracking, and related-record searching. Backward searching involved screening the reference lists of all included studies and relevant review articles. Forward citations were examined using Scopus and Web of Science on 3 April 2026 for all included studies. Related-record searches used database-native functions on 3 April 2026; the available search record does not retain a more specific function name. Records identified through these procedures were imported into the same screening database, deduplicated against the database-search results, and assessed using the same eligibility criteria. These supplementary procedures identified 34 additional records before duplicate removal. All database and supplementary-search records were deduplicated before title and abstract screening.

2.3. Eligibility Criteria and Review Scope

Studies were eligible if they reported original empirical evidence and examined a built environment used for sustained living, sleeping, social interaction, or recovery. Eligible studies also measured objective residential density, perceived crowding, or a related spatial condition and reported at least one mental-health, psychosocial, behavioural, sleep, or well-being outcome. Finally, they provided sufficient information on the population, setting, exposure, outcome, and principal findings.

The primary evidence base covered family housing, student dormitories, shared and rental housing, migrant and refugee accommodation, Indigenous housing, and temporary accommodation used for sustained residence. Institutional settings, principally prisons, were eligible only when residents lived and slept there for sustained periods and studies explicitly related spatial density or perceived crowding to relevant outcomes.

Because institutional occupancy is shaped by security, management, restricted movement, and limited choice, these studies were coded and synthesized separately. They informed only cross-setting comparisons of privacy loss and perceived control; their effect magnitudes, thresholds, and design implications were not extrapolated to ordinary housing.

2.4. Study Selection and Screening Reliability

The searches identified 932 database records and 34 additional records. After removal of 319 duplicates, 647 records underwent title and abstract screening; 398 were excluded. The full texts of 249 records were assessed, of which 173 were excluded because of ineligible exposure, outcome, setting, study type, or insufficient information. The final review included 76 studies. Table 1 provides the numerical audit trail, and Figure 2 presents the same process graphically. Two reviewers independently screened titles and abstracts and then assessed full texts against the prespecified criteria. Disagreements were resolved through discussion and, when necessary, consultation with a third reviewer. Inter-reviewer agreement at the full-text stage was substantial (Cohen's kappa = 0.79). A completed PRISMA 2020 checklist is provided in Supplementary Material S2.

Table 1. Numerical flow of study selection used for the PRISMA diagram.

Selection Stage	Number of Records
Records identified from databases	932
Additional records identified from supplementary searching	34
Duplicate records removed	319
Records screened by title and abstract	647

Table 1. Cont.

Selection Stage	Number of Records
Records excluded after title and abstract screening	398
Full-text records assessed for eligibility	249
Full-text records excluded	173
Studies included in the review	76

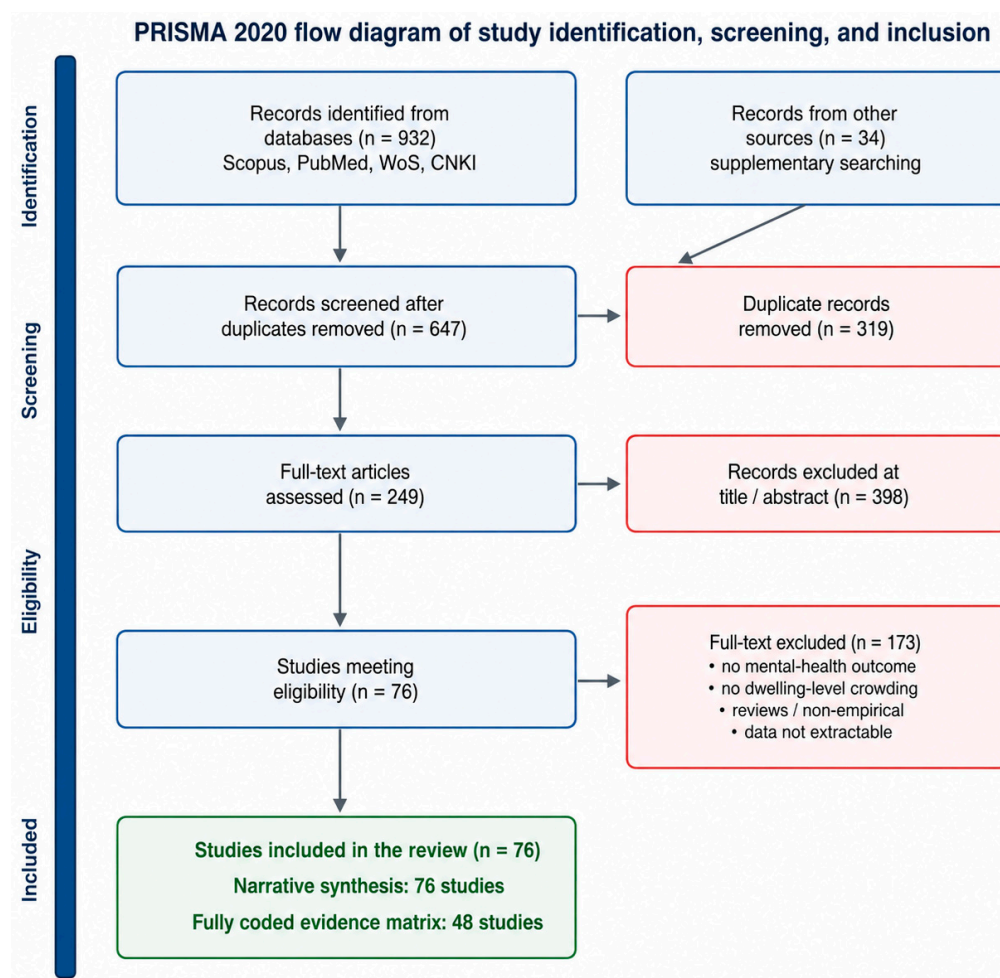


Figure 2. PRISMA 2020 flow diagram of study identification, screening, eligibility assessment, and inclusion. The full review corpus comprised 76 studies, of which 48 were fully coded into the structured evidence matrix.

2.5. Data Extraction, Coding, and Analytic Samples

For each included study, we extracted publication details, region, population, sample size, setting, design, exposure, outcome, covariates, findings, mechanisms, and design or management implications. Coding covered six dimensions: setting, design, population, exposure type, mechanism, and outcome domain. The form was piloted, and 20% of studies were double-coded. Variables were classified by their role in each study to avoid conceptual overlap. Objective density and perceived crowding were exposures. Privacy loss, reduced control, sleep disturbance, relational strain, weakened social support, impaired sense of home, and reduced restoration were mechanisms when they explained a pathway. Depression, anxiety, distress, loneliness, behavioural adjustment, well-being, and related endpoints were outcomes. Forty-eight of 76 studies had sufficient information on all six dimensions and formed the structured matrix (Table A1). The other 28 remained in the narrative synthesis but were excluded from computed cross-study figures. They

either pooled samples, treated crowding as secondary, or left at least one dimension unclear. Study-level matrix-inclusion decisions and audit rationales for all 76 eligible studies are reported in Table A3. The coded subset was then compared descriptively with the full corpus by setting, design, and region (Table 2). All quantitative summaries report their denominator.

Table 2. Composition of the fully coded subset compared with the full review corpus.

Dimension	Category	Coded Subset (<i>n</i> = 48), %	Full Corpus (<i>n</i> = 76), % (Approx.)
Setting	Family housing	54	~52
	Student dormitory	17	~16
	Shared/rental	8	~9
	Migrant/refugee/temporary	6	~8
	Indigenous/Arctic	8	~8
	Institutional/prison	6	~7
Design	Cross-sectional	69	~70
	Longitudinal/panel	13	~13
	Qualitative/mixed	13	~13
	Experimental/quasi-experimental	6	~4
Region	North America	33	~31
	East Asia	27	~24
	Europe	17	~20
	Other regions	23	~25

Notes: Full-corpus percentages are approximate descriptors derived from the corpus characterization and supplementary coding records. The comparison assesses broad compositional similarity; it is not a formal representativeness test and does not eliminate possible selection bias arising from incomplete reporting.

To make the architectural synthesis auditable, a second extraction pass recorded the most interpretable adjusted estimates expressed in explicit spatial units or contrasts. Eligible entries paired a psychological, psychosocial, sleep-related, or physiological outcome with floor or livable area, persons per room or bedroom, bedroom deficit, spatial dimensions, building-block density, or space per resident. Because populations, outcomes, models, and metrics differed, estimates were not pooled. These estimates retain their original units as empirical anchors, not universal design thresholds.

2.6. Quality Appraisal and Evidence Synthesis

Methodological quality was appraised using a prespecified ROBINS-E-style framework adapted to the heterogeneous quantitative and qualitative evidence base. The procedure was a domain-based judgement rather than a numerical score or an unmodified application of the ROBINS-E tool. Five domains were reported: D1, confounding, including sample selection and missing-data handling; D2, exposure measurement; D3, outcome measurement; D4, temporality; and D5, selective reporting. Study-level judgements are reported in Table A2.

Operational signalling criteria were defined in advance. D1 assessed confounder control for socioeconomic position, housing quality and tenure, household size and composition, demographic factors, baseline health, sample selection, and missing data. D2 assessed whether objective density and perceived crowding were distinguished and measured with reproducible spatial definitions or validated scales. D3 assessed validated or clearly specified mental-health and psychosocial outcome measures. D4 assessed temporal ordering in the proposed exposure–pathway–outcome relation; concurrent cross-sectional

measurement was a critical limitation for causal interpretation. D5 assessed completeness and consistency of reported outcomes and analyses, including whether selective reporting could reasonably be excluded.

Each applicable domain was rated Low, Some concerns, or High. Low indicated credible evidence with no important limitation in that domain. Some concerns indicated incomplete reporting or a limitation that reduced confidence without invalidating interpretation. High indicated a major limitation likely to distort the crowding-outcome inference materially. Temporality was not applicable to qualitative studies. Overall ratings were not calculated by summing domains. High was assigned when at least one critical limitation was likely to affect a study's contribution materially. Some concerns indicated noncritical limitations that reduced confidence; Low indicated no critical limitation likely to alter the study's contribution.

Two reviewers, Yu Li (YL) and Pinghao Liu (PL), independently appraised all 48 studies after calibrating the criteria on six studies. Agreement was calculated before consensus at both the domain and overall-rating levels using percentage agreement and weighted Cohen's kappa. Domain-level agreement was 89.6% (weighted $\kappa = 0.82$), and agreement for the overall rating was 91.7% (weighted $\kappa = 0.86$). Disagreements were resolved through discussion, and no third adjudicator was required.

Synthesis proceeded in three stages. First, the evidence was mapped by publication period, geography, setting, population, design, exposure, and outcome. Second, findings were synthesized within settings to preserve differences in tenure, autonomy, household relations, cultural context, and management. Third, evidence was reorganized by mechanism and translated into design- and management-relevant variables. Because of substantial heterogeneity, study-direction and mechanism-frequency summaries served only as descriptive maps and were not weighted by sample size. Interpretation instead considered effect magnitude and precision, design and temporality, measurement quality, confounder control, risk of bias, theoretical coherence, and contextual breadth. No majority rule or frequency threshold defined mechanism support. Mechanisms were described as showing cross-setting recurrence, context-dependent evidence, or sparse examination; these descriptors neither establish causal mediation nor constitute certainty ratings. Mechanisms could co-occur within a study and were not treated as independent observations. Publication bias and small-study effects were not formally tested because comparable effect estimates were unavailable, so publication and selective-reporting bias could not be excluded.

2.7. Evidence-to-Design Translation and Framework Derivation

To derive rather than assert the framework, candidate indicators were classified using four evidence codes. Q denoted an adjusted quantitative association in an explicit spatial unit; M, a tested architectural moderator; P, a recurrent environmental-psychological pathway; and S, an authoritative or validated operational standard. An indicator was core when directly measurable from dwelling and occupancy data and supported by Q plus P or S. Indicators supported mainly by M or repeated P evidence were extended. Tenure, exposure duration, household composition, cultural adequacy, and voluntariness were contextual descriptors because they modify interpretation but are not building attributes. International definitions were crosswalked against mental-health evidence to identify what each measure captures and omits [15,76]. Comparative measurement studies identified disagreements among persons-per-room, bedroom-based, and modified occupancy classifications [77–79]. Heterogeneous metrics and settings precluded weights or universal cut-offs. The output is a structured assessment protocol and minimum dataset, not a validated composite score.

For the CS-RPA table presented in Section 4.4, supporting-study counts were calculated by unique study. Q and M evidence was drawn from studies reporting explicit spatial-

unit estimates or tested architectural contrasts, whereas P evidence came from the 48-study matrix. Standards and the 28 narrative-only studies were excluded from these counts. Evidence levels were assigned comparatively rather than as GRADE ratings, based on directness, study design and temporality, consistency, measurement specificity, and transferability.

3. Results

The results are presented in four parts. These cover evidence scope and measurement (Section 3.1), setting-specific findings (Section 3.2), mechanism pathways (Section 3.3), and quantitative spatial evidence and design moderators (Section 3.4). Unless stated otherwise, figures and frequency summaries use the 48-study matrix. Section 3.4 reports unpooled adjusted estimates in their original spatial units.

3.1. The Evidence Base: Scope, Structure, and Measurement

The screening process yielded 76 eligible studies for narrative synthesis. Of these, 48 contained sufficiently complete information across the six coded dimensions and formed the structured evidence matrix used for the computed figures and tables. The evidence spans five decades, from 1976 to 2026, but publication growth accelerated markedly in recent years: approximately 44% of the coded studies were published from 2020 onward (Figure 3a). The coded evidence base was unevenly distributed across residential settings, study designs, and populations (Figure 3b,c; Table A5). Family housing accounted for 26 studies (54%), followed by student dormitories with 8 studies (17%). Shared or rental housing, Indigenous or Arctic housing, migrant, refugee, or temporary accommodation, and institutional settings were each represented by only three or four studies. Cross-sectional designs predominated (33 studies, 68.8%), whereas longitudinal or panel studies (6, 12.5%), qualitative studies (6, 12.5%), and experimental studies (3, 6.3%) remained limited. Adults were the most frequently examined population (22, 46%), followed by students (10, 21%) and children or adolescents (9, 19%). These distributions indicate that the available evidence is concentrated in conventional family housing and relies predominantly on cross-sectional associations.

Residential crowding was operationalized through two related but non-interchangeable registers (Figure 3d; Table A5). Objective density quantified resident-to-space allocation through persons per room or bedroom, floor area per capita, dwelling size, bedroom deficit, or room occupancy. Perceived crowding captured whether space adequately supported privacy, withdrawal, activity separation, and regulation of interpersonal contact. Objective density was the primary exposure in 22 studies (46%); 26 (54%) used perceived crowding or combined subjective measures. Objective measures indicate potential spatial load but not residents' experience, whereas subjective measures capture appraisal without identifying a specific physical cause. The registers were therefore retained separately, and association-direction maps were not treated as estimates of an equivalent exposure.

The keyword network (Figure 4) and chronology (Figure 5) show the field's progressive broadening. Early studies framed crowding as an environmental stressor linked to privacy loss, reduced control, aggression, and withdrawal. Later work connected crowding with housing inequality and vulnerable populations. Recent studies increasingly examine privacy, control, sleep, sense of home, communal-space quality, and sectional openness as pathways or design moderators. Research in China and other high-density Asian settings similarly shifted from behavioural adjustment and social support toward housing quality, control, sleep, and well-being. Overall, the literature moved from isolated density effects toward a conditional, relational housing-health process.

Descriptive structure of the included residential-crowding studies (n = 48)

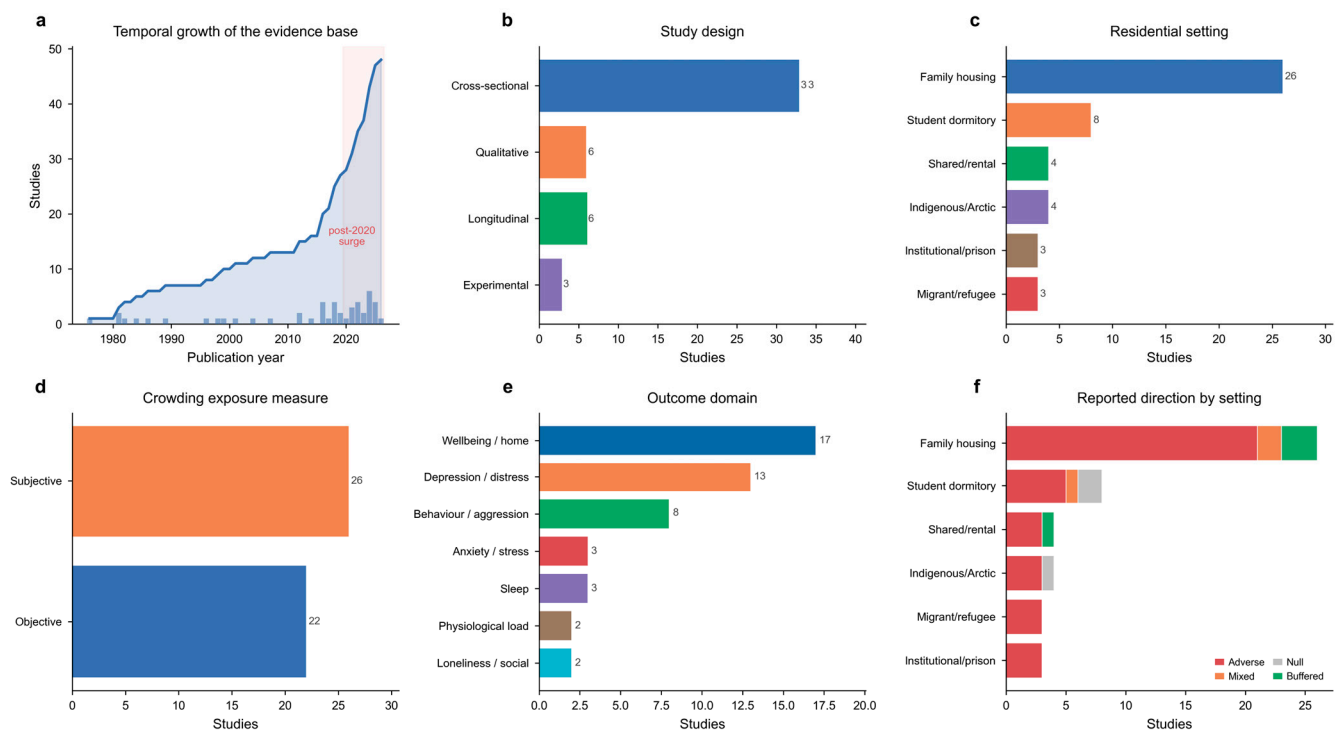


Figure 3. Descriptive structure of the included studies: (a) cumulative and annual publications; (b) study designs; (c) residential settings; (d) objective vs. subjective exposure measurement; (e) outcome domains; (f) reported direction of association by setting.

Keyword co-occurrence network of the included corpus (24 terms, 36 links)



Figure 4. Force-directed keyword co-occurrence network of the included corpus. Node size encodes keyword frequency; node colour encodes the mean publication year of the documents in which the term appears (temporal overlay); edges encode co-occurrence strength.

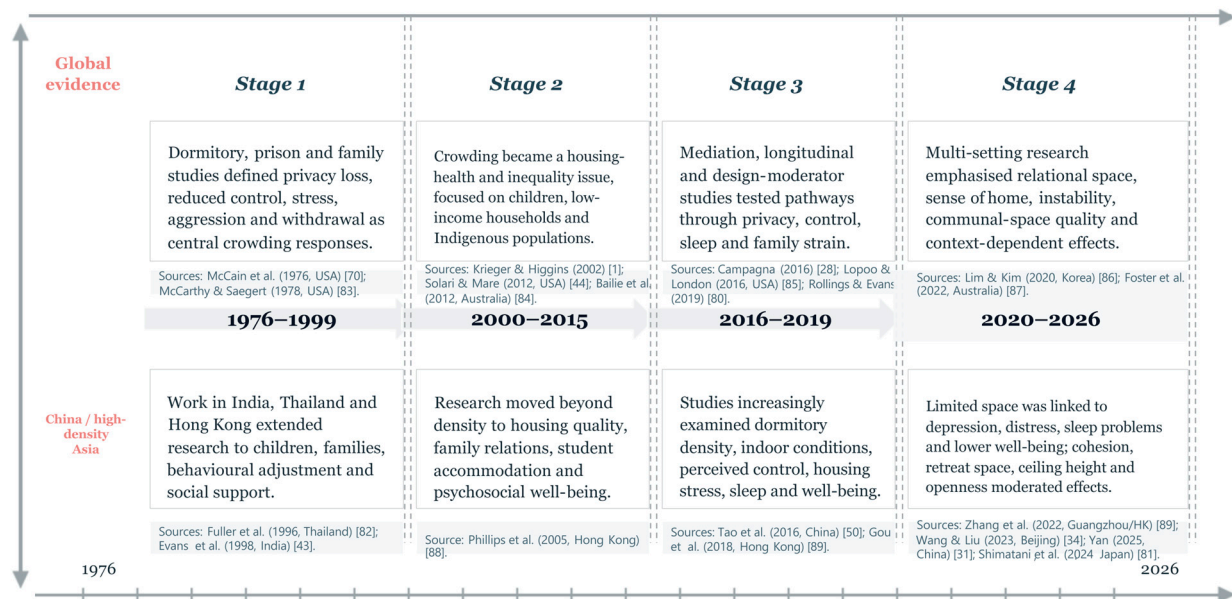


Figure 5. Interpretive chronology of residential-crowding research from 1976 to 2026, comparing the global literature with China and other high-density Asian settings. Phase boundaries are heuristic and representative studies are shown for orientation [1,28,31,34,43,44,50,70,80–90].

Geographically, the coded studies covered 15 countries across eight represented macro-regions and were concentrated in North America, East Asia, and Europe (Figure 6). North America accounted for 16 studies (33%), East Asia for 13 (27%), and Europe for 8 (17%). Evidence from South and Southeast Asia, Latin America, Oceania, and the circumpolar Arctic remained sparse, and no coded study represented Africa. This concentration limits generalization across housing systems, household structures, cultural norms, and welfare contexts.

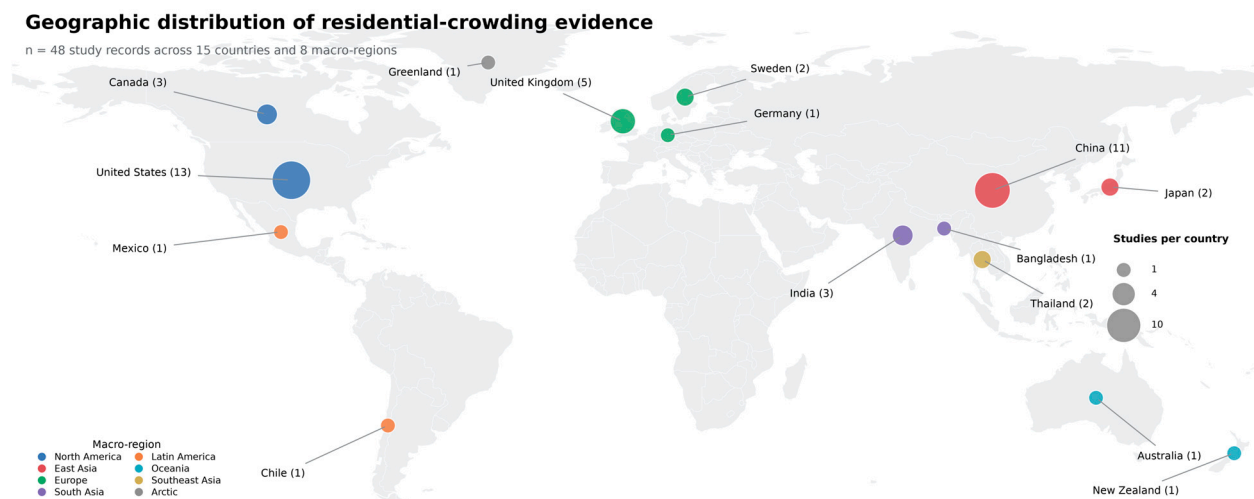


Figure 6. Annotated global distribution of the residential-crowding evidence. Symbol area is proportional to the number of coded studies per country; colour denotes macro-region; labels report study counts.

3.2. Setting-Specific and Contextual Evidence

Settings differed in household relationships, tenure, autonomy, spatial organization, management, and socioeconomic conditions; evidence was therefore synthesized by setting before mechanism-level comparison. Region and setting were treated as distinct contextual dimensions. Given the concentration of studies in North America, East Asia, and Europe,

the patterns below describe the available evidence rather than globally representative or population-level cultural differences.

Figure A1 maps the 48-study matrix by macro-region, setting, and population. Family housing was the largest and most geographically diverse group; migrant/refugee/temporary, Indigenous/Arctic, and institutional settings formed smaller, context-specific bodies of evidence. Categories were not treated as culturally homogeneous. The same density measure could reflect voluntary multigenerational co-residence, constrained rental sharing, displacement-related shortage, or imposed institutional occupancy, with different implications for privacy, autonomy, social support, and sense of home. Because cultural moderation was not formally tested, interpretation relied on reported household composition, voluntariness, tenure, residential stability, management, and cultural adequacy.

Within each setting, objective-density and perceived-crowding findings remained separate. Null findings for dormitory room occupancy do not exclude perceived crowding, and an association with perceived crowding does not identify a floor-area or occupancy threshold. Because few studies measured both registers together, the review assumed neither fixed correspondence nor causal mediation between them.

Table 3 summarizes descriptive setting-specific patterns rather than comparable effects. Across several settings, spatial load was linked to adverse outcomes when residents had limited capacity to regulate privacy, contact, activities, or withdrawal. Salient pathways differed by setting. Privacy loss was prominent in family housing, perceived control in dormitories and institutions, and social support in shared housing. Family strain was prominent in Indigenous and Arctic housing, and sense of home in migrant, refugee, and temporary accommodation. Mixed or null findings were most common in dormitories, where voluntariness, roommate relationships, and communal-space quality modified the consequences of occupancy. These patterns reflect the distribution of heterogeneous evidence, not fixed causal differences.

Table 3. Setting-specific mechanisms and main evidence limitations in the structured synthesis.

Residential Setting	Dominant Mechanism	Main Evidence Limitation
Family housing	Privacy loss	Predominantly cross-sectional; socioeconomic confounding
Student dormitory	Perceived control	Small and institution-specific samples
Shared/rental housing	Social support	Limited longitudinal evidence
Migrant/refugee/temporary	Sense of home, control, and sleep protection	Displacement, insecurity, temporary residence, and setting heterogeneity
Indigenous/Arctic	Family strain/social support	Strong cultural and structural confounding
Institutional/prison	Perceived control	Restricted generalizability

Notes: Settings are descriptive contextual groupings, not proxies for uniform cultural norms. Mechanisms are those most prominent within each group and are neither universal, mutually exclusive, nor causally established. Interpretation should consider household composition, voluntariness, tenure, stability, management, and socioeconomic conditions. Institutional/prison evidence informs boundary conditions for privacy and control, not thresholds or transferable design prescriptions for ordinary housing.

Institutional/prison studies formed a small, separate evidence group characterized by involuntary residence, restricted autonomy, surveillance, and externally regulated routines. Their emphasis on perceived control informed mechanism-level interpretation under constrained conditions, not equivalent effects or design implications for ordinary housing.

3.3. Environmental-Psychological Mechanism Pathways

After the setting-specific synthesis, the 48 coded studies were reorganized by mechanism to identify pathways recurring across settings and geographical contexts. Recurrence was interpreted as conceptual convergence, not identical meaning, magnitude, threshold, or causal priority. Eight processes were coded: reduced perceived control, privacy loss, weakened social support, impaired sense of home, sleep disturbance, family strain, diminished restoration, and physiological stress load. Figure 7 maps their distribution without imposing a universal hierarchy. “Candidate pathway” does not imply established causation. Evidence comprised directly tested mediation, mechanism-consistent correlations without formal indirect-effect tests, and theoretical or qualitative interpretations. Because most studies were observational and did not establish temporal ordering, the synthesis identifies plausible pathways rather than confirmed causal mechanisms. Mechanism coding also depended on the exposure register. In objective-density studies, privacy loss, control, and sleep represented proposed or tested pathways from spatial load to outcomes. In perceived-crowding studies, the exposure already incorporated appraisal and could overlap with privacy or control measures. Both types contributed to the mechanism map but were not treated as equivalent mediation tests. Recurrence therefore does not mean that objective density invariably produces perceived crowding or that perceived crowding is the sole pathway to mental-health outcomes.

Ribbon width in panel a represents coded evidence records ($n = 48$); panel b translates the same mechanisms into spatial variables and design responses.

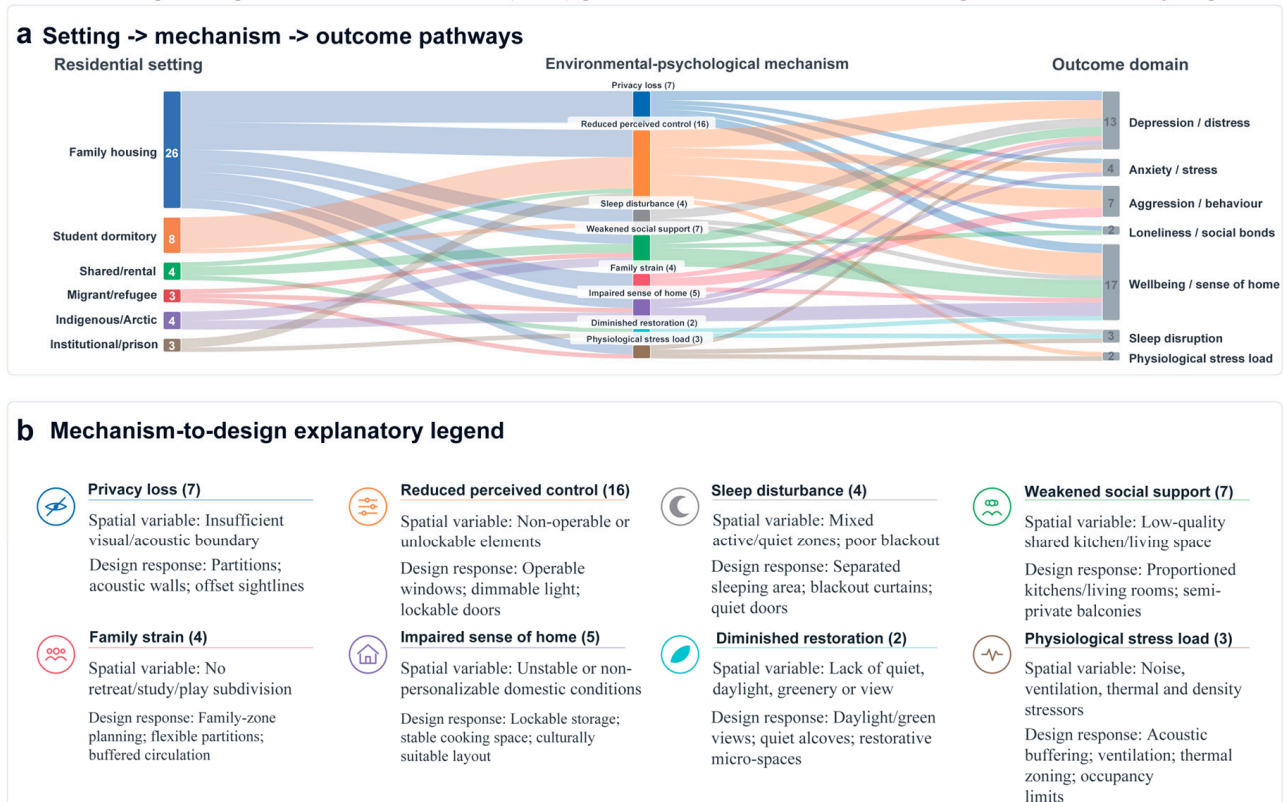


Figure 7. Residential-crowding pathways and design translation. (a) Setting–mechanism–outcome pathways in the structured evidence matrix ($n = 48$), with ribbon width representing the number of coded evidence records. Recurrence across settings indicates conceptual convergence rather than cultural invariance, equivalent effect magnitude, or universal causal importance. (b) Explanatory translation of the recurring mechanisms into design-relevant spatial variables and potential residential responses. Panel (b) is an interpretive design translation rather than evidence of independently tested intervention effects.

Reduced perceived control was the most frequently coded pathway ($n = 16$; Figure 7a). It concerned residents' capacity to regulate interpersonal contact, noise, shared facilities, routines, and withdrawal [24]. The pathway appeared most often in dormitories and institutions but also in family and shared housing [72,91]. Its expression varied from household decision-making and choice of co-residents to management of shared facilities and freedom from imposed routines.

Privacy loss recurred across several settings in seven studies. It included inadequate visual or acoustic separation, weak interpersonal boundaries, involuntary exposure, and limited retreat space [92,93], and was associated with distress, dissatisfaction, tension, and behavioural difficulties. Although privacy loss often co-occurred with reduced control, it specifically concerned unwanted access and exposure, whereas control described broader regulation of interactions, activities, and shared space [17,18]. Its salience varied with household roles, cultural expectations, and accepted forms of sharing.

Less frequently coded pathways were not necessarily less important because frequency partly reflected the settings, populations, and measures studied. Weakened social support appeared in seven studies, especially in shared, rental, migrant, refugee, and Indigenous housing [25,32]. Poorly regulated co-residence could encourage withdrawal, conflict, or avoidance of communal areas [26,94,95]. Impaired sense of home appeared in five studies and involved instability, limited personalization, insecure occupancy, and restricted control over domestic routines [96,97]. Its physical, personal, social, and symbolic meanings depend on tenure, autonomy, household composition, cultural identity, community relationships, and housing history [96,98–102]. This context is especially important for refugees, asylum seekers, and Indigenous populations experiencing displacement, cultural disruption, housing shortages, or insecurity [103–105]. Sleep disturbance and family strain each appeared in four studies. Sleep pathways involved shared sleeping areas, noise, activity overlap, and weak separation of active and quiet zones [106,107]. Family strain included maternal stress, parent–child conflict, competition for space, and compression of children's activities [47,95]. In relevant settings, these pathways may be as salient as privacy loss or reduced control.

Diminished restoration appeared in two studies and concerned insufficient quiet, visual relief, and space for withdrawal and recovery [27,108–110]. Physiological stress load appeared in three studies and included blood pressure, catecholamine responses, and allostatic load [69,80]. These small, heterogeneous groups provide supplementary evidence and are not equivalent to clinical mental-health outcomes. Figure 7b links coded mechanisms to corresponding spatial variables; these links summarize implicated characteristics rather than independently tested design effects. Figure A2a similarly maps the breadth of mechanism–outcome links, not causal priority. Reduced control and privacy loss spanned the widest outcome range, whereas other pathways were concentrated in specific settings and outcomes. Adjacent research on outdoor blue space supports the general relevance of restorative exposure but is not direct evidence about residential crowding [111].

Comparative pathway support considered consistency, design and temporality, measurement, confounder control, theoretical coherence, and contextual breadth (Figure A2b; Table 4). Reduced control and privacy loss showed the broadest cross-setting recurrence; social support, sense of home, family strain, and sleep were more context-dependent. Restoration and physiological stress had sparse, setting-specific evidence. Geographical concentration and inconsistent measurement preclude ranking any pathway as globally dominant.

Table 4. Level of support within this review for environmental-psychological mechanisms linking residential crowding with mental-health and psychosocial outcomes.

Support Within Review	Mechanism (Studies)	Predominant Evidence Type	Principal Outcomes	Synthesised Appraisal
Consistent	Reduced perceived control (n = 16)	Mainly correlational or interpretive; formal mediation not consistently tested	Distress, anxiety/stress, behavioural adjustment, residential well-being	Recurred across family housing, dormitories, shared housing, and institutional settings, supporting a cross-context regulatory principle. However, the source and meaning of control varied with household roles, voluntariness of sharing, tenure, and management systems.
Consistent	Privacy loss (n = 7)	Mainly correlational, qualitative, or interpretive	Distress, residential dissatisfaction, interpersonal tension, behavioural difficulties	Directionally convergent evidence implicated visual and acoustic separation, interpersonal boundaries, and retreat opportunities. However, acceptable privacy boundaries and expectations of personal space varied across household and cultural contexts.
Mixed	Weakened social support (n = 7)	Mixed mediation-based and correlational evidence	Distress, loneliness, withdrawal, reduced belonging	Generally coherent findings, but effects depended strongly on relationship quality, voluntariness of sharing, and housing stability; evidence was mainly cross-sectional or qualitative.
Mixed	Impaired sense of home (n = 5)	Mainly qualitative or interpretive	Lower well-being, insecurity, loss of belonging	Most evident in migrant, refugee, and Indigenous settings, where crowding was intertwined with displacement, cultural adequacy, tenure, and personalization.
Mixed	Family strain (n = 4)	Mixed mediation-based and observational evidence	Parent–child conflict, child behaviour, maternal stress	Repeatedly reported in family housing, especially for children, but based largely on observational and mediation studies with residual socioeconomic confounding.
Mixed	Sleep disturbance (n = 4)	Mixed pathway-based and correlational evidence	Sleep duration/quality, distress, impaired recovery	Directionally plausible and recurrent, but exposure and sleep measures varied and longitudinal evidence remained limited.

Table 4. Cont.

Support Within Review	Mechanism (Studies)	Predominant Evidence Type	Principal Outcomes	Synthesised Appraisal
Limited	Physiological stress load (n = 3)	Mainly correlational biomarker evidence	Blood pressure, catecholamines, allostatic load	Extends the evidence beyond self-report, but the small, heterogeneous evidence base and limited temporal designs prevent strong inference.
Limited	Diminished restoration (n = 2)	Mainly correlational or interpretive	Lower restoration, well-being, residential satisfaction	Theoretically plausible and design-relevant, but supported by very few context-specific studies.

Notes: Support levels are comparative judgements within this review based on consistency, study design and temporality, measurement quality, confounder control, theoretical coherence, and contextual breadth. “Consistent” indicates conceptual recurrence across more than one setting; it does not establish cultural invariance, measurement equivalence, equal effect magnitudes, formal GRADE certainty, or causal mediation.

3.4. Quantitative Spatial Evidence and Design Moderators

A subset of studies reported adjusted associations for objective-density indicators in explicit spatial units or for defined architectural contrasts (Table 5). These estimates quantify spatial load or configuration and are not direct measures of perceived crowding. Conversely, studies combining perceived crowding with architectural moderators address how spatial conditions are appraised and regulated, not objective occupancy thresholds. Heterogeneous measures and models precluded a single dose–response function; the estimates were treated as complementary empirical anchors.

Table 5. Quantitative spatial and architectural evidence linking residential crowding with psychological, psychosocial, sleep-related, and physiological outcomes.

Study/Setting	Spatial Exposure or Contrast	Outcome	Adjusted Quantitative Finding	Design-Relevant Interpretation
Liu et al. (2021) [33]; Chinese adults	Household overcrowding versus no overcrowding	Depressive mood	OR = 1.12 (95% CI 1.02–1.22). The association was significant after adjustment and was stronger in lower-income groups.	A modest population-level effect remains after socioeconomic adjustment; distributional vulnerability matters.
Wang and Liu (2023) [34]; Beijing, n = 1613	Livable area per resident; persons per bedroom	Screen-positive depression	Each additional 10 m ² /person corresponded to a 27.7% lower predicted probability of depression. For at least 1.51 persons/bedroom, logit beta = 1.198 (SE = 0.376) versus at most 1 person/bedroom.	Both private-area allowance and sleeping-room load should be measured; living-space-specific stress was the supported pathway.

Table 5. Cont.

Study/Setting	Spatial Exposure or Contrast	Outcome	Adjusted Quantitative Finding	Design-Relevant Interpretation
Sarkar et al. (2021) [112]; Hong Kong, n = 16,968, two waves	Livable floor area; housing units per building block	Probable major depression; depressive symptoms	Each 17 m ² increase in livable area was associated with aOR = 0.84 (0.71–0.98) for major depression and 0.93 (0.86–1.00) for symptoms. A 490-unit block-density increase produced aOR = 1.11 (1.01–1.22) for symptoms in single-exposure models.	Household and building-block density are distinct scales and may operate through different pathways.
Solari and Mare (2012) [44]; United States children	One additional person per usable room	Internalizing and externalizing behavioural problems	Internalizing problems increased by 2.6%; externalizing problems increased by 4.4% after demographic and socioeconomic adjustment.	Room load is more informative than household size alone and may operate through noise and reduced withdrawal.
Marsh et al. (2019) [113]; United Kingdom children, n = 2576	Additional 0.2 persons per room	Strengths and Difficulties Questionnaire	+0.20 SDQ points (95% CI 0.08–0.32; <i>p</i> < 0.001). Maternal stress, reduced sleep, and parent–child interaction jointly explained 15% of the association.	Small changes in room load are detectable; sleep and family-use conflicts are measurable intermediate processes.
Pierse et al. (2016) [35]; New Zealand, approximately 11,500 households	Bedroom deficit, including two-bedroom deficit	Psychological distress	Large cross-sectional associations were not reproduced in household fixed-effects models; significant changes were confined to moves into or out of a two-bedroom deficit and were not robust because such moves were rare.	Bedroom deficit is a useful severity indicator, but causal claims require repeated measured housing changes.
Ruiz-Tagle and Urria (2022) [36]; Chile, n = 10,024 households	Overcrowding at at least 2.5 persons/bedroom; change caused by bedroom loss versus household-size change	Depressive-symptom index	Increasing crowding: +0.327 points, or 0.14 SD. When driven by bedroom loss: +0.512 points, or 0.22 SD. A +1.1 persons/bedroom change from bedroom loss: +0.17 points, or 0.07 SD. Household-size-only change was not significant.	The strongest architecture-specific evidence: bedroom infrastructure, not household composition alone, explained the observed change.
Kawano et al. (2016) [114]; 30 Japanese shelters, 9031 patients	Less than 5.0 versus at least 5.0 m ² per evacuee; means 3.3 versus 8.6 m ²	Clinically recorded sleep disturbance	Crowded shelters had 2.6 additional cases per 1000 person-days (95% CI 0.2–5.0; <i>p</i> = 0.03) after adjustment.	A context-specific personal-space threshold was detectable for emergency sleeping environments; it should not be generalized to ordinary housing.

Table 5. *Cont.*

Study/Setting	Spatial Exposure or Contrast	Outcome	Adjusted Quantitative Finding	Design-Relevant Interpretation
Rollings and Evans (2019) [80]; children, mean age 9	Interior density; floor-plan depth and permeability; bedroom ceiling height, volume, and window area	Blood pressure; epinephrine; norepinephrine; allostatic load	Bedroom ceiling height significantly buffered the adverse association of high perceived home crowding with all four physiological stress indicators.	Sectional volume can moderate crowding stress even when plan-area load is unchanged.
Shimatani et al. (2024) [81]; Japan, n = 3859	Living room with a void or partially high ceiling	Poor psychological well-being, WHO-5	RR = 0.894 for taller males; detached houses RR = 0.905 (0.829–0.988); apartments RR = 0.849 (0.745–0.968). No comparable association was found for shorter males or females.	Ceiling height is a measurable but subgroup-dependent moderator, not a substitute for adequate floor area.

Notes: Estimates are reported in the original study units and are not directly comparable or pooled. They are empirical anchors rather than universal design thresholds. OR, odds ratio; RR, relative risk; SD, standard deviation; SDQ, Strengths and Difficulties Questionnaire.

At the dwelling scale, a 17 m² interquartile-range increase in livable area in Hong Kong was associated with lower depression risk [112]. Odds were 16% lower for probable major depression and 7% lower for depressive symptoms. In Beijing, each additional 10 m² per person corresponded to a 27.7% lower predicted probability of depression [34]. At least 1.51 persons per bedroom remained positively associated with depression. Another Chinese study linked household overcrowding to depressive mood (OR = 1.12, 95% CI 1.02–1.22) [33]. In the Southampton cohort, each 0.2-person increase per room corresponded to a 0.20-point increase in child behavioural difficulties [113]. Maternal stress, reduced sleep, and strained parent–child interaction jointly accounted for 15% of the association. One additional person per room was also associated with 2.6% more internalizing and 4.4% more externalizing problems among children [44]. In Chile, an increasing crowding trajectory predicted 0.14 SD more depressive symptoms, rising to 0.22 SD when bedroom loss drove the change [36]. Changes caused only by household size were not significant. New Zealand fixed-effects evidence was weaker and limited to moves involving a severe two-bedroom deficit [35].

The smaller moderator literature extended beyond plan area. Emergency shelters providing less than 5.0 m² per evacuee had 2.6 additional sleep-disturbance cases per 1000 person-days after adjustment [114]. Greater bedroom ceiling height buffered associations between perceived crowding and blood pressure, catecholamines, and allostatic load among highly crowded children [80]. In Japan, voids or partially high ceilings in living rooms were associated with lower risk of poor well-being [81]. Associations appeared in apartments (RR = 0.849, 95% CI 0.745–0.968) and detached houses (RR = 0.905, 95% CI 0.829–0.988), although effects were subgroup-specific. Together, the evidence distinguishes spatial load, spatial configuration, and regulatory capacity. It supports an indicator structure, not a universal crowding threshold.

Together, Sections 3.2–3.4 provide the empirical basis for CS-RPA. Explicit area, room, bedroom, and sleeping-space estimates in Table 5 constitute Q evidence for core spatial-load indicators. Tested contrasts in ceiling height, sectional openness, room location, and activity separation constitute M evidence for extended spatial-configuration and regulatory-capacity indicators. Privacy, control, sleep, withdrawal, social-support, and sense-of-home pathways in Figures 7 and A2 constitute P evidence explaining why spatial

and management conditions may matter. Setting-specific variation supports household composition, tenure, residential stability, cultural adequacy, and voluntariness as contextual descriptors rather than performance scores. Operational standards in Table 6 constitute S evidence retained as severity or housing-allocation screens. Applying Section 2.7 therefore yields three domains: spatial load, regulatory capacity, and occupancy context, without a weighted index or universal threshold.

Table 6. Authoritative crowding measures and their interpretive value for mental-health-oriented building research.

Measure/Source	Authoritative Operationalization	Primary Function	Mental-Health Evidence and Limitation	Use Within CS-RPA
WHO household crowding [15]	Occupants exceed dwelling capacity; may be measured by rooms, bedrooms, or floor area. WHO strongly recommends strategies to prevent and reduce crowding.	International health-hazard framework.	WHO identified significant mental-health associations in 8 of 13 studies, but thresholds and measures varied; no universal exposure-response cut-off was established.	Umbrella definition; requires at least one objective load measure plus a subjective or mechanism measure.
UN-Habitat sufficient living area [76]	A dwelling provides sufficient living area when no more than three people share a habitable room.	Global SDG 11.1.1 deprivation screen.	Useful for identifying severe deprivation, but too coarse to detect psychological gradients found below this level.	Severity screen only; retain continuous persons-per-room values.
Persons per room (PPR) [16,44,113]	Number of usual residents divided by usable or habitable rooms; room definition must be reported.	Simple continuous density measure and socioeconomic indicator.	Child studies found behavioural gradients per additional resident or 0.2 PPR; validation research shows that PPR, bedroom standards, and modified standards classify different households.	Core continuous indicator; report room-count rules and sensitivity to alternative definitions.
UK Bedroom Standard/occupancy rating [115]	Required bedrooms are derived from household age, sex, couple status, and relationships; an occupancy rating of −1 or less denotes overcrowding.	Composition-sensitive bedroom adequacy.	Panel evidence indicates that bedroom-loss-driven crowding is more strongly related to depressive symptoms than household-size-only change [36].	Core bedroom-deficit indicator; record one-, two-, and greater-bedroom shortfalls.
Canadian National Occupancy Standard [116]	Generally no more than two persons per bedroom, with age, relationship, and family-composition rules; one or more additional bedrooms required indicates crowding.	Housing suitability and allocation.	Improves sensitivity to household composition, but its categorical threshold is not itself a validated mental-health cut-off.	Alternative bedroom-adequacy algorithm where locally adopted; preserve actual persons per bedroom.

Table 6. *Cont.*

Measure/Source	Authoritative Operationalization	Primary Function	Mental-Health Evidence and Limitation	Use Within CS-RPA
Eurostat overcrowding rate [117]	Minimum room requirement depends on household, couple status, age, and sex composition.	Cross-national social statistics.	Supports comparable population surveillance but does not distinguish room size, privacy, acoustic separation, or control.	Contextual comparison measure; not sufficient as an architectural diagnosis.
Floor area per resident [34,112]	Net or livable floor area divided by usual residents; WHO recognizes floor area as a valid crowding measure but sets no universal threshold.	Continuous private-space allocation.	An additional 10 m ² /person and a 17 m ² livable-area increment were associated with lower depression risk in Beijing and Hong Kong.	Core indicator; report total livable area, m ² /person, and area-definition rules.
Emergency shelter area [15,114]	WHO cites 4.5–5.5 m ² per evacuee for cold-climate public shelters.	Short-term emergency accommodation planning.	In Japanese shelters, less than 5.0 m ² /person was associated with 2.6 additional sleep-disturbance cases per 1000 person-days.	Setting-specific benchmark only; do not transfer directly to ordinary housing.
Perceived crowding, privacy, and control [28,30,80]	No international physical threshold; measured by validated or study-specific appraisal scales.	Captures whether spatial load is experienced as unmanageable.	Perceived control and privacy loss were the most recurrent pathways and often predicted outcomes more strongly than occupancy alone.	Mandatory paired measure in health research; treat as appraisal or mechanism, not as an objective exposure.
Ceiling height, volume, and configuration [80,81]	Not included in conventional crowding standards.	Sectional spaciousness and design moderation.	Ceiling height buffered physiological stress in children; voids or partial high ceilings were associated with better well-being in selected subgroups.	Extended indicator; record clear height and room volume but do not substitute them for adequate plan area.

Notes: Official cut-offs are presented as comparative operational definitions, not as universal mental-health thresholds. CS-RPA therefore retains continuous variables wherever possible and uses categorical standards as severity or allocation screens. PPR, persons per room.

4. Discussion

4.1. Residential Crowding as a Relational and Context-Dependent Exposure

Objective density and perceived crowding are complementary, context-sensitive constructs [9,17,118]. Objective indicators describe the allocation of residential space; perceived crowding reflects its appraisal against residents' needs, routines, and expectations [10,28]. Household composition, cultural norms, voluntariness, tenure, stability, housing traditions, and socioeconomic constraints shape that appraisal [18,119]. Thus, an identical persons-per-room ratio can represent voluntary multigenerational co-residence, constrained rental sharing, displacement-related shortage, or imposed institutional occupancy, with different psychological meanings.

Their relationship is a conditional process, not a definitional substitution. Objective density creates potential spatial load, which residents appraise against their needs and the dwelling's capacity to regulate contact and activities [120]. High density need not produce

perceived crowding, while moderate density may feel crowded when privacy, control, or functional separation is inadequate. Because most studies did not measure every stage, perceived crowding cannot be assumed to mediate all associations between density and psychological outcomes.

The evidence's geographical concentration further limits interpretation. Region is not a proxy for culture, but reviewed settings illustrate how similar density measures can represent different arrangements. In East Asian family housing, multigenerational organization may shape privacy and sleeping expectations [39,40,66]. In Indigenous and Arctic communities, extended-family relations, cultural adequacy, and structural shortages are central [67–69]. Dormitory and shared-housing effects often depend on roommate relations, voluntariness, and communal-space quality [50–64]. Migrant and refugee accommodation commonly combines density with displacement, insecure tenure, temporary residence, and limited personalization [13,65]. These conditions alter the interpretation of privacy, control, sleep, and acceptable density.

The strongest cross-context conclusion is conditional rather than threshold-based. Spatial load was more burdensome when residents could not regulate contact, noise, visibility, activity overlap, sleep, or withdrawal [22,26,121]. Yet acceptable density and salient pathways varied by context. Co-residence may support connection when sharing is voluntary, culturally expected, and supported by communal and retreat spaces; it may contribute to distress when imposed, unstable, conflictual, or difficult to regulate.

Numerical standards remain essential for identifying severe deprivation but are not universal mental-health thresholds [15,16,76,79,122]. Assessment should combine spatial quantity with regulatory capacity and contextual descriptors such as household composition, voluntariness, tenure, stability, management, and cultural adequacy [77,78,93]. Because cultural moderation and measurement equivalence were rarely tested, cross-setting recurrence indicates conceptual convergence, not cultural invariance or equal effects. CS-RPA should therefore provide a common measurement structure whose interpretation requires local validation.

Sense of home also varies with housing systems, cultures, household forms, and residential histories. For migrants, refugees, Indigenous populations, insecure renters, and displaced people, it may depend strongly on cultural continuity, family connection, tenure security, community belonging, and restored routines. Impaired sense of home is therefore a context-dependent pathway, not a standardized mediator operating identically across populations.

4.2. Regulatory Capacity and Context-Dependent Mechanisms

No single mechanism dominated across settings. Reduced control and privacy loss recurred most broadly, but this partly reflects the populations, environments, and constructs studied [24,28]. They are best treated as cross-cutting regulatory concepts, not universal mediators or fixed causal priorities.

Mechanism salience varied by setting. Family housing combined privacy loss with sleep disturbance, competition for space, and parent–child strain [47,95]. Dormitories and shared housing emphasized voluntariness, roommate relations, communal space, and control of routines [60,123,124]. Migrant, refugee, and Indigenous settings emphasized stability, cultural adequacy, personalization, social support, and sense of home [13,65,104]. In prisons, perceived control was inseparable from involuntary residence, surveillance, restricted movement, and externally regulated routines [72].

Mechanisms may interact, operate in parallel, or vary in importance. Sleep disturbance, family strain, weakened social support, and sense of home may arise from restricted privacy or control but can also operate independently. With few formal mediation tests, these labels

identify plausible explanations rather than a causal sequence. Because several mechanisms could occur within one study or causal chain, their frequencies are neither independent nor additive.

4.3. Context, Autonomy, and Boundary Conditions

Variation across populations identifies crowding's boundary conditions. Children rely on the home for sleep, study, play, and family interaction but have limited authority to reorganize space [43,44]. In shared housing, occupancy effects depend on whether sharing is chosen, relationships are supportive, and communal areas are usable [60,123,124]. In migrant, refugee, Indigenous, and institutional settings, density often co-occurs with displacement, insecure tenure, cultural inadequacy, or restricted autonomy [13,65,104]. Autonomy is therefore a key contextual resource: co-residence may support residents when voluntary, reciprocal, and spatially bounded [25,32], but become burdensome when imposed and difficult to regulate [62,64]. Mixed and null findings support a conditional model rather than a universal threshold function [18,35,36,38,73,125].

Prisons provide a contrast case for examining privacy and control under sustained residence, shared space, surveillance, restricted movement, and externally regulated routines. These same conditions preclude direct equivalence with ordinary housing. Prison evidence was therefore used only to test whether privacy loss and reduced control remained salient under highly restrictive occupancy. It did not establish effect magnitudes, acceptable occupancy levels, thresholds, or design solutions for ordinary housing; only mechanisms also supported in non-institutional settings informed CS-RPA.

4.4. Crowding-Sensitive Residential Performance Assessment (CS-RPA)

CS-RPA is an evidence-to-design assessment protocol rather than a causal model or a universally calibrated scale. It comprises three domains, each grounded in a distinct evidence base. The spatial-load domain includes core measures of usable floor area, room and bedroom provision, and sleeping-space load. These measures are supported by Q evidence (Table 5) and S definitions (Table 6). The regulatory-capacity domain comprises extended indicators of layout, boundaries, environmental controls, sectional volume, activity separation, retreat space, and shared-facility load. These indicators are supported by architectural moderators (M) and recurring pathways (P) identified in Figures 7 and A2. The occupancy-context domain records exposure duration, tenure, household composition, residential stability, cultural adequacy, management, and voluntariness. These factors may modify the relationship between objective density and perceived crowding. Section 2.7 explains how Q–M–P–S evidence is used to classify items as core, extended, or contextual. Together, the three domains define a minimum dataset without imposing universal weights, thresholds, or causal priorities. Operationally, CS-RPA records objective density and perceived crowding as separate fields. Objective density is measured using area- and occupancy-based indicators, whereas perceived crowding requires validated self-report instruments or explicitly defined appraisal items. Agreement between the two may identify objectively high and subjectively burdensome spatial load. Disagreement is equally informative because it may reveal the modifying effects of layout, privacy, household relationships, cultural expectations, or residential choice. Both patterns should therefore be retained and interpreted in post-occupancy evaluation.

Table 6 illustrates why current standards are necessary but insufficient for mental-health-oriented assessment. WHO defines crowding as a mismatch between occupants and dwelling capacity while allowing context-appropriate measures [15]. UN-Habitat uses more than three persons per habitable room as a deprivation screen [76]. The United Kingdom, Canada, and Eurostat instead use household-composition-sensitive room or

bedroom requirements [115–117]. These definitions support surveillance and allocation but do not measure privacy, control, activity overlap, sleep protection, or perceived crowding [16,79]. CS-RPA retains categorical measures as severity screens and continuous area and occupancy variables for analysis. Table 7 then adds audits of room or bedroom shortfall, regulatory-capacity features, and occupancy context. It also links constraints to prespecified pathways and outcomes. The output is a multidimensional profile because evidence supports gradients and mechanism-specific deficits, not universal weights. It does not identify a point at which design quality offsets severe deprivation. CS-RPA should be used as a common data structure, not a universally calibrated scale. Indicator interpretation, weights, and decision thresholds require local validation that considers household organization, sleeping arrangements, voluntariness, stability, and culturally appropriate expectations of privacy and personal space.

Table 7. Crowding-Sensitive Residential Performance Assessment (CS-RPA): author-developed minimum dataset, empirical status, and evidence level within this review.

Tier and Domain	Operational Indicator	Measurement or Coding	Evidence Basis and Empirical Status	Supporting Studies, n	Study Design(s)	Evidence Level Within This Review	Required Output/Application
Core: spatial load	Private-area allowance	Net livable area (m ²); m ² per resident; state whether balconies, circulation, and shared areas are excluded.	Q + S—empirically quantified spatial indicator; not a tested architectural moderator.	3 direct Q studies	Cross-sectional observational (n = 3; one two-wave dataset)	Level A—direct, comparatively developed	Report total and per capita area continuously; flag locally defined insufficiency separately. Do not infer a universal threshold.
Core: spatial load	Persons per usable room	Usual residents/usable habitable rooms; retain the continuous value and the room-count definition.	Q + S—empirically quantified spatial indicator; not a tested architectural moderator.	2 direct Q studies	Cross-sectional (n = 1); longitudinal (n = 1)	Level A—direct, comparatively developed	Compare continuous PPR with UN-Habitat or locally applicable categorical screens.
Core: sleeping load	Persons per bedroom and shared sleeping	Persons per bedroom; actual sleeping pairs/groups; adults or children sleeping in living rooms.	Q + P—empirically quantified sleeping-load indicator; interpreted through sleep and privacy pathways.	2 direct Q studies	Cross-sectional (n = 1); longitudinal (n = 1)	Level A—direct, comparatively developed	Identify sleeping-space pressure concealed by total room count; retain the locally applicable bedroom-sharing rule.
Core: bedroom adequacy	Bedroom deficit	Required bedrooms minus available bedrooms using a stated standard; code 0, 1, 2, and 3+ shortfall.	Q + S—empirically quantified severity indicator; findings were not uniformly robust.	2 direct Q studies	Longitudinal (n = 2; one household fixed-effects analysis)	Level B—direct but limited/mixed	Distinguish crowding caused by bedroom loss from crowding caused only by household-size change.
Core: subjective appraisal	Perceived crowding	Validated scale or clearly reported items on insufficient space, unwanted contact, and difficulty withdrawing.	P—empirically assessed subjective exposure; heterogeneous measures and contexts; not a design moderator.	26 subjective or mixed-subjective exposure studies	Cross-sectional (n = 18); qualitative (n = 6); experimental (n = 2)	Level B—direct but heterogeneous	Pair with objective load to identify density-appraisal mismatch; do not treat subjective exposure counts as pooled effects.

Table 7. Cont.

Tier and Domain	Operational Indicator	Measurement or Coding	Evidence Basis and Empirical Status	Supporting Studies, n	Study Design(s)	Evidence Level Within This Review	Required Output/ Application
Extended: privacy	Visual boundary and retreat access	Direct sightlines into sleeping/private zones; closable private enclosure; number of retreat spaces; residents per retreat space.	P—pathway-derived recommendation from privacy-loss and restoration evidence; the component bundle was not independently tested.	9 unique pathway studies	Cross-sectional (n = 8); qualitative (n = 1)	Level C—indirect, pathway-based	Map where occupants can withdraw without blocking other household activities; treat the proposed measures as candidates for validation.
Extended: acoustics and sleep	Acoustic separation and protected quiet zone	Measured indoor noise or sound insulation where available; door/partition type; nighttime activity overlap.	P—pathway-derived recommendation from sleep-disturbance evidence; acoustic features were not independently tested as moderators.	4 pathway studies	Cross-sectional (n = 2); longitudinal (n = 2)	Level C—indirect, pathway-based	Document whether sleeping zones are protected from circulation, media, and household activity; validate acoustic measures prospectively.
Extended: control	Resident-controllable elements	Count/proportion of operable windows, blinds, lights, lockable doors and storage, and access controls.	P—pathway-derived recommendation from perceived-control evidence; the listed element bundle was not independently tested.	16 pathway studies	Cross-sectional (n = 12); longitudinal (n = 1); qualitative (n = 1); experimental (n = 2)	Level C—indirect, pathway-based	Record whether each resident can regulate contact, light, ventilation, storage, and access; analyze elements separately before creating a score.
Extended: configuration	Activity-zone separation and adaptability	Number of independently usable sleep, study, social, and care zones; movable or fixed partitions; circulation through rooms.	P—pathway-derived recommendation from family-strain and spatial-negotiation evidence; configuration effects were not consistently isolated.	5 unique pathway studies	Cross-sectional (n = 3); longitudinal (n = 1); qualitative (n = 1)	Level C—indirect, pathway-based	Identify incompatible activities forced into the same zone and opportunities for reconfiguration; test proposed configuration metrics directly.
Extended: section	Ceiling height and room volume	Clear ceiling height (m); room volume (m ³); m ³ per resident; void or partial-high-ceiling condition.	M—empirically tested design moderator/architectural contrast; effects were subgroup- and context-dependent.	2 direct M studies	Cross-sectional observational (n = 2)	Level B—direct but limited	Use as a moderator and explanatory variable, never as a substitute for adequate floor area.
Extended: shared-space capacity	Communal and facility load	Communal m ² /resident; users per kitchen, bathroom, laundry, and lounge; access schedule and governance.	P—pathway-derived recommendation from social-support, conflict, and belonging evidence; the load metrics were not independently validated.	7 pathway studies	Cross-sectional (n = 4); longitudinal (n = 1); qualitative (n = 2)	Level C—indirect, pathway-based	Assess whether interaction is optional and facilities are usable without recurrent conflict; report each facility denominator explicitly.

Table 7. *Cont.*

Tier and Domain	Operational Indicator	Measurement or Coding	Evidence Basis and Empirical Status	Supporting Studies, n	Study Design(s)	Evidence Level Within This Review	Required Output/ Application
Context	Stability, duration, and voluntariness	Tenure; months exposed; move history; chosen versus imposed sharing; relationship among co-residents.	Q + P—contextual interpretation supported by tenure/change and sense-of-home evidence; not an independently tested design effect.	6 unique contextual/pathway studies	Cross-sectional (n = 2); longitudinal (n = 1); qualitative (n = 2); experimental (n = 1)	Level D—contextual/interpretive	Interpret identical spatial loads differently where residents lack security, choice, or an exit option.
Context	Household and cultural suitability	Age structure; children; disability; caregiving; culturally preferred sleeping and household arrangements.	P + S—contextual and standards-based requirement; no universal composition-to-effect relation was established.	9 unique context-relevant pathway studies	Cross-sectional (n = 5); longitudinal (n = 1); qualitative (n = 2); experimental (n = 1)	Level D—contextual/operational	Avoid treating one composition-sensitive standard as universally appropriate; state the cultural and household assumptions used.
Outcome linkage	Mechanism-specific outcome set	At minimum: depression/distress, perceived control, privacy, sleep, family/roommate strain, social support, and well-being.	Framework specification—outcome-linkage rule; not an exposure or design-effect claim.	Not applicable	Not applicable	Not rated—framework specification	Link each spatial deficit to a prespecified mechanism and validated outcome rather than a single generic satisfaction score.

Notes. Q = adjusted quantitative association reported in an explicit spatial unit; M = empirically tested architectural moderator or contrast; P = recurrent environmental-psychological pathway; S = authoritative or validated operational standard. Standards are not counted as studies. Supporting-study counts were calculated at the level of unique studies. Direct Q/M counts came from the explicit spatial-unit and architectural-contrast evidence in Table 5. P counts came from the 48-study matrix and mechanism synthesis in Table 4. A study was counted once per indicator even when it contributed several records. The 28 narrative-only studies were excluded because they lacked complete coding across the prespecified matrix dimensions.

For pathway-derived rows, n denotes the number of unique studies supporting the named mechanism or contextual interpretation, not the number of studies that directly tested the listed architectural component. This distinction prevents theoretically translated design recommendations from being presented as validated design effects.

Evidence levels are comparative judgements within this review, not formal GRADE ratings. Level A denotes direct and comparatively developed evidence; Level B denotes direct but limited, heterogeneous, mixed, or context-dependent evidence. Level C denotes indirect pathway support requiring direct component validation; Level D denotes contextual or operational support. “Not rated” identifies a framework specification. No level establishes a universal crowding threshold or validates CS-RPA as a weighted score.

Figure 8 integrates the setting-specific, mechanism-level, and design-oriented findings into an evidence-derived framework for residential crowding as a context-sensitive housing-health process. The framework is not a fixed causal sequence. It shows how geographical context, cultural norms, occupancy conditions, and built residential characteristics shape spatial-load appraisal, pathway salience, and mental-health and psychosocial outcomes. It also shows how these evidence streams inform the three CS-RPA domains.

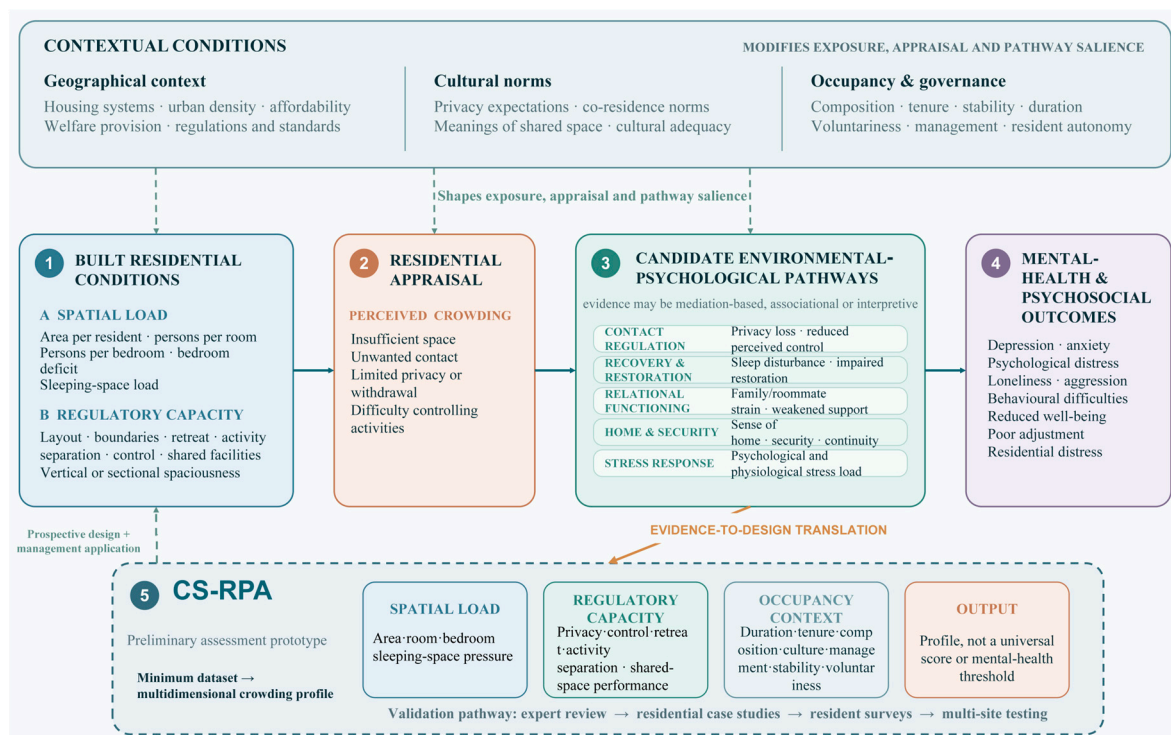


Figure 8. Evidence-derived, context-sensitive framework linking residential crowding to mental health and design-responsive assessment.

4.5. Limitations and Future Research

The evidence is heterogeneous and predominantly cross-sectional, limiting pooled estimation and causal inference. Residual confounding, residential selection, and common-method bias remain possible, while migrant, refugee, Indigenous, and institutional evidence is sparse. Concentration in North America, East Asia, and Europe also means that recurring mechanisms cannot be assumed culturally invariant. Future studies should test measurement equivalence and cultural moderation directly. Although all 76 studies informed narrative synthesis, only 48 supported complete structured coding, and Table 5 estimates are illustrative rather than meta-analytic or threshold-defining. International definitions in Table 6 also serve different policy purposes and are not interchangeable. Longitudinal, relocation, renovation, and natural-experiment studies should apply the Table 7 minimum dataset and jointly measure objective load, spatial configuration, privacy, control, sleep, social relations, and mental health. Such work could validate indicators, reduce the instrument, assess inter-rater reliability, and develop local decision rules. Experimental studies could additionally use EEG, eye tracking, and immersive virtual environments to test experiences of spatial constraint and regulatory capacity [126,127].

Frequency summaries map published evidence rather than population associations or certainty. Unweighted counts ignore sample size, precision, effect magnitude, design strength, and confounder adjustment, and may reflect geographical concentration, measurement availability, selective reporting, or publication bias. Heterogeneous exposures, outcomes, and cultural meanings also prevent numerical agreement from establishing measurement equivalence. Thus, labels such as “consistent”, “mixed”, and “limited” describe evidential patterns; interpretation depends on methodological and contextual triangulation.

CS-RPA is a preliminary, literature-derived prototype rather than a validated instrument. Validation could proceed in three stages. Expert evaluation would assess indicator relevance and establish preliminary weights. Pilot residential case studies would examine feasibility and inter-rater reliability. Resident surveys, preferably prospective, would test

construct and predictive validity against mental-health and psychosocial outcomes. Multi-site testing would then determine whether indicators and weights require recalibration across cultural and residential settings.

5. Conclusions

Residential crowding cannot be represented by a universal floor-area or occupancy threshold. Objective density measures the allocation of residents to space; perceived crowding captures whether that allocation supports privacy, control, withdrawal, and daily activities. Because neither substitutes for the other, spatial load must be interpreted with perceived crowding, regulatory capacity, household composition, social relationships, cultural adequacy, and residential stability.

CS-RPA translates this conditional understanding into a framework combining spatial load, regulatory capacity, and residential context. It supports comparable surveys, post-occupancy evaluations, and intervention studies rather than a single mental-health standard. Categorical crowding measures remain useful for identifying severe deprivation but are not universal psychological thresholds. Design improvements also cannot be assumed to offset severe spatial deprivation, unaffordability, insecure tenure, or institutional constraints.

Supplementary Materials: The following supporting information can be downloaded at <https://www.mdpi.com/article/10.3390/buildings16183612/s1>, Supplementary Material S1, complete database-specific search strategies for Scopus, PubMed, Web of Science Core Collection, and CNKI; Supplementary Material S2, completed PRISMA 2020 checklist. Supplementary Material S3: Included Studies in the Systematic Review (n = 76), containing the complete reference list of the 76 studies included in the review.

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

Abbreviations

The following abbreviations are used in this manuscript:

aOR	adjusted odds ratio
CI	confidence interval
CNKI	China National Knowledge Infrastructure
COVID-19	coronavirus disease 2019
CS-RPA	Crowding-Sensitive Residential Performance Assessment
D1–D5	ROBINS-E risk-of-bias domains: confounding; exposure measurement; outcome measurement; temporality; selective reporting

EEG	electroencephalography
GRADE	Grading of Recommendations Assessment, Development and Evaluation
m ²	square metres
M	tested architectural moderator (evidence-class code)
n	sample size
O/S	objective density/subjective crowding (evidence-matrix coding)
OR	odds ratio
P	recurrent environmental-psychological pathway (evidence-class code)
PPR	persons per room
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
Q	adjusted quantitative association in an explicit spatial unit (evidence-class code)
ROBINS-E	Risk Of Bias In Non-randomized Studies of Exposures
RQ	research question
RR	relative risk
S (CS-RPA)	authoritative or validated operational standard (evidence-class code)
SD	standard deviation
SDG	Sustainable Development Goal
SDQ	Strengths and Difficulties Questionnaire
SE	standard error
UN-Habitat	United Nations Human Settlements Programme
UK	United Kingdom
WHO	World Health Organization
WHO-5	WHO Five Well-Being Index
WoS	Web of Science

Appendix A. Coded Evidence Matrix

Table A1. Full evidence matrix of the 48 coded studies underlying the quantitative figures and Tables 3, 4 and A5. Exposure: O = objective density, S = subjective crowding. Direction reflects the predominant reported association between crowding and the outcome.

Study	Year	Country	Setting	Design	Population	Exp.	Dominant Mechanism	Outcome	Direction
Evans et al. [30]	1989	India	Family housing	Cross-sectional	Adults	O	Social support	Distress	Adverse
Fuller et al. [82]	1996	Thailand	Family housing	Cross-sectional	Adults	O + S	Perceived control	Well-being	Adverse
Evans et al. [43]	1998	India	Family housing	Cross-sectional	Children	O	Physiological stress	Behavioural	Adverse
Chan [118]	1999	China	Family housing	Cross-sectional	Adults	S	Privacy loss	Well-being	Mixed
Evans et al. [128]	2001	United States	Family housing	Cross-sectional	Children	O	Perceived control	Behavioural	Adverse
Wells & Harris [129]	2007	United States	Family housing	Longitudinal	Women	O	Social support	Distress	Adverse
Solari & Mare [44]	2012	United States	Family housing	Cross-sectional	Children	O	Family strain	Behavioural	Adverse
Campagna [28]	2016	United States	Family housing	Cross-sectional	Adults	S	Perceived control	Well-being	Adverse
Pierse et al. [35]	2016	New Zealand	Family housing	Longitudinal	Adults	O	Perceived control	Distress	Mixed
Yang Zhu [130]	2017	China	Family housing	Cross-sectional	Adults	S	Perceived control	Well-being	Adverse
Marsh et al. [113]	2019	United Kingdom	Family housing	Longitudinal	Children	O	Sleep disturbance	Behavioural	Adverse

Table A1. Cont.

Study	Year	Country	Setting	Design	Population	Exp.	Dominant Mechanism	Outcome	Direction
Rollings & Evans [80]	2019	United States	Family housing	Cross-sectional	Children	S	Physiological stress	Physiological	Buffered
Liu et al. [33]	2021	China	Family housing	Cross-sectional	Adults	O	Privacy loss	Depression	Adverse
Sarkar et al. [112]	2021	China	Family housing	Cross-sectional	Adults	O	Privacy loss	Depression	Adverse
Chang & Chiang [48]	2022	China	Family housing	Longitudinal	Children	O	Sleep disturbance	Sleep	Adverse
Ruiz-Tagle & Urria [36]	2022	Chile	Family housing	Longitudinal	Adults	O	Privacy loss	Well-being	Adverse
Sirikul et al. [131]	2022	Thailand	Family housing	Cross-sectional	Mothers	O	Family strain	Distress	Adverse
Wang & Liu [34]	2023	China	Family housing	Cross-sectional	Adults	S	Perceived control	Depression	Adverse
Costa Santos et al. [108]	2024	United Kingdom	Family housing	Qualitative	Children	S	Privacy loss	Restoration	Buffered
Lorentzen et al. [49]	2024	Sweden	Family housing	Qualitative	Children	S	Sense of home	Well-being	Adverse
Shimatani et al. [81]	2024	Japan	Family housing	Cross-sectional	Adults	S	Restoration	Well-being	Buffered
Weber et al. [132]	2024	United Kingdom	Family housing	Cross-sectional	Adults	S	Privacy loss	Aggression	Adverse
Guo et al. [133]	2025	China	Family housing	Cross-sectional	Adults	O	Family strain	Behavioural	Adverse
Mejia-Castillo et al. [29]	2025	Mexico	Family housing	Cross-sectional	Adults	S	Restoration	Restoration	Adverse
Yan [31]	2025	China	Family housing	Cross-sectional	Adults	S	Sleep disturbance	Sleep	Adverse
Yin et al. [125]	2025	China	Family housing	Cross-sectional	Adults	O	Social support	Distress	Adverse
Riva et al. [14]	2014	Greenland	Indigenous/Arctic	Cross-sectional	Adults	O	Physiological stress	Well-being	Adverse
Pepin et al. [134]	2018	Canada	Indigenous/Arctic	Longitudinal	Children	O	Family strain	Depression	Null
Perreault et al. [104]	2020	Canada	Indigenous/Arctic	Cross-sectional	Adults	S	Sense of home	Well-being	Adverse
Simard et al. [135]	2024	Canada	Indigenous/Arctic	Cross-sectional	Adults	O	Social support	Well-being	Adverse
Cox et al. [136]	1984	United States	Institutional/prison	Cross-sectional	Prisoners	S	Perceived control	Physiological	Adverse
Ruback et al. [137]	1986	United States	Institutional/prison	Cross-sectional	Prisoners	S	Perceived control	Stress	Adverse
Lawrence & Andrews [138]	2004	United States	Institutional/prison	Cross-sectional	Prisoners	S	Perceived control	Aggression	Adverse
Kawano et al. [114]	2016	Japan	Emergency shelter/disaster evacuees	Cross-sectional	Adults	O	Sleep disturbance	Sleep	Adverse
Mangrio & Zdravkovic [13]	2018	Sweden	Migrant/refugee	Cross-sectional	Migrants	O	Sense of home	Distress	Adverse
Rast et al. [65]	2024	Germany	Migrant/refugee	Qualitative	Migrants	S	Perceived control	Well-being	Adverse

Table A1. *Cont.*

Study	Year	Country	Setting	Design	Population	Exp.	Dominant Mechanism	Outcome	Direction
Ortega-Alcazar & Wilkinson [60]	2021	United Kingdom	Shared/rental	Qualitative	Adults	S	Sense of home	Well-being	Adverse
Morris et al. [123]	2022	Australia	Shared/rental	Qualitative	Students	S	Social support	Loneliness	Adverse
Worsley et al. [51]	2023	United Kingdom	Shared/rental	Cross-sectional	Students	S	Social support	Depression	Adverse
Siddika & Badhan [61]	2026	Bangladesh	Shared/rental	Qualitative	Adults	S	Social support	Well-being	Buffered
Baron et al. [52]	1976	United States	Student dormitory	Experimental	Students	O	Perceived control	Social	Adverse
Baum & Gatchel [139]	1981	United States	Student dormitory	Experimental	Students	S	Perceived control	Distress	Adverse
Walden et al. [140]	1981	United States	Student dormitory	Cross-sectional	Students	S	Privacy loss	Aggression	Adverse
Ronchi & Sparacino [54]	1982	United States	Student dormitory	Cross-sectional	Students	O	Perceived control	Stress	Null
Clark et al. [53]	2012	United States	Student dormitory	Cross-sectional	Students	O	Perceived control	Distress	Null
Tao et al. [50]	2016	China	Student dormitory	Cross-sectional	Students	S	Perceived control	Anxiety	Adverse
Neethu et al. [124]	2018	India	Student dormitory	Cross-sectional	Students	S	Perceived control	Well-being	Adverse
Yang Yongle et al. [55]	2018	China	Student dormitory	Experimental	Students	S	Sense of home	Well-being	Mixed

Table A2. Study-level risk-of-bias appraisal (ROBINS-E-style domains) of the 48 coded studies, derived from study design and exposure measurement. Ratings: Low/Some concerns/High; n/a where a domain does not apply (qualitative studies). D1 confounding, D2 exposure measurement, D3 outcome measurement, D4 temporality, D5 selective reporting.

Study	Year	Design	D1	D2	D3	D4	D5	Overall
Campagna [28]	2016	Cross-sectional	Some concerns	Some concerns	Some concerns	High	Some concerns	High
Chan [118]	1999	Cross-sectional	Some concerns	Some concerns	Some concerns	High	Some concerns	High
Chang & Chiang [48]	2022	Longitudinal	Some concerns	Low	Some concerns	High	Some concerns	High
Clark et al. [53]	2012	Cross-sectional	Some concerns	Low	Some concerns	High	Some concerns	High
Cox et al. [136]	1984	Cross-sectional	Some concerns	Some concerns	Some concerns	High	Some concerns	High
Evans et al. [43]	1998	Cross-sectional	Some concerns	Low	Some concerns	High	Some concerns	High
Evans et al. [128]	2001	Cross-sectional	Some concerns	Low	Some concerns	High	Some concerns	High
Evans et al. [30]	1989	Cross-sectional	Some concerns	Low	Some concerns	High	Some concerns	High
Fuller et al. [82]	1996	Cross-sectional	Some concerns	Some concerns	Some concerns	High	Some concerns	High

Table A2. *Cont.*

Study	Year	Design	D1	D2	D3	D4	D5	Overall
Guo et al. [133]	2025	Cross-sectional	Some concerns	Low	Some concerns	High	Some concerns	High
Kawano et al. [114]	2016	Cross-sectional	Some concerns	Low	Some concerns	High	Some concerns	High
Lawrence & Andrews [138]	2004	Cross-sectional	Some concerns	Some concerns	Some concerns	High	Some concerns	High
Liu et al. [33]	2021	Cross-sectional	Some concerns	Low	Some concerns	High	Some concerns	High
Mangrio & Zdravkovic [13]	2018	Cross-sectional	Some concerns	Low	Some concerns	High	Some concerns	High
Mejia-Castillo et al. [29]	2025	Cross-sectional	Some concerns	Some concerns	Some concerns	High	Some concerns	High
Neethu et al. [124]	2018	Cross-sectional	Some concerns	Some concerns	Some concerns	High	Some concerns	High
Perreault et al. [104]	2020	Cross-sectional	Some concerns	Some concerns	Some concerns	High	Some concerns	High
Riva et al. [14]	2014	Cross-sectional	Some concerns	Low	Some concerns	High	Some concerns	High
Rollings & Evans [80]	2019	Cross-sectional	Some concerns	Some concerns	Some concerns	High	Some concerns	High
Ronchi & Sparacino [54]	1982	Cross-sectional	Some concerns	Low	Some concerns	High	Some concerns	High
Ruback et al. [137]	1986	Cross-sectional	Some concerns	Some concerns	Some concerns	High	Some concerns	High
Sarkar et al. [112]	2021	Cross-sectional	Some concerns	Low	Some concerns	High	Some concerns	High
Shimatani et al. [81]	2024	Cross-sectional	Some concerns	Some concerns	Some concerns	High	Some concerns	High
Simard et al. [135]	2024	Cross-sectional	Some concerns	Low	Some concerns	High	Some concerns	High
Sirikul et al. [131]	2022	Cross-sectional	Some concerns	Low	Some concerns	High	Some concerns	High
Solari & Mare [44]	2012	Cross-sectional	Some concerns	Low	Some concerns	High	Some concerns	High
Tao et al. [50]	2016	Cross-sectional	Some concerns	Some concerns	Some concerns	High	Some concerns	High
Walden et al. [140]	1981	Cross-sectional	Some concerns	Some concerns	Some concerns	High	Some concerns	High
Wang & Liu [34]	2023	Cross-sectional	Some concerns	Some concerns	Some concerns	High	Some concerns	High
Weber et al. [132]	2024	Cross-sectional	Some concerns	Some concerns	Some concerns	High	Some concerns	High
Worsley et al. [51]	2023	Cross-sectional	Some concerns	Some concerns	Some concerns	High	Some concerns	High
Yan [31]	2025	Cross-sectional	Some concerns	Some concerns	Some concerns	High	Some concerns	High
Yang Yongle et al. [55]	2018	Experimental	Some concerns	Some concerns	Some concerns	High	Some concerns	High

Table A2. Cont.

Study	Year	Design	D1	D2	D3	D4	D5	Overall
Yang Zhu [130]	2017	Cross-sectional	Some concerns	Some concerns	Some concerns	High	Some concerns	High
Yin et al. [125]	2025	Cross-sectional	Some concerns	Low	Some concerns	High	Some concerns	High
Baron et al. [52]	1976	Experimental	Low	Low	Some concerns	Low	Some concerns	Low
Marsh et al. [113]	2019	Longitudinal	Low	Low	Some concerns	Low	Some concerns	Low
Pepin et al. [134]	2018	Longitudinal	Low	Low	Some concerns	Low	Some concerns	Low
Pierse et al. [35]	2016	Longitudinal	Low	Low	Some concerns	Low	Some concerns	Low
Ruiz-Tagle & Urria [36]	2022	Longitudinal	Low	Low	Some concerns	Low	Some concerns	Low
Wells & Harris [129]	2007	Longitudinal	Low	Low	Some concerns	Low	Some concerns	Low
Baum & Gatchel [139]	1981	Experimental	Low	Some concerns	Some concerns	Low	Some concerns	Some concerns
Costa Santos et al. [108]	2024	Qualitative	Some concerns	Some concerns	Some concerns	n/a	Some concerns	Some concerns
Lorentzen et al. [49]	2024	Qualitative	Some concerns	Some concerns	Some concerns	n/a	Some concerns	Some concerns
Morris et al. [123]	2022	Qualitative	Some concerns	Some concerns	Some concerns	n/a	Some concerns	Some concerns
Ortega-Alcazar & Wilkinson [60]	2021	Qualitative	Some concerns	Some concerns	Some concerns	n/a	Some concerns	Some concerns
Rast et al. [65]	2024	Qualitative	Some concerns	Some concerns	Some concerns	n/a	Some concerns	Some concerns
Siddika & Badhan [61]	2026	Qualitative	Some concerns	Some concerns	Some concerns	n/a	Some concerns	Some concerns

Table A3. Study-level coding status and audit rationale for all 76 eligible studies. “Yes” indicates inclusion in the 48-study structured evidence matrix; “No” indicates retention in the narrative synthesis only. Matrix inclusion required sufficiently explicit information on residential setting, study design, population, exposure type, candidate pathway, and outcome domain.

Study Identifier	Country/Region	Study Design	Exposure Type	Outcome Domain	Matrix	Study-Specific Audit Rationale
Park et al. (2023) [5]	South Korea and the Netherlands	Cross-sectional two-country online survey	Mixed/subjective: workspace-size satisfaction, perceived crowding, and multiple workspace features	Perceived crowding, workspace satisfaction, general health, and productivity	No	Perceived crowding also functioned as an intermediate outcome, and health and productivity were downstream self-reports; therefore, one unambiguous exposure–pathway–outcome coding state could not be assigned.
Cable & Sacker (2019) [16]	United Kingdom	Cross-sectional measurement-validation study	Objective: persons per room, bedroom standard, and modified bedroom standard	Measure agreement/validity, self-rated health, and GHQ-12 mental health	No	The competing exposure definitions were the object of the study and no candidate pathway was tested, so a single matrix exposure–pathway record would be arbitrary.

Table A3. Cont.

Study Identifier	Country/Region	Study Design	Exposure Type	Outcome Domain	Matrix	Study-Specific Audit Rationale
Evans et al. (1996) [22]	United States	Cross-sectional correlational mediated-moderation study	Objective household density $\times$ architectural depth	Psychological distress; social withdrawal as mediator	No	A single study-level exposure and pathway code would conflate the density exposure, the architectural moderator, and the mediator.
Evans et al. (2002) [23]	Austria	Cross-sectional epidemiological study	Objective persons per room $\times$ house type	Child self-reported mental health and teacher-rated classroom behaviour	No	It did not directly measure a candidate psychological pathway such as privacy or perceived control, so the pathway dimension could not be coded without inferring it from the design discussion.
Baum et al. (1978) [24]	United States	Mixed field survey and laboratory experiment	Architecturally mediated social density, corridor design, residential group size, and duration of residence	Control motivation/learned helplessness, mood, behaviour, and dormitory experience	No	Its multiple designs and control-, mood-, and behaviour-related outcomes could not be reduced to one study-level design–exposure–outcome state.
Evans & Lepore (1993) [25]	United States	Quasi-experimental laboratory follow-up of a longitudinal cohort	Objective household density plus a laboratory stressor/social-support manipulation	Perceived and enacted social support, social withdrawal, and stress response	No	The principal outcomes were support and withdrawal rather than a new independent crowding–mental health endpoint; coding it as a separate simple matrix row would both duplicate the cohort and collapse the compound design.
Evans et al. (2000) [26]	United States	Two-study package: naturalistic field study and laboratory experiment	Chronic objective residential density plus manipulated acute crowding/blocked withdrawal	Social memory, perceived stress, and perceived crowding	No	The designs, exposure states, and outcomes differed, so no single article-level coding state was defensible.
Lepore et al. (1991) [32]	United States	Prospective longitudinal cohort (three waves)	Objective household density	Psychological distress and perceived social support	No	Assigning one stable candidate-pathway code would erase the time-varying causal role that the study was designed to demonstrate.
Gove et al. (1979) [37]	United States (Chicago)	Cross-sectional household survey	Objective persons per room plus subjective social-demand and privacy-loss measures	Multiple mental-health, physical-health, family-relationship, childcare, and external-social outcomes	No	The article did not yield one dominant exposure–pathway–outcome tuple without discarding substantial parts of the reported analysis.
Hadziabdic & Kohl (2025) [38]	Switzerland	Longitudinal household-panel transition/event study	Objective transitions into overcrowding and under-occupation	Emotional states, life/domestic satisfaction, leisure, social ties, and social anomie	No	These opposing exposure states and multiple time-dependent outcomes could not be represented by one matrix record.
Li & Liu (2018) [39]	China (12 cities)	Cross-sectional migrant survey	Objective: per capita living space and room-sharing with non-family members within a multi-exposure housing-stress model	Perceived stress and mental health	No	The paper did not report a crowding-specific mediation test, so the candidate pathway and crowding-specific contribution could not be separated from the overall housing-stress specification.
Wang et al. (2023) [40]	China	Cross-sectional survey	Housing affordability; crowding was not modelled	Depressive symptoms (CES-D)	No	Crowding appeared in the background literature but was not operationalized or entered as an exposure in the reported models; therefore, the required crowding-exposure dimension was absent.
Chambers et al. (2015) [41]	United States (Bronx, New York)	Cross-sectional survey	Subjective perceived crowding as one secondary housing predictor	Depressive symptoms and hostility	No	Perceived crowding was one secondary predictor and was associated with hostility but not the depressive-symptom result; no crowding-specific mediator was tested, so a single pathway–outcome code was not available.

Table A3. Cont.

Study Identifier	Country/Region	Study Design	Exposure Type	Outcome Domain	Matrix	Study-Specific Audit Rationale
Keller et al. (2022) [42]	Denmark, France, and the United Kingdom	Cross-sectional individual-participant-data meta-analysis of four cohorts	Cohort-varying household density, room-standard crowding, household composition, and other housing conditions	Loneliness, anxiety, and life satisfaction	No	One study-level country, population, exposure, and outcome record would conflate heterogeneous samples and measurements.
Evans et al. (1999) [47]	United States (Midwest)	Secondary longitudinal correlational analysis	Objective persons per room, analyzed secondarily	Parental verbal responsiveness and speech complexity	No	The measured outcomes were parental verbal responsiveness and speech complexity—developmental-process proxies rather than a mental-health or psychosocial outcome domain—so complete matrix coding was not possible.
McCartney & Rosenvasser (2023) [57]	North America (framework; no participant sample)	Conceptual/taxonomic framework development	Unmeasured conceptual crowding/privacy/control typology (HUC/HIPAT)	No empirical participant-level outcome	No	It did not provide a measured crowding exposure, an empirical study population, or a mental-health outcome for matrix computation.
Beder & İmamoğlu (2023) [58]	Türkiye	Cross-sectional questionnaire with multiple field comparisons	Objective room density, corridor design, room location/distance, and subjective crowding/privacy	Dormitory satisfaction, privacy, crowding, and relational/disturbance experiences	No	Density, corridor type, and room location were analyzed against several satisfaction, privacy, and crowding outcomes, so one design-exposure-pathway-outcome state could not represent the study.
Kaya & Erkip (2001) [59]	Türkiye	Cross-sectional dormitory survey	Floor height was the primary exposure; room occupancy was held equal and perceived crowding was an outcome	Perceived room size, perceived crowding, privacy, and dormitory satisfaction	No	Perceived crowding was an outcome rather than the exposure, and no mental-health endpoint was measured.
Hwang & Shrimali (2023) [62]	United States (San Francisco Bay Area)	Longitudinal database study with difference-in-differences and ecological COVID analysis	Gentrification was the primary exposure; transition into crowded housing was an intermediate/outcome state	Entry into crowded housing and area-level COVID-19 case rates	No	Crowding was not a mental-health exposure in the individual analysis, and no mental-health outcome or candidate psychological pathway was tested.
Lim-Soh et al. (2025) [63]	Singapore	Longitudinal panel study (four waves)	Objective floor area per occupant together with co-residence and access to private open space	Life satisfaction and spousal relationships	No	Privacy, stress, and household tension were discussed as explanations but were not measured as mediators, so the candidate-pathway dimension could not be assigned without inference.
Raynor et al. (2022) [64]	Australia (Victoria)	Longitudinal two-wave survey	Crowding embedded within a multidimensional subjective housing-inadequacy index	Self-reported mental-health deterioration	No	Crowding was embedded with privacy and use-of-space items in a housing-inadequacy mediator, so a crowding-specific exposure, pathway, and effect could not be separated from the composite.
Li et al. (2018) [66]	China (national, 25 provinces)	Cross-sectional national survey	Tenure and migrant status; extreme overcrowding (≤ 8 m ² /person) was the dependent variable	Extreme-overcrowding status; no mental-health outcome	No	The paper did not analyze a mental-health or psychosocial consequence of crowding and did not test a candidate pathway.
Lauster & Tester (2010) [67]	Canada (Nunavut case material)	Conceptual/methodological case analysis	Critical comparison of persons-per-room and Canadian National Occupancy Standard measures	No participant-level outcome analysis	No	It did not report a participant-level exposure-outcome analysis, so the design, population, candidate-pathway, and outcome coding dimensions were not applicable as a single empirical record.
Larcombe et al. (2011) [68]	Canada (two Manitoba First Nations communities)	Community-based mixed-method cross-sectional housing survey	Objective persons per room, household size, and temporary-visitor crowding	Housing conditions and tuberculosis/physical-health indicators; no mental-health outcome	No	No mental-health outcome or candidate psychological pathway was analyzed.

Table A3. *Cont.*

Study Identifier	Country/Region	Study Design	Exposure Type	Outcome Domain	Matrix	Study-Specific Audit Rationale
Riva et al. (2014) [69]	Canada (Nunavik, Québec)	Cross-sectional population-health survey	Objective household size, number of children, and >1 person per room	Allostatic-load composite of 14 physiological biomarkers	No	Stress pathophysiology was the conceptual explanation rather than a separately measured mediator, so the candidate pathway could not be distinguished from the physiological outcome.
McCain et al. (1976) [70]	United States (prison and county jail)	Observational field study combining individual and aggregate samples	Social density/housing type and square feet per person, measured differently in two facilities	Stress-related physical-illness complaint rates	No	The two samples used different units and exposure metrics, while psychological stress was inferred rather than measured; no single design–population–exposure–outcome record was available.
Megargee (1977) [71]	United States (Florida prison)	Ecological three-year prison-unit time series	Population size, square feet per person, population density, and temperature	Aggregate disciplinary misconduct	No	The outcome was aggregate misconduct and no participant-level candidate pathway was measured.
Schaeffer et al. (1988) [72]	United States (federal prison)	Cross-sectional observational prison study	Housing type jointly varying social density, architectural enclosure, and privacy, plus perceived crowding	Perceived crowding, illness complaints, and urinary catecholamines	No	The perceived, illness, and biochemical outcomes showed non-linear and partly inconsistent patterns, so neither a density-specific exposure nor one dominant pathway–outcome state could be isolated.
Mangrio & Zdravkovic [13] (2018)	Sweden	Cross-sectional	Objective	Distress	Yes	Crowded living conditions were recorded separately from accommodation type and stability, while mental ill-health was assessed with the GHQ-12; the migrant housing setting, cross-sectional design, population, residential crowding exposure, housing/sense-of-home context, and distress outcome were therefore identifiable for one analytic sample.
Riva et al. [14] (2014)	Greenland	Cross-sectional	Objective	Well-being	Yes	Household crowding and composition, perceived social support, and mental well-being were measured separately and the mediating role of social support was tested, making the Indigenous/Arctic setting, adult population, objective exposure, candidate pathway, and well-being outcome unambiguous.
Campagna [28] (2016)	United States	Cross-sectional	Subjective	Well-being	Yes	The family-housing context, adult population, crowding exposure, regulatory-control pathway, and well-being outcome were reported in one structural model and could be coded without combining independent samples.
Mejia-Castillo et al. [29] (2025)	Mexico	Cross-sectional	Subjective	Restoration	Yes	Because the adult family-housing sample, cross-sectional design, subjective exposure, restoration pathway, and restoration outcome were defined by separate validated scales within one model, all six coding dimensions were available.
Evans et al. [30] (1989)	India	Cross-sectional	Objective	Distress	Yes	Objective residential density, social support, and nonspecific psychological symptoms were measured separately, and social support was explicitly tested as a mediator; the setting, cross-sectional design, adult population, exposure, pathway, and distress outcome therefore formed a unique matrix record.

Table A3. *Cont.*

Study Identifier	Country/Region	Study Design	Exposure Type	Outcome Domain	Matrix	Study-Specific Audit Rationale
Yan [31] (2025)	China	Cross-sectional	Subjective	Sleep	Yes	Subjective well-being and self-perceived social status were tested as psychosocial mediators, so the subjective crowding exposure, candidate pathway structure, and sleep outcome were explicitly separable.
Liu et al. [33] (2021)	China	Cross-sectional	Objective	Depression	Yes	Depressive mood was measured independently with a standardized symptom scale; thus, family housing, cross-sectional design, adult population, crowding exposure, privacy-related pathway, and depression outcome were all directly codable.
Wang & Liu [34] (2023)	China	Cross-sectional	Subjective	Depression	Yes	Living-space-specific stress was examined separately from general life stress and CESD-10 depression, providing a clear family-housing setting, cross-sectional design, population, spatial-load exposure, regulatory-stress pathway, and depression outcome.
Pierse et al. [35] (2016)	New Zealand	Longitudinal	Objective	Distress	Yes	The family-housing setting, longitudinal design, adult population, objective crowding exposure, housing-control/tenure context, and distress outcome were explicitly distinguished, including the mixed cross-sectional and longitudinal result.
Ruiz-Tagle & Urria [36] (2022)	Chile	Longitudinal	Objective	Well-being	Yes	These objective overcrowding trajectories were analyzed against CES-D depressive symptoms, with loss of personal space, privacy, and environmental control specified as the relevant pathway; one longitudinal family-housing coding state was therefore available.
Evans et al. [43] (1998)	India	Cross-sectional	Objective	Behavioural	Yes	Persons-per-room crowding was recorded separately from blood pressure, learned helplessness, parent-child conflict, school behaviour, and academic performance; the objective exposure, physiological/interpersonal pathways, and behavioural outcome domain were therefore distinguishable within one cross-sectional child sample.
Solari & Mare [44] (2012)	United States	Cross-sectional	Objective	Behavioural	Yes	Caregiver-reported internalizing and externalizing behaviour, academic performance, and health were reported separately; because the two datasets supported the same population-exposure-family strain-behaviour coding structure, the article yielded one comparable matrix classification.
Chang & Chiang [48] (2022)	China	Longitudinal	Objective	Sleep	Yes	Household crowding and housing quality were distinguished from family functioning and maternal mental health, and path analysis related these variables to child sleep duration; the longitudinal family-housing setting, child population, objective exposure, pathway, and sleep outcome were explicit.

Table A3. Cont.

Study Identifier	Country/Region	Study Design	Exposure Type	Outcome Domain	Matrix	Study-Specific Audit Rationale
Lorentzen et al. [49] (2024)	Sweden	Qualitative	Subjective	Well-being	Yes	Participants consistently described confinement, lack of personal space, insecurity, family conflict, stress, and impaired child well-being and schooling, allowing the child-focused family-housing setting, qualitative design, perceived exposure, sense-of-home pathway, and well-being outcome to be coded clearly.
Tao et al. [50] (2016)	China	Cross-sectional	Subjective	Anxiety	Yes	The student-dormitory setting, population, subjective high-density exposure, control pathway, and anxiety outcome were defined by named measures in one sample.
Worsley et al. [51] (2023)	United Kingdom	Cross-sectional	Subjective	Depression	Yes	These variables provided a single shared/rental-housing record with an explicit student population, subjective accommodation exposure, social-support pathway, and depression outcome.
Baron et al. [52] (1976)	United States	Experimental	Objective	Social	Yes	Double- and triple-occupancy groups were compared on perceived crowding, control over room activities, privacy, interpersonal attitudes, and social adjustment, so the dormitory setting, experimental design, objective occupancy exposure, control pathway, and social outcome were all identifiable.
Clark et al. [53] (2012)	United States	Cross-sectional	Objective	Distress	Yes	The dormitory setting, comparative cross-sectional design, student population, objective occupancy exposure, perceived-control interpretation, and distress outcome were stated clearly; the null direction did not affect matrix eligibility.
Ronchi & Sparacino [54] (1982)	United States	Cross-sectional	Objective	Stress	Yes	Objective room occupancy was assessed alongside environmental appraisal, self-monitoring, blood pressure, heart rate, psychosomatic symptoms, and subjective well-being, providing one cross-sectional student sample with a clear density exposure, regulatory-control context, and stress outcome, despite null principal findings.
Yang Yongle et al. [55] (2018)	China	Experimental	Subjective	Well-being	Yes	Perceived crowding, subjective well-being, school belonging, and interpersonal relations were evaluated separately, making the dormitory setting, experimental design, student population, subjective crowding exposure, belonging/sense-of-home pathway, and well-being outcome codable within one study.
Ortega-Alcazar & Wilkinson [60] (2021)	United Kingdom	Qualitative	Subjective	Well-being	Yes	The shared/rental setting, qualitative design, adult female population, perceived housing constraint, sense-of-home pathway, and well-being outcome were therefore explicit in the thematic analysis.
Siddika & Badhan [61] (2026)	Bangladesh	Qualitative	Subjective	Well-being	Yes	Social interaction and support were analyzed as potential resources for subjective well-being, giving a clear shared-living setting, qualitative design, adult population, perceived crowding exposure, social-support pathway, and buffered well-being outcome.

Table A3. Cont.

Study Identifier	Country/Region	Study Design	Exposure Type	Outcome Domain	Matrix	Study-Specific Audit Rationale
Rast et al. [65] (2024)	Germany	Qualitative	Subjective	Well-being	Yes	Overcrowding, lack of privacy, entry controls, restricted autonomy, uncertainty, and feeling confined were linked to psychosocial health and well-being, so the reception-centre setting, migrant population, subjective exposure, perceived-control pathway, and outcome were all identifiable.
Costa Santos et al. [108] (2024)	United Kingdom	Qualitative	Subjective	Restoration	Yes	Privacy, agency, ownership, and restoration were reported as distinct experiences with consequences for well-being, yielding a clear family-home setting, qualitative design, child population, perceived spatial constraint, privacy pathway, and restoration outcome.
Rollings & Evans [80] (2019)	United States	Cross-sectional	Subjective	Physiological	Yes	Psychological distress, learned helplessness, and physiological stress markers were assessed as outcomes and design features were tested as moderators, making the family-housing setting, cross-sectional child sample, subjective crowding exposure, physiological-stress pathway, and physiological outcome explicit.
Sarkar et al. [112] (2021)	China	Cross-sectional	Objective	Depression	Yes	These spatial exposures were analyzed separately from PHQ-9 depressive symptoms and probable major depression, with crowding-related psychosocial stress and loss of privacy identified as the candidate pathway; the study supplied a coherent adult family-housing record.
Marsh et al. [113] (2019)	United Kingdom	Longitudinal	Objective	Behavioural	Yes	Strengths and Difficulties Questionnaire behavioural scores were analyzed alongside maternal stress, child sleep duration, and parent–child conflict and closeness as potential mediators, providing a clear longitudinal family-housing, child-population, objective-exposure, sleep/family pathway, and behavioural-outcome record.
Kawano et al. [114] (2016)	Japan	Cross-sectional	Objective	Sleep	Yes	Mean shelter space per evacuee was used to distinguish crowded from non-crowded shelters and was related to the daily incidence of clinically recorded sleep disturbance, making the emergency-shelter setting, adult evacuee population, objective spatial exposure, sleep pathway, and sleep outcome unambiguous.
Shimatani et al. [81] (2024)	Japan	Cross-sectional	Subjective	Well-being	Yes	Perceived spaciousness and restoration supplied the design-relevant pathway, so the family-housing setting, cross-sectional design, adult population, subjective spatial exposure, pathway, and well-being outcome were clearly reported.
Chan [118] (1999)	China	Cross-sectional	Subjective	Well-being	Yes	The analysis directly tested whether privacy and environmental satisfaction intervened between spatial constraint and residential well-being, allowing the family-housing setting, cross-sectional design, adult population, subjective crowding exposure, privacy pathway, and well-being outcome to be coded.

Table A3. *Cont.*

Study Identifier	Country/Region	Study Design	Exposure Type	Outcome Domain	Matrix	Study-Specific Audit Rationale
Morris et al. [123] (2022)	Australia	Qualitative	Subjective	Loneliness	Yes	Forced sharing, dwelling layout, common-space usability, co-tenant composition, and power differences were linked to opportunities for social connection and loneliness, providing a clear shared/rental setting, student population, perceived housing exposure, social-support pathway, and loneliness outcome.
Neethu et al. [124] (2018)	India	Cross-sectional	Subjective	Well-being	Yes	Residential crowding, perceived control, and subjective well-being were measured as separate variables and mediation analysis tested perceived control between crowding and well-being; all six coding dimensions were therefore directly available from one student sample.
Perreault et al. [104] (2020)	Canada	Cross-sectional	Subjective	Well-being	Yes	Multilevel analysis retained households and communities explicitly, making the Indigenous/Arctic setting, cross-sectional design, adult population, crowding exposure, sense-of-home pathway, and well-being outcome unambiguous.
Yin et al. [125] (2025)	China	Cross-sectional	Objective	Distress	Yes	Family communication and emotional support and neighbourhood social cohesion were analyzed as potential buffers, providing one adult family-housing record with an objective exposure, social-support pathway, and distress outcome.
Fuller et al. [82] (1996)	Thailand	Cross-sectional	Objective + subjective	Well-being	Yes	The analysis explicitly tested subjective crowding as the process through which objective density affected distress, unhappiness, irritability, and suicidal ideation, so the combined exposure and perceived-control/appraisal pathway were fully codable.
Evans et al. [128] (2001)	United States	Cross-sectional	Objective	Behavioural	Yes	Because both samples shared the family-housing setting, child population, objective exposure, control/helplessness pathway, and behavioural outcome structure, the article supported one harmonized matrix classification.
Wells & Harris [129] (2007)	United States	Longitudinal	Objective	Distress	Yes	Changes in housing quality and crowding, social withdrawal, and psychological distress were measured separately, and social withdrawal was tested as a mediator; the family-housing setting, longitudinal design, female population, objective exposure, social-relational pathway, and distress outcome were therefore clear.
Yang Zhu [130] (2017)	China	Cross-sectional	Subjective	Well-being	Yes	The single family-housing sample and cross-sectional analysis provided an explicit subjective housing exposure, perceived housing control/satisfaction pathway, and well-being outcome, allowing all six dimensions to be assigned without combining studies.

Table A3. Cont.

Study Identifier	Country/Region	Study Design	Exposure Type	Outcome Domain	Matrix	Study-Specific Audit Rationale
Sirikul et al. [131] (2022)	Thailand	Cross-sectional	Objective	Distress	Yes	Household members and number of rooms supplied the crowding information, while unequal household chores, caregiving pressure, negative lockdown experiences, and maternal mental-health symptoms were measured separately, yielding a clear family-strain pathway and distress outcome in one maternal sample.
Weber et al. [132] (2024)	United Kingdom	Cross-sectional	Subjective	Aggression	Yes	It tested the sequential relationship from limited space through privacy control and crowding to aggression, making the adult family-housing setting, cross-sectional design, subjective exposure, privacy-loss pathway, and aggression outcome directly codable.
Guo et al. [133] (2025)	China	Cross-sectional	Objective	Behavioural	Yes	Residential crowding and housing expenditure were analyzed separately from health, social support, parenting burden, and reported corporal punishment, giving a clear family-housing setting, parent population, objective housing exposure, family-strain pathway, and behavioural outcome.
Pepin et al. [134] (2018)	Canada	Longitudinal	Objective	Depression	Yes	Household overcrowding was measured as people per room and adolescent psychological distress was operationalized as depressive symptoms and suicidal thoughts; the longitudinal Indigenous/Arctic setting, child population, objective exposure, family-housing stress pathway, and depression outcome were explicit, including the null result.
Simard et al. [135] (2024)	Canada	Cross-sectional	Objective	Well-being	Yes	Overcrowding was defined as more than one person per room and perceived social support was measured independently and analyzed by age and gender, providing an unambiguous Indigenous/Arctic setting, adult population, objective exposure, social-support pathway, and psychosocial well-being outcome.
Cox et al. [136] (1984)	United States	Cross-sectional	Subjective	Physiological	Yes	For the structured matrix, the inmate field component supplied a coherent institutional setting, prisoner population, subjective crowding exposure, cognitive-strain/control pathway, and physiological outcome, while the broader archival findings remained interpretive context.
Ruback et al. [137] (1986)	United States	Cross-sectional	Subjective	Stress	Yes	The common institutional setting, cross-sectional design, prisoner population, subjective exposure, control pathway, and stress outcome allowed a harmonized article-level matrix code.
Lawrence & Andrews [138] (2004)	United States	Cross-sectional	Subjective	Aggression	Yes	Perceived crowding, personal-space preference, stress, arousal, psychological well-being, and interpretations of aggressive events were measured separately, making the institutional setting, prisoner population, subjective exposure, control/stress pathway, and aggression outcome explicit.

Table A3. Cont.

Study Identifier	Country/Region	Study Design	Exposure Type	Outcome Domain	Matrix	Study-Specific Audit Rationale
Baum & Gatchel [139] (1981)	United States	Experimental	Subjective	Distress	Yes	Perceived crowding, attributions of control, reactance, and learned helplessness were repeatedly assessed, providing a clear student-dormitory setting, experimental design, subjective exposure, perceived-control pathway, and distress/helplessness outcome.
Walden et al. [140] (1981)	United States	Cross-sectional	Subjective	Aggression	Yes	Privacy values and expectations, locus of control, aggression, withdrawal, environmental attitudes, and roommate responses were measured separately, allowing the student setting, cross-sectional design, subjective crowding exposure, privacy-loss pathway, and aggression/coping outcome to be assigned from the full text.

Table A4. Summary of database searches and supplementary identification procedures.

Information Source	Search Date (Reported Precision)	Coverage and Search Fields	Language and Document-Type Restrictions	Records Retrieved
Scopus	3 April 2026	Database inception to 3 April 2026; title, abstract, and keyword fields; complete search string in Supplementary Material S1.	Recorded as no database-level language or document-type filters	Database-specific count not retained; combined database total = 932
PubMed	3 April 2026	Database inception to 3 April 2026; title/abstract, MeSH terms and controlled vocabulary where available; complete search string in Supplementary Material S1.	Recorded as no database-level language or document-type filters	Database-specific count not retained; combined database total = 932
Web of Science Core Collection	3 April 2026	Database inception to 3 April 2026; topic field in Web of Science Core Collection; complete search string in Supplementary Material S1.	Recorded as no database-level language or document-type filters	Database-specific count not retained; combined database total = 932
CNKI	3 April 2026	Database inception to 3 April 2026; subject, topic, title, and keyword fields; complete search string in Supplementary Material S1.	Recorded as no database-level language or document-type filters	Database-specific count not retained; combined database total = 932
Citation tracking and related-record searches	3 April 2026	Backward reference checking of all included studies and relevant reviews; forward citation tracking in Scopus and Web of Science; database-native related-record searches.	Same eligibility criteria as database searches	34

Table A5. Characteristics of the coded evidence matrix (n = 48 fully coded studies).

Characteristic	Category	Studies (n = 48)
Residential setting	Family housing	26 (54%)
	Student dormitory	8 (17%)
	Indigenous/Arctic	4 (8%)
	Shared/rental	4 (8%)
	Migrant/refugee/temporary	3 (6.3%)
	Institutional/prison	3 (6%)
Study design	Cross-sectional	33 (68.8%)
	Qualitative	6 (12.5%)
	Longitudinal	6 (12.5%)
	Experimental	3 (6.3%)

Table A5. Cont.

Characteristic	Category	Studies (n = 48)
Study population	Adults	22 (46%)
	Students	10 (21%)
	Children	9 (19%)
	Prisoners	3 (6%)
	Migrants	2 (4%)
	Mothers	1 (2%)
	Women	1 (2%)
Macro-region	North America	16 (33.3%)
	East Asia	13 (27.1%)
	Europe	8 (16.7%)
	South Asia	4 (8.3%)
	Oceania	2 (4.2%)
	Latin America	2 (4.2%)
	Southeast Asia	2 (4.2%)
	Arctic	1 (2.1%)
Crowding exposure	Subjective	26 (54%)
	Objective	22 (46%)
Reported direction	Adverse	38 (79%)
	Buffered	4 (8%)
	Mixed	3 (6%)
	Null	3 (6%)

Hierarchical composition of the residential-crowding evidence base



Figure A1. Hierarchical composition of the coded evidence matrix by macro-region, residential setting, and study population (n = 48). Ring angle is proportional to the number of coded studies.

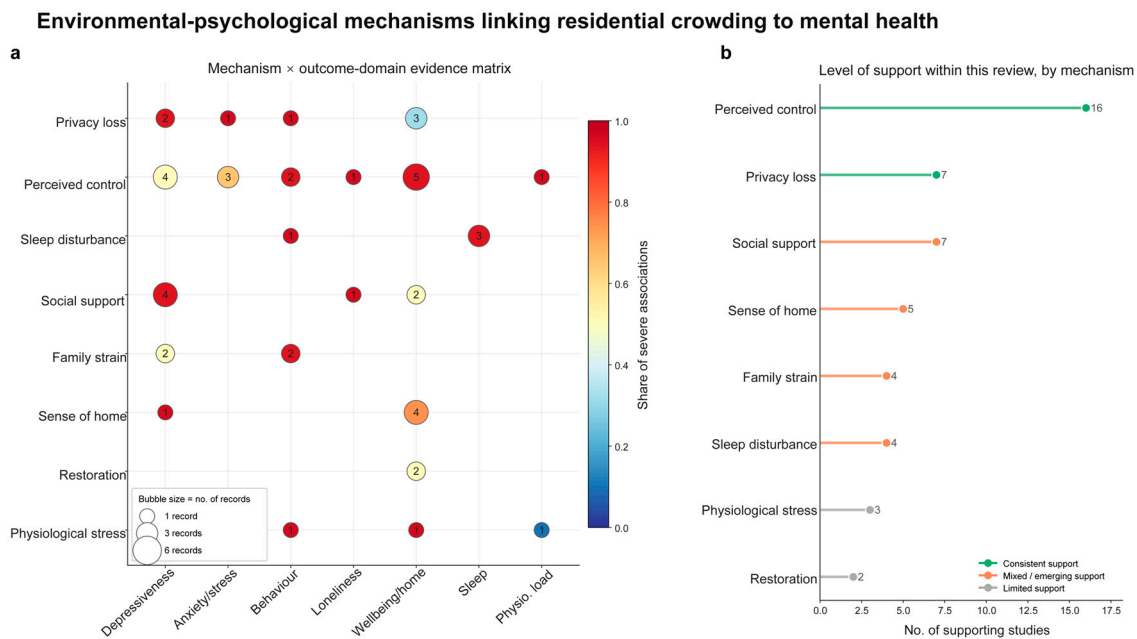


Figure A2. Environmental-psychological mechanisms linking residential crowding with mental-health and psychosocial outcomes. (a) Mechanism-by-outcome evidence matrix; bubble size represents the number of coded records and colour represents the descriptive proportion reporting adverse associations. These aggregated patterns do not imply equivalent effect magnitudes or culturally uniform mechanisms across settings. (b) Relative level of support for each mechanism within the review.

Across the 48 coded studies, overall risk of bias was judged Low in 6, of Some concern in 7, and High in 35, the last driven chiefly by the cross-sectional designs that limit temporality and confounder control. This profile is the basis for the cautious, association-level language used throughout.

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