

Article

Insights into Agricultural Machine Injuries in Pakistan: An Orthopedic Surgeons Survey (2022–2023)

Mian Muhammad Sajid Raza ¹, Zamir Hussain Tunio ², Ikram Din Ujjan ³ and Salah F. Issa ^{1,*} 

¹ Department of Agricultural and Biological Engineering, University of Illinois at Urbana-Champaign, Urbana, IL 61801, USA; mmraza2@illinois.edu

² Department of Orthopedic Surgery and Traumatology, Liaquat University of Medical and Health Sciences (LUMHS), Jamshoro 76090, Pakistan; drzamirhussain@gmail.com

³ Department of Pathology and Office of Vice Chancellor, Liaquat University of Medical and Health Sciences (LUMHS), Jamshoro 76090, Pakistan; ikramujjan@lumhs.edu.pk

* Correspondence: salah01@illinois.edu

Abstract: As one of the most perilous industries, agriculture presents both fatal and non-fatal risks to farmers. Pakistan, a notable Asian nation, heavily depends on agriculture, which constitutes 23% of its GDP and employs 37.4% of its workforce. The study investigates the challenges within Pakistan's agriculture sector and enriches the existing literature by gathering data on agricultural machine-related injuries in Pakistan during 2022–2023. The survey, conducted from November 2022 to April 2023, involved 55 respondents, predominantly from Sindh and Punjab. The findings indicate a total of 507 injuries, with approximately a quarter being fatal (121 incidents). Sindh emerges as a significant hotspot, with the majority of injuries documented there. With respect to the key sources of injuries, the fodder cutter is a primary source of injuries with 201 injuries documented, accounting for approximately 40% of all injuries. Threshers contributed to 197 injuries, approximately 39% of the total, and about 52 are tractor-related injuries, making up about 10% of machine injuries. Regarding the severity and demographics of injuries, about 38% of cases involve amputation, with a higher incidence among males (77%) and individuals aged 15–34 years (65%). It is important to acknowledge the study's limitations, including a small participant pool and a brief data collection period. This research advocates for safety regulations, accident reduction measures, and increased safety awareness among farmers, aiming to foster a safer and more sustainable agricultural environment in Pakistan.



Citation: Raza, M.M.S.; Tunio, Z.H.; Ujjan, I.D.; Issa, S.F. Insights into Agricultural Machine Injuries in Pakistan: An Orthopedic Surgeons Survey (2022–2023). *Safety* **2024**, *10*, 55. <https://doi.org/10.3390/safety10030055>

Academic Editor: Raphael Grzebieta

Received: 2 April 2024

Revised: 20 June 2024

Accepted: 21 June 2024

Published: 25 June 2024



Copyright: © 2024 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

Keywords: machinery injuries; survey; fodder cutter; thresher; amputation; safety awareness; Pakistan; Sindh; Punjab

1. Introduction

The agriculture sector employs one-third of the global population, ranking as the second-largest source of employment worldwide [1]. In developing nations, agriculture accounts for 44% of the total employment share [2]. Agriculture is one of the most perilous sectors, causing fatal and non-fatal injuries [3]. In a 2014–2015 study by the Pakistan Bureau of Statistics, agriculture was listed as the most hazardous industry, accounting for 48% of all injuries and diseases. Construction ranked second, with 16.3% of all injuries [4]. More recently, agriculture represented 29.3–38.6% of all occupational injuries in Pakistan from 2018–2021 [5]. In terms of research publications, there has been a series of papers published by doctors and researchers on fodder cutter-related injuries. Ch. et al. [6] reported 73 fodder cutter injuries over a 15-month period in an emergency department in southern Punjab. In 2018, a three-year study reported 196 fodder cutter injuries in Sialkot and another study reported 75 injuries over six months in Bahawalpur [7,8]. In 2021, fodder cutter injuries were documented in Hyderabad (56 cases over 1 year), Lahore (30 cases over 6 months), and Khairpur (193 cases over 32 months) [9–11]. While the number of fodder cutter injuries

is troubling, there are no recent studies investigating the frequency of fodder cutter injuries with respect to other agricultural machine injuries.

The only recent study documenting the agent of injury in Pakistan was conducted by Rabbani et al. [12] in 2018. They conducted a survey of rural councils in Hyderabad and documented injuries according to severity, type of injury, and the agent of injury. They estimated the occupational injury incident rate to be approximately 35 incidents per 100 workers per year. The majority of these injuries were due to hand tools (71%), were cuts (70%), and were moderate (58%). Only 2% of incidents were caused by machines and 1% involved amputations [12]. This survey was conducted in 2013 over a three-month period and injury statistics were obtained for up to six months prior to interviews. In a study conducted in India, the major sources of injuries were fodder cutters, tractor rollovers, hand tools, falls from trolleys, sugarcane crushers, animal attacks (including snake bite cases and bull attacks), falls from combine harvesters, and unintentional entanglement [13]. The fatality rate of agriculture in South-East Asia remained high (27.5) compared to Europe (17.01) and America (8.7) [14]. There are a variety of reasons associated with high injury rates in agriculture in comparison to the general population [13,15–17]. The prevalence of small-sized and family-run farms contributes significantly to the risk landscape, as does the diverse range of outdoor activities undertaken by operators, necessitating the use of various tools and equipment. The reliance on outdated tractors and machinery further exacerbates the risk, as these often lack compliance with safety regulations and modern technical solutions. The widespread use of plant protection products and chemicals, along with the physically demanding nature of the work conducted in extreme environmental conditions, creates a challenging occupational environment [15]. Lastly, the isolation experienced at workplaces, coupled with a low level of training among workers, further amplifies the occupational hazards faced by agricultural workers, resulting in a heightened risk of accidents and injuries [8,15,16,18].

The agriculture sector in Pakistan makes up about 23% of the GDP and provides employment for 37.4% of the national labor force [19]. The major crops include cotton, wheat, sugarcane, rice, and maize. The crop seasons include “kharif”, which is during the summer months (May to November) and is when rice, corn, cotton, and sugarcane are grown. The Rabi season ranges from December to April and is when wheat, barley, and millet are grown [20]. To cope with its agricultural needs, Pakistan has relied on agriculture mechanization. For example, the number of tractors used in the 1990s was 150,000 and the number rose to 400,000 in early 2000 [21]. In addition, there were a total of 6000 combine harvesters and 137,000 threshers in use by 2004.

While the use of specialized machines has transformed agriculture, it has also introduced risks, leading to severe injuries and fatalities among farm workers. The majority of these injuries could be prevented by adhering to safe operating practices. Unfortunately, a significant challenge arises as many farm workers, often lacking literacy, do not follow safety instructions. In addition, a lack of orthopedic and plastic surgeons increases the risk of injury mismanagement, leading to amputations in most cases. These amputations lead to significant social, cultural, and financial losses [12]. In a recent literature review of agricultural injuries in Asia, the primary causes of agricultural injuries were tractors (38%), hand and power tools (23%), and harvesting machinery (13%) [22]. There is a need to understand machine injury trends in Pakistan to develop targeted research programs, new safety awareness, or regulation campaigns to reduce machine injuries. This research adds to the literature by conducting a nationwide survey to collect data on injuries related to agricultural machines in Pakistan.

2. Materials and Methods

A survey of orthopedic surgeons was conducted to analyze the pattern of agricultural machine injuries in each district of Pakistan. Orthopedic surgeons were selected as the survey participants due to their recent work in documenting agricultural injuries [6–11].

2.1. Survey Instruments

A survey questionnaire was developed using the university's registered software, the Qualtrics CoreXM package, which enables users to create questions and analyze collected data [23]. The questionnaire was structured following previous studies using survey experiments [24]. The survey consisted of 8 questions. All questions were programmed within the survey software to be mandatory, necessitating participants to answer each question before proceeding to the next phase of the survey. Input validation features within Qualtrics were utilized to ensure respondents provided a response to every question in order to proceed with the survey. The study required the participants to be 18 years of age or older. This serves as the primary criterion participants must meet to commence the survey. The first question was if they had treated any agricultural-related injuries in the last six months. If the participant responded "no", indicating no agriculture-related injuries, the surgeons were prompted to answer two questions regarding the hospital's province and the surgeon/physician's department before marking the survey as complete. If the participant responded "yes" to the first question, the survey continues after asking questions on district and department. The participants were asked:

- How many farm-related injuries occurred to each operator/worker from November to April?
- How many of the agriculture patients you receive were (age group)?
- How many of the agriculture patient you receive were due to (source of injury)
- How many of the agriculture patient you receive were due to (type of injury)?

Each of these questions were set up in a matrix format with the options (such as age group) listed in Table 1. The options were developed through consulting the literature reports from Pakistan and a global literature review conducted recently [6,9,11,22]. Each of the options was listed as a column, with either gender (for source, type, and age questions) or fatality (for the month question) in the row, and participants were requested to complete the matrix. Month options were reduced to six months to reduce the impact of recollection bias. Privacy and confidentiality were rigorously maintained by anonymizing the data under IRB guidelines.

Table 1. Questionnaire includes provinces, hospital department, sex, fatal/non-fatal, source and type of injury, age of injured person, and month.

Province	Department	Gender	Fatality	Source of Injury	Type of Injury	Age Group	Month
Sindh	Emergency	Male	Yes	Fodder cutter	Laceration	0–4	November
Punjab	Orthopedic	Female	No	Thresher	Amputation	5–14	December
Balochistan	Other			Tractor	Fracture	15–24	January
Khyber Pakhtunkhwa				Tractor Trolley	Crushed	25–34	February
Gilgit				Power takeoff	Burns	35–44	March
				Hand tools	Bruise	45–54	April
				Portable cutter	Cut	>55	
				Other	Sprain		
					Pinch		
					Other		

2.2. Recruitment

The target population for the survey was orthopedic or emergency room surgeons who might have been exposed to agricultural injuries in their operation rooms. Surgeons were instructed to report on all injured farm workers they handled in their hospitals between November 2022 and April 2023. This survey was sent out to a list of 200 registered Orthopedic Surgeons using Qualtrics, representing about 20% of all registered orthopedic surgeons in Pakistan (1100) according to the Pakistan Orthopedic Association (POA)'s press release in 2019 [25]. The survey was sent out by surgeons at the Liaquat University of Medical & Health Sciences (LUMHS) to encourage participation.

2.3. Survey Delivery

To encourage respondents, the survey link was emailed, and two reminders were sent to participants to complete the survey between May 2023 and July 2023. A total of 55 surveys were completed: 62% of the respondents were from the Sindh region, 18% were from Punjab, 11% were from KPK, 7% were from Baluchistan, and 2% were from Gilgit. In addition, 80% of respondents were surgeons associated with the Orthopedic department, 9% were with the Medical Emergency Unit, and 11% were associated with other units such as general surgery.

2.4. Data Analysis

Data analysis included documenting the average, mean, percentage, and total for each variable listed in Table 1. Linear regression analysis was conducted on each of the matrix variables to assess any potential correlation. This included evaluating the correlation between the number of injuries reported (in a given month) and the fatality rate. Microsoft Excel was used for the data analysis, including descriptive statistics of type and source of injury, the demographic traits of injured workers, and the variation in fatality rates across different provinces and months. ArcGIS Pro mapping techniques were used to conduct spatial analysis to identify hotspots (districts) in each province of Pakistan.

2.5. Datasets

Data on the population of farm workers were obtained using the 2010 Pakistan Agricultural Census, which documents the number of farm members over the age of 10 engaged in agriculture (the latest data available on the farming population are based on the 2010 Pakistan Agricultural Census) [26]. The data for the number of hospitals in Sindh and Punjab were extracted from the Bureau of Statistics, which were made available in 2022 and 2023, respectively, whereas the numbers of hospitals for Baluchistan and KPK were obtained from the Directorate General of Health, which was published on 28 April 2017 [27,28]. For districts where the farm worker population was missing in the census data, it was noted in the table. Another approach could use nearby farm population data based on previous work [29].

2.6. IRB Approval

In this work, the survey checklist was submitted to the Office for the Protection of Research Subjects at the University of Illinois Urbana-Champaign, and it was determined as exempted because it was not research on human subjects and does not require IRB approval (IRB#23788) [30].

3. Results

A total of 55 respondents participated in the survey, representing a survey completion rate of 27.5%, in line with other survey efforts [24]. The majority of responses were from Sindh, followed by Punjab. A limited number of respondents completed the survey from the Baluchistan and Khyber Pakhtunkhwa provinces. A total of 507 injuries were documented, with approximately one quarter being fatal (121 incidents). The fatality rate was dependent on the month of injury, with an 8.2% fatality rate in December (54 cases) vs. 33.3% in April (129 cases). The fatality rate was correlated ($R^2 = 0.81$) with the number of injuries documented in a given month. The larger the number of injuries documented in a given month, the higher the fatality rate was. The overall fatality rate was 23.91%, with Quetta reporting 51 fatalities (86% fatality rate).

3.1. Major Sources of Injuries

The largest source of injuries reported were fodder cutters, mainly used for chopping feed for animals, with 201 out of 507 injuries documented, accounting for approximately 40% of all machine-related injuries. The second largest source was threshers, mainly used for wheat harvesting, contributing to 197 injuries, which is approximately 39% of total

injuries. There were about 52 tractor- and implement (PTO and trolley)-related injuries, making up about 10% of all injuries. Subsequently, tools and cutters (hand tools and portable cutters) used for manual harvesting such as picking, cutting, or collecting crops by hand accounted for 41 injuries, constituting approximately 8% of all injuries. There were considerable differences in the source of injury by district (Figure 1). For example, fodder cutters represented 80% or more of injuries in Khairpur and Jhang, while representing less than 10% of injuries in Quetta and Diamer. Threshers represented over 60% of injuries in Nawab Shah, Quetta, and Karachi. Tractors and Implements were approximately 50% of injuries in Badin and Diamer (Gilgit).

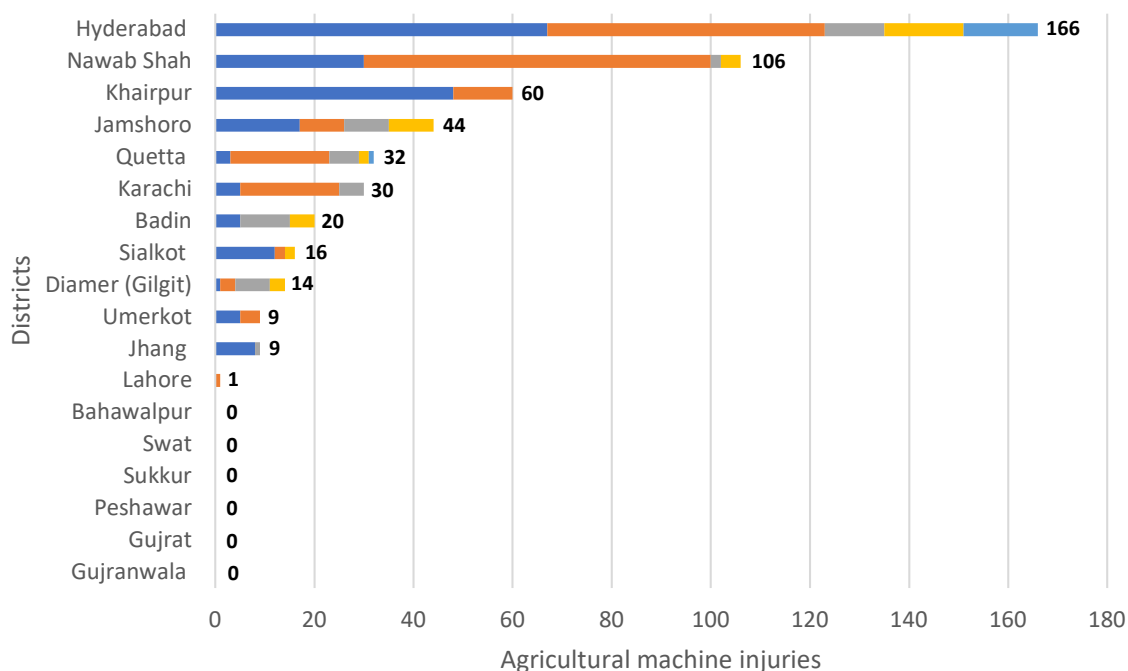


Figure 1. Number of fatal and non-fatal agricultural machine injuries by district and source of injury in Pakistan (November 2022–April 2023).

3.2. Visualization of Injuries by District in Pakistan

Figure 2 displays a map of Pakistan, illustrating a total of 507 reported agricultural machine injuries over the six months. As for districts, Hyderabad contributed 166 injuries, constituting 32.74% of all injuries. The second-highest number of injuries is in Nawab Shah with 106 injuries, making up 20.90% of the total, followed by Khairpur with 60 injuries, which was 11.83% of the total. The fourth highest occurrence of injuries was in Jamshoro with 8.67%. Other districts such as Peshawar, Bahawalpur, Gujranwala, Gujrat, Sukkur, and Swat reported no injuries. It is important to note that these numbers are whole numbers and do not take into account the number of respondents. For example, the survey received 16 respondents from Hyderabad, while only receiving one from Badin, Jhang, and other districts. In addition, the number of respondents varied widely by province, with Sindh accounting for 62% of all respondents, Punjab followed with 18% (10 respondents), KPK with 11% (six respondents), Baluchistan with 7% (four respondents), and Gilgit with 2% (with one respondent). This can be compared with the farming populations for each province, with Sindh, Punjab, KPK, and Baluchistan each accounting for 37%, 43%, 11%, and 8% of the overall number of farms, respectively (Table 2). The surveys collected represent 18 out of 166 districts in Pakistan. These districts contain 31% of all farmers in Pakistan (Table 3). The percentage of livestock farmers in these districts was 29%, slightly lower than national levels (32%). The number of hospitals and trauma centers for each district was also documented. Given the prominence of fodder cutter injuries, the percentage of livestock farms was calculated and documented in Figure 3.

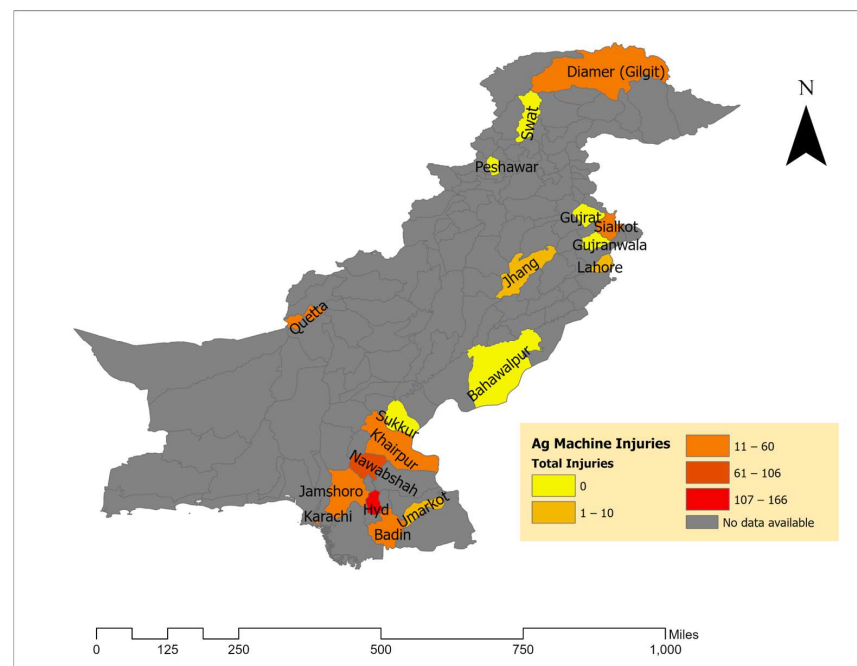


Figure 2. Map of the districts of Pakistan with the number of agricultural machine injuries reported over a six-month period.

Table 2. Agricultural farming population according to the 2010 Agricultural Census in Pakistan [26].

Province	Farm Family Workers	Livestock Family Workers	Hired Workers	Total
Punjab	5,296,964	2,008,041	20,400,250	27,705,255
Sindh	3,553,909	2,722,747	5,206,730	11,483,386
KPK	1,554,608	353,876	2,523,520	4,432,004
Baluchistan	1,039,588	352,741	539,928	1,932,257
Total	11,445,069	5,437,405	28,670,428	45,552,902

Table 3. Agricultural machine injury per district in Pakistan. Table includes number of surgeons who completed the survey, surgeons who reported more than 0 injuries, number of hospitals with trauma centers in each district [27,28], and farm owner/worker population based on the 2010 census [26].

Districts	Number of Injuries	Survey Respondents	Survey Respondents with >0 Injuries Reported	Number of Government Hospitals with DHQ and Emergency Department	Number of Trauma Centers	Family Workers	Hired Workers
Quetta	32	4	3	2	0	18,708	
Karachi	30	3	1	11	3	20,152	6774
Hyderabad	166	16	8	9	1	137,996	108,645
Jamshoro	44	4	2	4	0	61,928	19,858
Gilgit	14	1	1	5	1	*	*
Nawab Shah	106	3	3	2	0	317,336	165,492
Khairpur	60	3	2	2	0	808,887	392,068
Badin	20	1	1	5	0	284,789	98,009
Sialkot	16	2	2	8	0	475,123	146,692
Umerkot	9	1	1	5	0	278,697	221,074
Jhang	9	1	1	8	1	564,534	362,310
Lahore	1	3	1	72	0	181,790	255,286
Gujranwala	0	1	0	21	0	345,058	428,256
Gujrat	0	1	0	16	1	320,221	147,724

Table 3. Cont.

Districts	Number of Injuries	Survey Respondents	Survey Respondents with >0 Injuries Reported	Number of Government Hospitals with DHQ and Emergency Department	Number of Trauma Centers	Family Workers	Hired Workers
Peshawar	0	2	0	4	1	211,508	173,411
Sukkur	0	3	0	4	2	242,026	53,513
Swat	0	4	0	1	0	279,716	150,927
Bahawalpur	0	2	0	12	0	547,729	534,173
Total	507	55	26	191	10	5,118,472	3,264,212

Different colors indicate the provinces of Pakistan: blue signifies Punjab, yellow denotes Sindh, and white shows both KPK and Baluchistan. * Gilgit farm worker population was not documented by Pakistan's 2010 Agricultural Census [26].

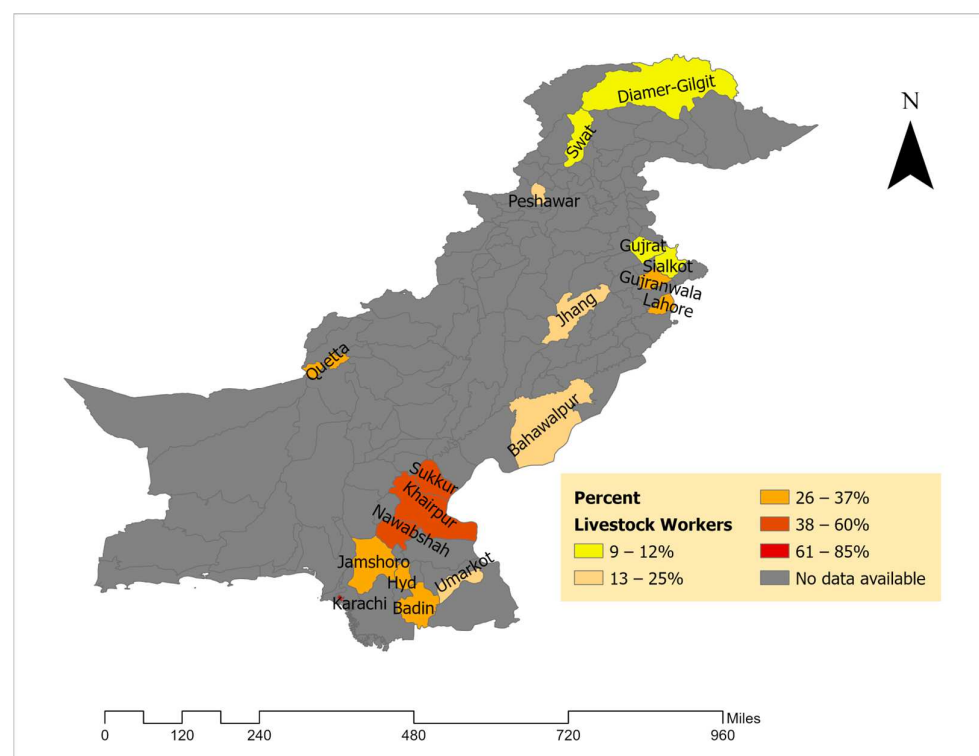


Figure 3. Map representing the percentage of livestock family workers as a percentage of the total number of family workers by district based on the 2010 Pakistan Census [26].

3.3. Nature of Agricultural Injuries

The analysis in Figure 4 reveals that out of 507 cases, 194 were associated with amputation, accounting for 38.26% of all injuries. Hyderabad reported the highest number of amputation cases at 55, with an amputation rate of 35%. In terms of rates, approximately 80% of all Khairpur incidents ended in amputation and approximately 50% in Karachi, Jhang, and Umerkot were amputations. The second largest category of injury was fracture-related cases, totaling 117, representing 23.08% of cases. Nawab Shah reported the highest number of fractures at 50 (~37%). Lacerations/cuts were the third largest with 106 incidents (20.90%), and both Hyderabad and Nawab Shah reported the highest number, at 26 cases each, out of all of the districts in Pakistan.

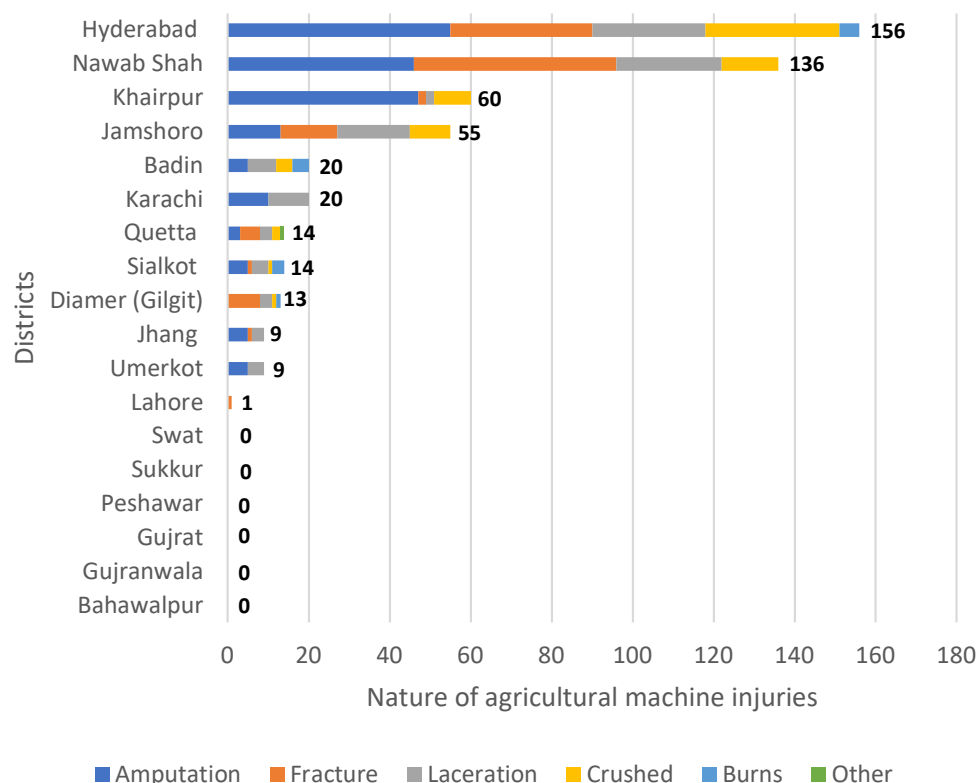


Figure 4. Number of fatal and non-fatal agricultural machine injuries by districts and nature of injury in Pakistan (November 2022–April 2023).

The last main category for nature of injury was crushing-related injuries, totaling 74 cases, with Hyderabad contributing 33 cases, making up 44.59% of the total among all districts. Burns accounted for 13 cases, while other injuries were reported in one case.

3.4. Agricultural Machine Injuries by Gender and Age

Figure 5 illustrates that out of 507 cases, 388 were males, accounting for approximately 77%, while females constituted 119 cases, representing about 23%. Hyderabad emerged as the highest contributor, with 116 injured males (about 74%) and 40 injured females, which amounted to more than 25%. The second-highest contributor was Nawab Shah, with a total of 136 injuries, including 102 males and 34 females (75% and 25%, respectively). In incidents in Jhang and Karachi, female incidents represented 50% or more of the injuries. In Jamshoro, about 42% of all injuries occurred in females.

Figure 6 shows that a substantial number of injuries occurred in the youth, with approximately 40% of injuries occurring to those under the age of 25. In addition, young adults (age 25–34), represented about 35% of all injuries. Only 1.4% of all incidents occurred to farmers over the age of 55. While there were trend differences by district, due to limited data, these were hard to discern. Of the 415 incidents where the age was known, 99 affected individuals were females, constituting about 24% of these cases. Female incident trends were similar to overall trends, with approximately 38% of females being under the age of 25 and 33% were young adults (aged 25–34). Only 1% of female incidents were in those over the age of 55.

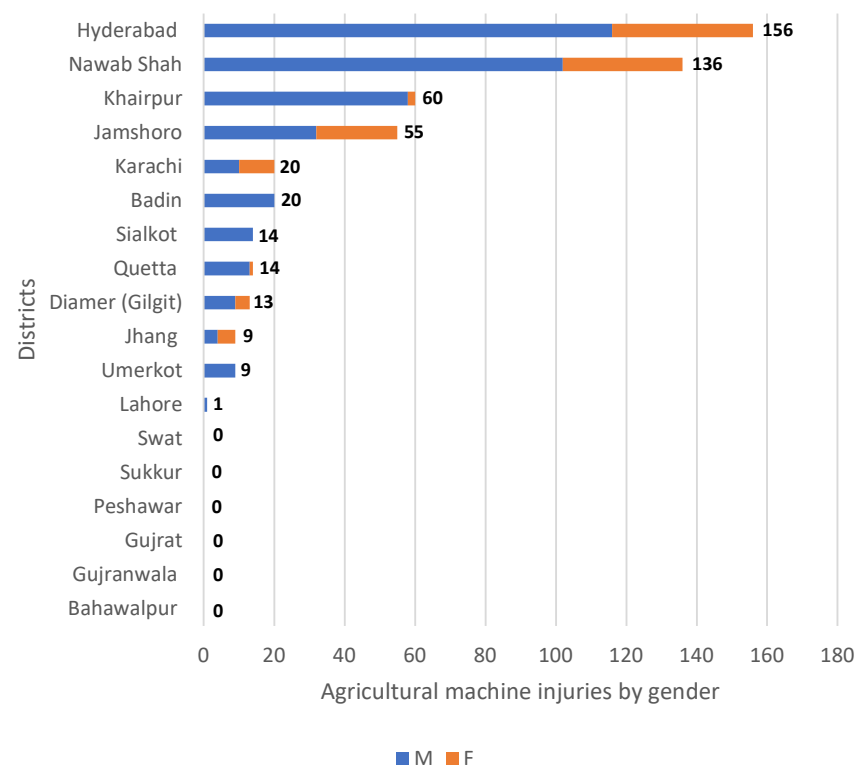


Figure 5. Agricultural machine injuries by gender (Male or Female) (November 2022–April 2023).

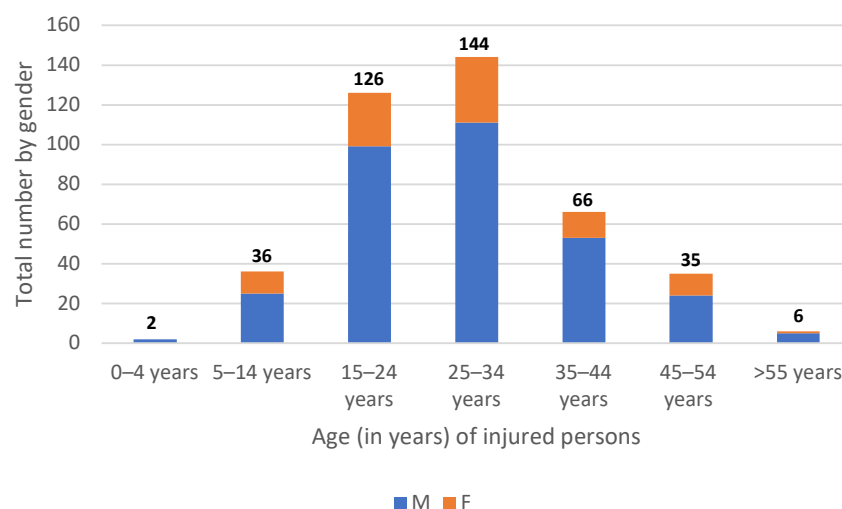


Figure 6. Agricultural machine injuries across age by gender (November 2022–April 2023). Gender and age were not specified in 92 cases.

4. Discussion

The survey conducted to analyze agricultural machine injuries in various districts of Pakistan offers valuable insights into the sources, nature, and demographics of these injuries. With a total of 55 respondents, the majority of responses were from Sindh, followed by Punjab. Based on the findings of Rabbani et al. [31], the adoption of mechanized agricultural methods has boosted agricultural productivity in Pakistan; however, it also increased traumatic injuries among agricultural workers. Fodder cutter injuries are now emerging as a prominent cause of morbidity in this group, affecting both genders across all age ranges, with male counterparts being predominantly affected. Many of these injuries involve

complete digit or hand amputations, necessitating specialized microvascular services for their management [31].

4.1. Type of Equipment

The primary sources of agricultural machine injuries identified in the survey include fodder cutters, threshers, tractors and implements (power takeoff and tractor trolley), and tools and cutters (hand tools and portable cutters). Fodder cutters and threshers emerged as the leading causes, collectively responsible for nearly 80% of reported injuries. The substantial number of fodder cutter injuries corroborates the prior literature that highlight a considerable number of fodder cutter injuries in Pakistan [27,28]. Most of these studies were conducted by surgeons and they reported an average of 77 fodder incidents per year (st. dev 36.2). In comparison, the number of fodder cutter injuries in this study ranged from 0 to 42 incidents per report for a six-month period. This study's finding supports that some emergency hospitals are reporting considerable numbers of fodder cutter injuries. Fodder cutter injuries also appear to be a concern among developing nations, with 47 injuries occurring in Kenya, 36 in India, and 55 in Nepal [32–34]. In a literature review conducted by Kumar et al. [35] in 2000, fodder cutter injuries represented 6% and 11% of all machinery injuries in Pakistan and India, respectively, in the 1980s. Threshers accounted for 16% and 2% of injuries in Pakistan and India, respectively. Tractors accounted for 31% and 5% of injuries in Pakistan and India, respectively [35]. A more recent study in India by Chopra et al. [13] found fodder cutters caused the highest proportion of injuries at 29.4%, followed by tractors at 25.7% [13]. The difference in injury trends could be a reflection of the changing landscape over time (1980s vs. 2020s). There are two types of fodder cutters: manual and electric. Electric motor-controlled machines are currently more commonly used and can cause more severe injuries. The introduction of electric motors has led to a higher incidence of traumatic injuries related to agriculture [9]. It is unclear when electric motor-controlled fodder cutters in Pakistan became more prevalent and this might explain the difference between the results of this survey and Kumar et al. [35].

4.2. Injury Distribution by District

Figure 2 illustrates the distribution of injuries across different districts in Pakistan, revealing agricultural injury concentrations in Hyderabad, Nawab Shah, and Jamshoro. One would expect higher fodder cutter injuries in Sindh compared to the other provinces because this province has more livestock holders [26], and fodder production in Sindh and Punjab was 654,760 vs. 188,580 metric tons, respectively [27,28]. However, these results might not be supported by the literature. There were four Punjab studies reporting fodder cutter injuries, with an average incident rate of 83 incidents per year (st.dev 44.5) [6–8,31]. In comparison, there were 64 incidents per year (st.dev 11.6) in Sindh based on two studies [9,11]. The numbers become closer if one limits the analysis to datasets with one year of data or longer, with two studies in Punjab remaining with an average incident rate of 62 incidents per year (st.dev 4.9) [6,7].

In this study, two surveys in Sindh reported numbers comparable to the literature review. One was from Khairpur with 42 incidents, and the second was from Nawab Shah with 30 incidents (reminder: these data points represent 6 months of data). Due to the number of respondents, Hyderabad and Jamshoro could be considered to have met the threshold as well (Table 1). The closest that a Punjab district comes to this range is Sialkot with two reports of seven and five fodder incidents. These results indicate that Punjab is under-sampled in this study. At the same time, given the number of surgeons reporting zero (or low) fodder cutter incidents even in hotspots like Hyderabad, the numbers reported in the literature might be a reflection of the higher end for fodder incident rates (at a hospital level).

4.3. Injury Type

The findings indicate that the highest number of injuries are amputations (38%). This is supported by the high number of fodder cutter and thresher injuries which tend to end in amputations [9,24]. In fodder-related injuries, the upper limb is frequently affected, with amputation being the most common type of injury, often involving the right upper limb at various levels such as phalanx, hand, forearm, and arm [6,9,11,31]. Fractures and cuts were the next highest types of injury, with 23% and 20%, respectively. It is important to note that these results are reflective of survey participants (orthopedic surgeons) and their caseloads. These results are important but should not be considered representative of all agricultural injuries. In a survey of a rural community in Hyderabad, Rabbani et al. [12] found that the majority (58%) of injuries were moderate (defined as requiring hospitalization or observation in hospital) and 9.6% were severe (vitals were impacted or caused disability). Cuts represented 70%, fractures 16%, and amputations/bruises/stabs/punctures 14% of all injuries. Based on these results, this survey captures an important subset of severe agricultural machinery-related injuries.

4.4. Injury by Demographic

The demographic breakdown of injuries by gender reveals that males constitute a higher proportion of reported injuries (77%) compared to females (23%), with a st.dev of 21.6% between districts. In comparison with the literature (six studies), on average, 38% of all incidents occurred to females with a st.dev of 13% [6–9,11,31]. Youth accounted for the majority of incidents, with those under 25 representing 40% of all incidents and ages 25–34 representing another 34% of incidents. This compares similarly to other fodder cutter studies, with an average of 62% of incidents (st.dev 17%) occurring to those aged 30 or younger [6–9,11,31]. This demographic highlights the vulnerability of young agricultural workers to machine-related injuries, necessitating safety protocols tailored to this demographic group. With about 25% of incidents impacting females, addressing agricultural injuries in Pakistan must be considered an important developmental goal to achieve equity and support all farmers in Pakistan.

4.5. Seasonality of Injuries

Farmers and their families regularly employ fodder cutter machines in their daily routines to prepare livestock feed, leading to potential impacts on their well-being throughout the year [31]. However, certain tools that pose injury risks are dependent on seasonal factors. For instance, Pakistan experiences two primary crop seasons known as ‘Kharif’ and ‘Rabi.’ The ‘Kharif’ season (April–June) is conducive to cultivating summer crops such as rice, sugarcane, cotton, maize, and pulses. In contrast, the ‘Rabi’ season (October–December) is dedicated to the cultivation of wheat, lentils, tobacco, rapeseed, barley, and mustard [20]. During these seasons, injuries commonly arise from the use of threshers, tractors, and cutters. The variability of injury rates by month supports this theory, with injuries peaking in March–April (239 incidents) vs. November–December (115 incidents).

5. Conclusions

This article highlights the importance of the agriculture sector in Pakistan and the challenges associated with agricultural mechanization. Despite its transformative impact, mechanization introduces risks, resulting in severe injuries and fatalities among farmworkers. There is limited work performed in this area and this project adds to the literature on agriculture in the developing world and highlights the need to address unique agricultural machine-related injury challenges in the Global South.

The research relied on a survey approach to collect data on agricultural injuries to explain the nature, sources, and patterns of injuries. The findings of data that were collected between 2022–2023 reveal that, among the various machines used, the main sources of injuries are associated with fodder cutters and threshers. Moreover, across different injuries, amputations tend to be the leading type of injury. The findings of the study highlight the

importance of advocating for safety regulations, injury reduction, and safety awareness among farmers. In addition, the findings highlight the variations across regions and demographics and the need for a tailored response to these injuries. It is important to note that despite the significance of these findings, there are certain limitations that range from the limited number of respondents to potential bias due to the exclusive participation of orthopedic surgeons and the limited temporal domain.

Future work should investigate the causes of agricultural machinery-related injuries by gathering information from injured workers, examining manufacturing or design issues in the machines, and understanding behavioral challenges related to their use. These efforts should lead to safety optimization proposals to manufacturers or providing them with machine-related safety optimization. In addition, future work should investigate solutions to address data availability challenges for developing countries. For example, Austrian agricultural operators are required to report fatality or severe injuries (>3 days out of work) to an insurance institution [36]. The feasibility of similar solutions should be investigated.

6. Study Limitations

The study's limitations stem from the relatively small number of participants. This limited involvement raises concerns regarding potential bias, particularly in regions with limited response rates. Additionally, the data collection spanned just six months, which may not fully capture the nuances of injuries over a more extended period. It is crucial to acknowledge that the study's foundation is rooted in survey data collected from a selected number of hospitals, further emphasizing the need for cautious interpretation of its findings. We observed that in 12 surveys, surgeons did not provide the same total number of injuries for the source of injury and the nature of injury. The average deviation in their answers was about 4.6 incidents. This variation did not alter the total number of injuries (507). This might be because surgeons were either estimating values and providing round numbers or due to topographical errors by participants as they were completing the survey.

Author Contributions: Conceptualization, all authors; methodology, all authors; software, all authors; validation, all authors; formal analysis, all authors; investigation, all authors; resources, all authors; writing—original draft preparation, M.M.S.R.; writing—review and editing, all authors; visualization, M.M.S.R. and S.F.I.; supervision, S.F.I.; project administration, S.F.I. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding. This survey was funded by the UIUC ACES International Program (internal funding source).

Institutional Review Board Statement: The Office for the Protection of Research Subjects [30] has reviewed and determined that the research study, as described and reported to OPRS, does not meet the criteria for Human Subjects Research. IRB approval is not required. It has been determined that this project, as described, does not meet the definition of Human Subjects Research as defined in 45CFR46(d)(f) or 21CFR56.102(c)(e) and does not require IRB approval.

Informed Consent Statement: Not applicable.

Data Availability Statement: Available upon request.

Acknowledgments: I would like to express my sincere gratitude to Pakistan Orthopedic Surgeons for contributing to this research.

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

References

1. Employment Indicators 2000–2019 (Global and Regional Trends). Food and Agriculture Organization of the United Nations. (n.d.). Available online: [https://www.fao.org/statistics/highlights-archive/highlights-detail/New-FAOSTAT-data-release-Employment-indicators-2000-2019-\(Global-and-regional-trends\)/en](https://www.fao.org/statistics/highlights-archive/highlights-detail/New-FAOSTAT-data-release-Employment-indicators-2000-2019-(Global-and-regional-trends)/en) (accessed on 14 April 2024).
2. Qaisrani, M.I.; Baig, N.; Rathore, T.; Yousuf, F. Occupational Health Hazards of livestock workers in Pakistan. *Pak. J. Public Health* **2018**, *8*, 52–57. [CrossRef]

3. Asha, K.R.; Kumar, A.; Singh, J.K.; Kushwaha, H.; Kushwaha, D.K.; Bhowmik, A. Sensor-based safety alarm system for injury prevention in Chaff Cutter Machine. *Smart Agric. Technol.* **2023**, *5*, 100282. [\[CrossRef\]](#)
4. Pakistan—Labour Force Survey 2014–2015. 14 April 2024. Available online: <https://webapps.ilo.org/surveyLib/index.php/catalog/6839/related-materials> (accessed on 14 April 2024).
5. Pakistan Bureau of Statistics. Labour Force Survey 2021. Pakistan—Labour Force Survey 2021. 14 April 2024. Available online: <https://webapps.ilo.org/surveyLib/index.php/catalog/7929> (accessed on 14 April 2024).
6. Ch, N.A.; Azeem, M.; Iqbal, M.Z.; Ch, A.A. Fodder Cutter Amputations-Evaluation of Risk Factors. *J. Pak. Orthop. Assoc.* **2016**, *28*, 46–49.
7. Ahmed, S.; Hamid, K.; Shabir, F.; Latif, A. Pattern of Fodder Cutting Machine Injuries in Sialkot Region. *Pak. J. Med. Health Sci.* **2018**, *12*, 220–224.
8. Zulfiqar, Z.; Bubak, S.Z.; Jahangir, A.; Ali, Z. Frequency of traumatic amputation of upper extremity presenting at tertiary care hospital in Southern Punjab Pakistan. *Med. Forum* **2018**, *29*, 60.
9. Tunio, Z.H.; Jhatiyal, R.A.; Jokhio, M.F.; Ali, S.M.; Baloch, R.A.; Makhdoom, A. Fodder Cutter Machine Injuries: An Unsafe Household Item in Rural Sindh in Pakistan. *J. Liaquat Univ. Med. Health Sci.* **2021**, *20*, 96–99.
10. Ali, D.; Kaiser, M.A.; Khokhar, M.I.; Zeb, A.; Zaheer, H.; Afzal, M.F. Fodder Cutter (Tokka) injuries; a preventable morbidity. *J. Pak. Med. Assoc.* **2020**, *71*, 1022–1024. [\[CrossRef\]](#)
11. Bhatti, S.H.; Abbasi, M.K.; Naqvi AS, A.H. Pattern of fodder cutting machine injury in Gambat region, Sindh, Pakistan. *Rawal Med. J.* **2021**, *46*, 560.
12. Rabbani, U.; Fatmi, Z. Incidence, patterns and associated factors for occupational injuries among agricultural workers in a developing country. *Med. J. Islam. Repub. Iran* **2018**, *32*, 88. [\[CrossRef\]](#)
13. Chopra, S.; Kumar, P.; Kumar, M. Severity of agricultural injuries and its economic consequences in border belt of Gurdaspur District of Punjab, India. *J. Agromedicine* **2023**, *29*, 179–188. [\[CrossRef\]](#)
14. Noman, M.; Mujahid, N.; Fatima, A. The assessment of occupational injuries of workers in Pakistan. *Saf. Health Work.* **2021**, *12*, 452–461. [\[CrossRef\]](#) [\[PubMed\]](#)
15. Jarén, C.; Ibarrola, A.; Mangado, T.; Adin, A.; Arnal, P.; López-Maestresalas, A.; Ríos, A.; Arazuri, S. Fatal tractor accidents in the agricultural sector in Spain during the past decade. *Agronomy* **2022**, *12*, 1694. [\[CrossRef\]](#)
16. Kim, K.; Kim, H.; Lee, M.; Jung, W.; Choi, D. Incidence rates of agricultural machine-related injuries in South Korea. *Int. J. Environ. Res. Public Health* **2022**, *19*, 15588. [\[CrossRef\]](#)
17. Kogler, R.; Quendler, E.; Boxberger, J. Occupational accidents with agricultural machinery in Austria. *J. Agromed.* **2016**, *21*, 61–70. [\[CrossRef\]](#) [\[PubMed\]](#)
18. Shaver, J.; McRoberts, D.; O’Byrne, B.; Morgan, B.; Krall, K.; Surjan, C.; Mayberry, J. Farming and ranching related injuries in Southern Idaho. *Am. J. Surg.* **2017**, *213*, 881–884. [\[CrossRef\]](#)
19. FAO in Pakistan | Food and Agriculture Organization of the United Nations. Available online: <http://www.fao.org/pakistan/our-office/pakistan-at-a-glance/en/> (accessed on 14 April 2024).
20. Climate-Smart Agriculture in Pakistan. (n.d.). Available online: <https://climateknowledgeportal.worldbank.org/sites/default/files/2019-06/CSA-in-Pakistan.pdf> (accessed on 14 April 2024).
21. Iqbal, M.A.; Iqbal, A.; Afzal, S.; Akbar, N.; Abbas, R.N.; Khan, H.Z. In Pakistan, agricultural mechanization status and future prospects. *Am.-Eurasian J. Agric. Environ. Sci.* **2015**, *15*, 122–128.
22. Raza, M.M.; Li, S.; Issa, S.F. Global patterns of agricultural machine and equipment injuries—A systematic literature review. *J. Agromed.* **2024**, *29*, 214–234. [\[CrossRef\]](#)
23. Illinois.qualtrics.com. (n.d.). Available online: <https://illinois.qualtrics.com/homepage/ui> (accessed on 14 April 2024).
24. Singh, R.; Sharma, A.; Jain, S.; Sharma, S.; Magu, N. Wheat Thresher Agricultural Injuries: A by-product of mechanised farming. *Asia Pac. J. Public Health* **2005**, *17*, 36–39. [\[CrossRef\]](#)
25. Pakistan Orthopedic Association. 11 February 2024. Available online: <http://p-o-a.org/> (accessed on 11 February 2024).
26. Agricultural Census 2010—Pakistan Report | Pakistan Bureau of Statistics. (n.d.). Available online: <https://www.pbs.gov.pk/publication/agricultural-census-2010-pakistan-report> (accessed on 5 May 2024).
27. Publications and Reports. Bureau of Statistics, Punjab. 14 June 2023. Available online: <https://bos.punjab.gov.pk/publicationreports#PHS> (accessed on 14 April 2024).
28. Statistics: Sindh Bureau of Statistics. 2022. Available online: <https://sbos.sindh.gov.pk/> (accessed on 14 April 2024).
29. Amitha, P.; Binu, V.S.; Seena, B. Estimation of missing values in aggregate level spatial data. *Clin. Epidemiol. Glob. Health* **2021**, *9*, 304–309. [\[CrossRef\]](#)
30. Office of the Vice Chancellor for Research and Innovation. Notice of Not Human Subjects Research Determination. 12 April 2023. Available online: <https://oprs.research.illinois.edu/> (accessed on 12 April 2024).
31. Rabbani, M.J.; Haq, A.U.; Aslam, F.; Khan, H.; Tarar, M.N. Fodder cutter (Toka) injuries, a preventable tragedy. Our experience at Jinnah Hospital Lahore. *Pak. J. Plast. Surg.* **2012**, *1*, 13–20.
32. Kumar, A.; Singh, J.K.; Singh, C. Prevention of chaff cutter injuries in rural India. *Int. J. Inj. Control Saf. Promot.* **2013**, *20*, 59–67. [\[CrossRef\]](#) [\[PubMed\]](#)
33. Wanjara, S.; Oduor, P. Hand injuries in Kenya: A Chaff Cutter Menace. *F1000Research* **2022**, *11*, 1255. [\[CrossRef\]](#) [\[PubMed\]](#)

34. Shrestha, K.M.; Shrestha, B.; Kandel, P.R.; Baral, R.; Pandey, A.; Singh, G.P. Fodder cutter machine injuries of hand. *J. Univers. Coll. Med. Sci.* **2018**, *6*, 14–18. [[CrossRef](#)]
35. Kumar, A.; Varghese, M.; Mohan, D. Equipment-related injuries in agriculture: An international perspective. *Inj. Control. Saf. Promot.* **2000**, *7*, 175–186. [[CrossRef](#)]
36. Mayrhofer, H.; Quendler, E.; Boxberger, J. Occupational incidents with self-propelled machinery in Austrian agriculture. *J. Agromed.* **2013**, *18*, 359–367. [[CrossRef](#)]

Disclaimer/Publisher’s Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.