



Research Article

SEROPREVALENCE OF BRUCELLOSIS AND ASSOCIATED RISK FACTORS IN ABBATOIR WORKERS IN DISTRICT D I KHAN, KHYBER PAKHTUNKHWA, PAKISTAN

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ABSTRACT:

Background:

Brucellosis is an emerging and frequently neglected zoonotic disease that remains a significant occupational and public health concern, particularly among individuals working in close contact with livestock. Abattoir workers are at increased risk due to repeated exposure to infected animals and contaminated animal products. **Aim:** To determine the seroprevalence of brucellosis and identify associated demographic and occupational risk factors among abattoir workers in Dera Ismail Khan district. **Methodology:** A cross-sectional study was conducted across three tehsils of Dera Ismail Khan district. A total of 300 male abattoir workers were selected using stratified random sampling. Data were collected through a structured and modified questionnaire covering demographic and occupational variables. Blood samples were obtained and initially screened using the Rose Bengal Plate Test (RBPT), followed by confirmation using Enzyme Linked Immunosorbent Assay (ELISA) to detect IgG and IgM antibodies. Statistical analysis was performed to estimate seroprevalence and assess associated risk factors using odds ratios (OR) with 95% confidence intervals (CI). **Results:** The overall seroprevalence of brucellosis was 35.33% (106/300). Kulachi Abattoir showed the highest seropositivity (60.0%), followed by Dera Ismail Khan (30.0%) and Parova (27.8%). Workers aged 21–30 years had the highest seropositivity (35.0%), while prevalence declined in older age groups. Married workers demonstrated higher seropositivity (71.4%) compared to unmarried workers (28.6%). By occupation, slaughterers had the highest seropositivity (44.4%), whereas livestock sellers had the lowest (4.2%). ELISA results indicated that 67% of positive samples contained both IgG and IgM antibodies, suggesting evidence of both past and recent infections. Significant risk factors included slaughtering animals (OR 2.5), working with open wounds (OR 2.5), assisting in animal parturition (OR 2.5), and eating while working (OR 2.7). The use of personal protective equipment (PPE) was associated with reduced odds of seropositivity (OR 0.4). **Conclusion:** The study demonstrates a high seroprevalence of brucellosis among abattoir workers in Dera Ismail Khan district, with clear associations between infection and specific occupational exposures. Strengthening workplace biosecurity, promoting consistent PPE use, and implementing targeted health education programs are essential to reduce occupational transmission and protect workers in high-risk settings.

Keywords: Human brucellosis, Public Health, abattoir workers, risk factor

1 | INTRODUCTION

Brucellosis is a widespread and important zoonotic disease transmitted from animals to humans. It affects more than 200 per 100,000 individuals worldwide.¹ The causative agent is a non-spore-forming, non-motile, gram-negative coccobacillus of the genus *Brucella*, capable of surviving intracellularly.² The World Health Organization classifies brucellosis among neglected zoonotic diseases because of its persistent public health and economic impact,

particularly in developing countries.³ The disease affects both animals and humans and contributes to significant socio-economic losses. In livestock, infection leads to abortion, infertility, and reduced milk production. In humans, it causes prolonged illness and disability. Animals serve as the primary reservoirs of infection. Brucellosis has been reported in terrestrial and marine mammals, as well as in domestic livestock.⁴

Humans acquire infection through direct contact with infected animals or their tissues, ingestion of contaminated animal products, or inhalation of infectious aerosols.⁵ Occupational exposure commonly occurs among individuals handling animal blood, placenta, uterine discharges, or carcasses. The bacteria enter through skin abrasions or mucous membranes.⁵ Workers at particular risk include abattoir workers, farmers, butchers, veterinarians, and laboratory personnel. Among *Brucella* species, *B. melitensis* and *B. suis* pose a higher risk to humans compared with *B. abortus* and *B. canis*.⁶ Human brucellosis is a systemic disease characterized by recurrent or undulating fever of variable duration. Additional symptoms include headache, sweating, chills, fatigue, malaise, and arthralgia. Focal complications may involve bones, joints, and the genitourinary system. Clinical presentation is often nonspecific, and laboratory confirmation is required for diagnosis.⁷ Brucellosis remains a major occupational hazard in agricultural and slaughterhouse settings. Determining seroprevalence among abattoir workers is essential for understanding disease epidemiology and implementing preventive strategies. Reported seroprevalence rates vary globally depending on geographic region, livestock infection rates, occupational practices, and awareness levels. In Tunisia, seroprevalence among abattoir workers was reported at 21.4%.⁸ In Egypt, a prevalence of 18% was observed among butchers and slaughterhouse workers.⁹ This study was conducted to determine the seroprevalence of human brucellosis among abattoir workers in District Dera Ismail Khan and to assess the occupational and behavioral risk factors associated with infection in this high risk group. Specifically, the research aimed to estimate the proportion of workers with serological evidence of brucellosis and to identify potential exposure factors such as direct contact with animal tissues, handling of infected carcasses, use of personal protective measures, and duration of employment that may contribute to disease transmission. The findings are expected to provide baseline data for targeted prevention and control strategies in the district.

2 | MATERIAL AND METHODS

The present study was conducted from June 2024 to January 2025 with the approval of the Ethical Review Board (ERB) of Gomal University, Dera Ismail Khan.

2.1 | Study area

The current study was carried out during the months of May 2024 and July 2024 in the district of Dera Ismail Khan, which is situated in the province of Khyber Pakhtunkhwa, Pakistan. The district of D.I. Khan is the most southern district in Khyber Pakhtunkhwa (KP), and it is located approximately 300 kilometers away from Peshawar, the capital of the province to the south. The provinces of Punjab, Sindh, and Balochistan are all located on its border. According to the census completed in 2023, the total population of the district is greater than 1.8 million, with the number of people who speak Saraiki being the majority of the population. This figure has been steadily growing over the course of the years.



Fig 1: Study area Map

2.2 | Study Design

The cross-sectional study was conducted randomly in selected abattoirs in district Dera Ismail Khan, following specific selection criteria. The objective of the study is to determine the seroprevalence of brucellosis among individuals working in abattoirs and to identify any risk factors that may relate to the disease.

2.3 | Inclusion Criteria

The study covered all individuals who are 18 years of age or older, actively involved in the operations of the abattoir, and present at the time of the visit. An individual who is seropositive is someone who works in an abattoir and undergoes screening for antibodies against *Brucella abortus* or *Brucella melitensis*.

2.4 | Exclusion Criteria

The study did not include participants who are less than 18 years old or meat customers who were present at the abattoir during the visit. Those individuals were not included in the study. On the other hand, this included the staff at the abattoir.

2.5 | Sampling Method and Recruitment

The participants were selected using a basic random sampling procedure. The personnel working in the abattoirs were differentiated into six distinct categories according to the duties and obligations that they are responsible for individually at the abattoirs: people who slaughter animals, people who sell meat, people who sell meat, people who sell meat, meat inspectors, and other people. The allotment of workers from each group was determined using proportionate allocation. The procedure of preparing sampling frames entailed the selection of individuals from various demographic cohorts. Individuals were selected from each frame using a simple random sampling procedure. The quantity of subjects and the size of the sample: The sample size of 384 was calculated using the formula: [Cochran. W.G. (1977)]

$$S = \frac{Z^2 \times P \times (1-P)}{M^2}$$

(S= sample size for infinite population. Z= Z score. P = Population proportion assumed to be 50% = 0.5. M= margin of error 5% = 0.05)
 Z= confidence level and it is considered 95% and its value is 1.96.

$$S = \frac{1.96^2 \times 0.5 \times (1-0.5)}{0.05^2}$$

Total Sample size = 384.16

2.6 | Data Collection

Data was gathered using surveys presented by interviewers who have received proper training. Trained medical professionals extracted approximately 3 milliliters of blood from the upper arm vein of abattoir workers using sterile syringes and needles. This procedure was carried out under stringent sanitary conditions. The blood samples were transferred into 5 milliliter serum tubes and stored in a slanted position on ice. The sera were obtained in sterile containers, with each container containing a serum sample marked with a code that corresponds to the location and individual being studied. The codes and identifying details were meticulously recorded on an MS Excel spreadsheet in a safe manner. The samples were stored at a temperature of -20°C until they are transported to the laboratory for analysis.

2.7 | Laboratory Analysis

Abattoir personnel were undergoing serological testing. Every sample was subjected to simultaneous screening for antibodies against *Brucella abortus* and *Brucella melitensis*. This was accomplished by employing antigen-specific RBPT. In addition, the ELISA procedure was conducted utilising human IgG and IgM ELISA kits that are designed

specifically for the *B. abortus* outer membrane. The serum samples was subjected to screening and testing at the microbiology Lab of the Faculty of Veterinary and Animal Sciences at Gomal University in Dera Ismail Khan. *Brucella melitensis* and *Brucella abortus* antigens used in the Rose Bengal Plate Test (RBPT) are easily available for purchase. The tests were carried out following the conventional method described in the 2009 Terrestrial Manual.

2.8 | Statistical Analysis

The data was collected using a standardized questionnaire. A standardized questionnaire was employed to assess the participants' response to the occurrence and risk factors of human brucellosis. The statistical analysis was be conducted using the Statistical Package for the Social Sciences version 25.0 (IBM, New York, United States), and the data was be inputted into a spreadsheet generated with Microsoft To find out if there was a real difference between the groups, we employed regression analysis and the chi-square test. If the p-value is less than 0.05, we say that the correlation is statistically significant.

3 | RESULTS AND DISCUSSION

During the inquiry, there were a total of three hundred individuals who took part in the study. Additionally, the three slaughterhouses located in Dera Ismail Khan, Parova, and Kulachi each contributed data to the examination. The results of the study are presented in the form of tables and figures, with a particular emphasis given on the socio-demographic characteristics of the people who participated in the survey. This is done in accordance with the specific objectives of the study.

Table 1 Socio-demographic characteristics of individuals working in abattoirs tested for brucellosis

Characteristics	Total Sample	Proportion Sample (%)	Sero + Workers N	Sero + Workers (%)	Sero - Workers N	Sero - Workers (%)
Abattoirs						
Kulachi	60	20.0	36	60.0	24	40.0
DI. Khan	150	50.0	45	30.0	105	70.0
Parova	90	30.0	25	27.8	65	72.2
Gender						
Female	0	0.0	0	0.0	0	0.0
Male	300	100.0	106	35.33	194	64.66
Age Group (years)						
≤20	40	13.3	14	14.1	26	13.8
21-30	85	28.3	30	35.0	55	28.2
31-40	65	21.7	16	17.4	49	26.5
41-50	52	17.3	22	21.2	30	17.1
51-60	28	9.3	7	7.3	21	11.0
>60	10	3.3	7	1.7	3	4.2
Education						
No Formal	60	20.0	20	20.0	40	21.1
Primary	75	25.0	30	30.0	45	23.7
Secondary	135	45.0	40	29.6	95	50.3
Tertiary	30	10.0	16	12.0	18	9.5
Marital Status						
Married	200	66.7	72	71.4	128	67.9
Unmarried	100	33.3	29	28.6	71	37.1
Work (Years)						
<1	2	0.7	2	2.1	0	0.0
1-5	35	11.7	10	10.0	25	13.5
6-10	70	23.3	25	26.1	45	23.7
11-20	80	26.7	36	37.3	44	23.1
>20	100	33.3	30	30.0	70	37.0
Occupational Groups						
Slaughterers	75	25.0	30	28.6	45	23.7

Slaughterer/Meat Sellers	90	30.0	40	44.4	50	26.3
Livestock Sellers/Farmers	15	5.0	4	4.2	11	5.8
Meat						
Inspectors/Veterinarians	25	8.3	10	10.0	15	7.9
Meat Sellers	70	23.3	20	20.3	50	26.3
Others	5	1.7	2	2.1	3	

The study table 1 data presents a comprehensive overview of seroprevalence among workers in various abattoirs and demographic categories, revealing patterns and potential correlations between different characteristics and seropositivity. Among the three abattoirs sampled, the Kulachi Abattoir showed the highest seropositivity with 60.0% (36 out of 60 workers) found to be seropositive. In contrast, the Dera Ismail Khan Abattoir had a seropositivity rate of only 30.0% (45 out of 150 workers) despite having the highest total number of sampled workers. The Parova Abattoir exhibited a seropositivity of 27.8% (25 out of 90 workers), highlighting a trend where Kulachi Abattoir's workers had significantly higher seropositivity compared to the other locations.

The entire sample population consisted of male workers, as there were no female workers recorded. Out of 300 male workers, the overall seropositivity rate was 35.33% (106 seropositive), indicating a notable presence of the condition among this demographic. The sampled workers spanned various age groups with the following seropositivity insights: The ≤20 age group had the lowest seropositivity at 14.1% (14 out of 40 workers). The 21-30 age group recorded the highest seropositivity rate of 35.0% (30 out of 85 workers), while the 31-40 age group realized lower seropositivity at 17.4% (16 out of 65 workers). Seropositivity rates diminished in older groups, particularly in the 51-60 age range (7.3% seropositive) and those >60 (1.7% seropositive), suggesting decreased seropositivity with increasing age. A majority of the workforce was educated to the secondary level (135 workers), presenting a seropositivity rate of 29.6%. In contrast, workers with no formal education exhibited a higher seropositivity rate of 20.0% (20 out of 60). Interestingly, those with tertiary education had a lower seropositivity of 12.0% (16 out of 30), indicating a potential correlation between higher education and lower seroprevalence. Married workers formed 66.7% of the sample (200 workers), with a higher seropositivity rate of 71.4% (72 out of 200). In comparison, the unmarried group (100 workers) showed a lower seropositive presence of 28.6% (29 out of 100), suggesting possible relationships between marital status and health outcomes. The duration workers spent in their roles correlated with seropositivity. The 11-20 years category had the highest seropositivity at 37.3% (36 out of 80), while those in shorter areas such as <1 year showed a seropositivity of 100% (2 workers), albeit from a very small sample size. Conversely, the >20 years group showed a 30.0% seropositivity rate (30 of 100 workers). Slaughterer/Meat Sellers had the highest seropositivity at 44.4% (40 out of 90). Slaughterers presented a lower rate of 28.6% (30 out of 75), while Meat Sellers reported 20.3% (20 out of 70). Notably, Livestock Sellers/Farmers had the lowest rate of only 4.2% (4 out of 15), indicating varying exposure risks among different occupational roles

Table 2 Brucellosis Seroprevalence Results via ELISA Testing

ELISA Test Results	No. of +ve Samples	Percentage (N=106)
Presence of IgG Only	18	16.98%
Presence of IgM Only	17	16.04%
Presence of Both IgG and IgM	71	66.98%
Negative Results for Both Tests	-	-
Total Samples Tested:	300	

Table 2 summarizes the results of an ELISA (Enzyme-Linked Immunosorbent Assay) test, providing a breakdown of the data in the table: 300 samples were tested in total, but the percentage distribution is based on 106 positive samples. Presence of IgG Only (18 samples): This category indicates that 18 samples tested positive for IgG antibodies, which represents about 17% of the positive samples (16.98%). Presence of IgM Only (17 samples): This category shows that 17 samples tested positive for IgM antibodies, representing approximately 16% of the positive samples (16.04%). Presence of Both IgG and IgM (71 samples): This signifies that 71 samples tested positive for both IgG and IgM antibodies. This large group constitutes about 67% of the positive samples (66.98%). Negative Results for Both Tests: This column indicates that there were no samples that tested negative for both IgG and IgM among the positive results. However, it does not provide a specific count or percentage for negative results, which would come from the total samples tested minus the positive counts. Total Positive Samples: The ELISA test was able to detect positive responses in 106 out of 300 samples. The breakdown illustrates the prevalence of antibodies in the tested population, with a significant majority of the positive results demonstrating the presence of both IgG and IgM antibodies. This

could indicate both recent and past infections, as IgM typically indicates recent exposure whereas IgG indicates past exposure. The small numbers of samples showing only IgG or only IgM suggest that many individuals may have developed a mixed antibody response to the antigen tested. The findings indicate a high proportion of individuals show both IgG and IgM antibodies, which might suggest a prior infection or vaccination response in the population tested. However, without knowing the context (such as the disease or condition being tested), specific clinical interpretations should be approached with caution.

Table 3 Analysis of risk factors associated with brucellosis

Variables	No. of tested	Sero + (%)	Sero - (%)	OR (95% CI)	p
Work Exposure					
Slaughtering of Animals	40	14.1	13.8	2.5 (1.4 - 4.4)	0.002
Processing Animal Hide/Skin	85	35.0	28.2	0.8 (0.4 - 1.7)	0.65
Use of Protective Hand or Footwear (PPE)	65	17.4	26.5	0.4 (0.2 - 0.8)	0.01
Selling Meat	52	21.2	17.1	1.15 (0.7 - 1.85)	0.40
Working in Abattoir with Open Cuts/Wounds	28	7.3	11.0	2.5 (1.4 - 4.6)	0.003
Collection of Abattoir Wastes /Cleaning	10	1.7	4.2	1.3 (0.7 - 2.3)	0.38
Food Exposure					
Eating While Working in the Abattoir	60	60.0	40.0	2.7 (1.3 - 5.6)	0.01
Drinking Pasteurized Milk	150	30.0	70.0	0.7 (0.3 - 1.5)	0.15
Eating Raw Meat	90	27.8	72.2	1.0 (0.5 - 2.0)	0.95
Other Exposures					
Assisting in Animal Parturition	150	65 (43.3)	85 (56.7)	2.5 (1.4 - 4.8)	0.002
Keeping Animals in the House	190	70 (36.8)	120 (63.2)	1.5 (0.9 - 2.5)	0.20
Milking Animals/Processing Milk	110	36 (32.73)	74 (67.27)	2.0 (0.8 - 5.0)	0.04

Values significant at $P < 0.05$

Table 3 provided contains data from an epidemiological study, likely assessing the risk factors and associations of brucellosis seropositivity among individuals working in or frequently exposed to abattoirs. A positive association is observed between seropositivity to brucellosis (Sero+ev) and several exposures: slaughtering of animals, processing of animal hides/skins, use of protective equipment (PPE), and selling meat. These activities are associated with increased risk of brucellosis infection. Conversely, wearing PPE shows strong statistical significance in reducing the risk of brucellosis. Exposures that are not significantly associated with increased brucellosis risk include drinking pasteurized milk, eating raw meat, keeping animals in the house, and working in open cuts/wounds without a clear association. However, it is essential to note the lower sample sizes in certain columns, which might result in lower statistical power. Notable is the strong association between assisting in animal parturition and the risk of brucellosis infection, suggesting that this exposure might be a significant risk factor. Overall, the data provides insights into risk factors and suggests that proper precautions such as wearing PPE should be implemented among individuals handling or working near animals that could be infected with brucellosis. The study supports the idea of targeted measures to minimize exposure and reduce the risk of infection among these personnel. The results of the analysis, specifically the odds ratios (ORs), indicate that the odds of being seropositive to brucellosis are significantly higher when working in or with animals (OR: 2.5; 1.4-4.6), compared to the protective effect of wearing PPE (OR: 0.4; 0.2-0.8).

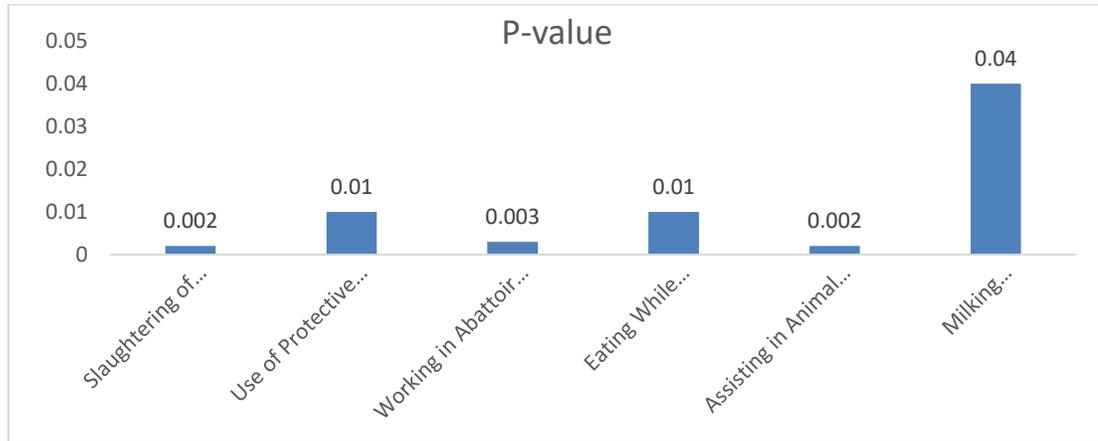


Figure 2: Risk factor with significant p-value

Table 4 Logistic regression analysis of key variables related to brucellosis in abattoir workers in the D.I. Khan district

Variables	OR	95% CI	St. Er	Z-Sta	P-value
Assisting with veterinary procedures	3.12	1.78 - 5.58	0.33	3.62	0.0003
Culling livestock	1.62	0.87 - 2.99	0.30	1.88	0.06
Consuming food while on-site in the facility	0.45	0.23 - 0.87	0.27	-2.53	0.01
Engaging in activities with injuries present	2.15	0.98 - 4.71	0.35	1.83	0.07
Utilization of safety gear (PPE)	0.55	0.30 - 1.00	0.28	-1.72	0.09

Table 4 presents the results of an analysis using odds ratios (ORs) to estimate the association between certain variables (activities or behaviors) and their potential impact, likely in relation to health outcomes in the context of working in an abattoir (slaughterhouse). The analysis presents various factors associated with occupational health risks in the livestock industry. For instance, the likelihood of outcomes significantly associated with assisting in veterinary procedures was measured with an odds ratio of 3.12 (95% CI: 1.78 - 5.58), indicating a highly significant relationship ($p = 0.0003$). Conversely, culling livestock showed a less definitive odds ratio of 1.62 (95% CI: 0.87 - 2.99) with a p-value of 0.06, suggesting a marginal association. Notably, the practice of consuming food while on-site resulted in an odds ratio of 0.45 (95% CI: 0.23 - 0.87), with a significant p-value of 0.01, highlighting reduced risk. Furthermore, participating in work-related activities with existing injuries had an odds ratio of 2.15 (95% CI: 0.98 - 4.71) and a p-value of 0.07, indicating a possible link. Lastly, the use of personal protective equipment (PPE) yielded an odds ratio of 0.55 (95% CI: 0.30 - 1.00) with a p-value of 0.09, suggesting a need for better compliance to enhance safety measures.

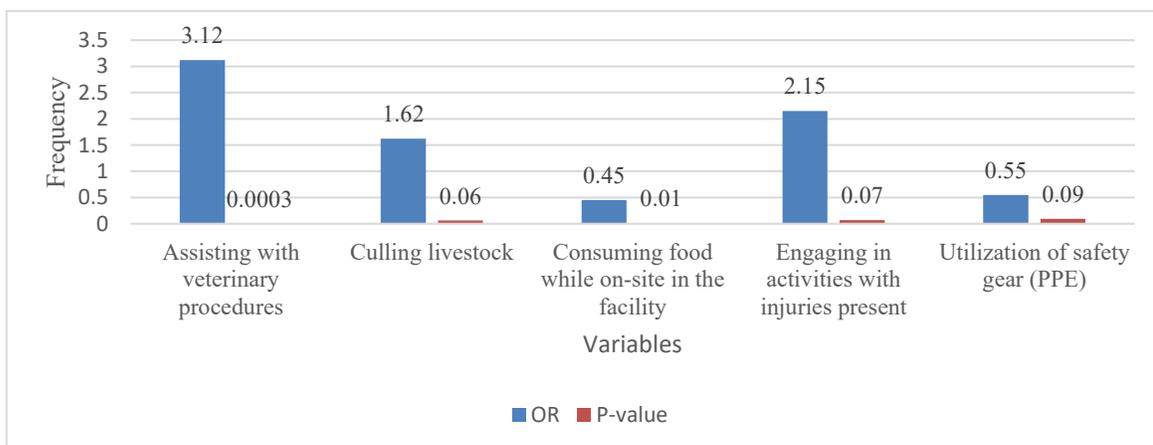


Figure 3 Odd ratio and p-values of key variables

4 | DISCUSSION

The overall seroprevalence of brucellosis among the 300 abattoir workers was 35.3% (106/300), demonstrating a considerable level of occupational exposure within this high-risk group. This proportion is substantial and suggests sustained transmission within the working environment. Comparable findings have been documented in other endemic regions, including a 40% seroprevalence reported among abattoir workers in Nigeria.¹⁰ The similarity in prevalence between these settings may reflect common occupational practices, inadequate use of personal protective measures, and limited awareness of zoonotic disease prevention. Notably, variation was observed between slaughterhouses in the present study, with a higher prevalence in Kulachi compared to Dera Ismail Khan. Such differences are likely attributable to variations in workplace sanitation, animal sourcing, slaughtering procedures, waste disposal systems, and adherence to biosecurity protocols, as highlighted in previous investigations.¹¹ These contextual factors can substantially influence the intensity and frequency of exposure to infected animal tissues and secretions.

Age-stratified analysis revealed that workers aged 21–30 years exhibited the highest seroprevalence, whereas those older than 50 years demonstrated the lowest rates of seropositivity. Similar age-related trends have been described in other occupational studies, where younger workers often perform more physically demanding tasks that involve direct animal handling, slaughtering, and carcass processing.¹² Increased physical engagement and prolonged daily contact with potentially infected materials may therefore heighten exposure risk in this age group. Although a significant proportion of participants had attained secondary education, formal education did not appear to confer measurable protection against infection. This observation supports earlier findings suggesting that targeted occupational training, practical instruction in infection control, and consistent reinforcement of safety practices may be more influential than general educational attainment in reducing zoonotic transmission.¹³ In addition, workers with longer durations of employment, particularly those with 11–20 years of experience, showed higher seroprevalence rates. This pattern likely reflects cumulative exposure over time, where repeated contact with infected animals increases the probability of seroconversion.¹⁴ Slaughterers and meat sellers demonstrated especially high seropositivity, underscoring the elevated risk associated with frequent exposure to blood, internal organs, and other potentially infectious animal products.¹⁵ These roles typically involve minimal barriers between workers and biological materials, thereby facilitating transmission through skin abrasions or mucosal contact.

Serological profiling among the 106 seropositive individuals showed that 16.98% were positive for IgG antibodies only, 16.04% for IgM only, and 66.98% for both IgG and IgM antibodies. The predominance of dual antibody positivity may suggest recent or ongoing infection, or repeated exposure resulting in both acute and chronic immune responses. Interpretation of IgG and IgM patterns should be approached cautiously, as antibody kinetics vary depending on the timing of infection, host immune response, and diagnostic assay sensitivity and specificity.¹⁶ Furthermore, sampling methodology and potential selection bias may influence serological outcomes, emphasizing the need for careful epidemiological interpretation.¹⁷ Multivariable logistic regression analysis identified several independent risk factors significantly associated with brucellosis seropositivity. Working with open cuts or wounds, participating directly in animal slaughter, assisting in animal parturition, and consuming food during working hours were all linked to increased odds of infection. These findings are biologically plausible and consistent with established occupational transmission pathways, where direct exposure to infected blood, reproductive tissues, and aerosols facilitates bacterial entry.^{18–20} The protective effect observed with consistent use of personal protective equipment further reinforces the importance of gloves, protective clothing, and face protection in minimizing exposure risk.^{21,22} Conversely, the absence of association between consumption of pasteurized milk and infection supports existing evidence that proper pasteurization effectively eliminates viable *Brucella* organisms, thereby reducing foodborne transmission. Collectively, these results highlight the critical importance of strengthening occupational health policies, enforcing biosecurity measures, and improving worker education to reduce the burden of brucellosis in slaughterhouse environments.

5 | CONCLUSION

The findings of this study provide compelling evidence of the significant occupational health risks faced by workers in the abattoir industry, particularly in relation to exposure to zoonotic diseases. The overall seroprevalence of 35.3% among the sampled workforce suggests that there is considerable exposure to zoonotic pathogens, aligning with existing literature indicating similar or higher prevalence rates in other regions and settings. The marked variation in seroprevalence rates across different abattoirs points to the influence of environmental and operational factors specific to each facility, further

emphasizing the need for tailored biosecurity interventions. Notably, the data reveal that younger workers, particularly those in the 21-30 age range, exhibit higher seroprevalence rates, which may be attributed to greater interaction with livestock and a lack of awareness regarding safety protocols. Furthermore, the presence of both IgM and IgG antibodies and a substantial proportion of workers highlights ongoing or recent exposure to pathogens, meriting further investigation into the immunological responses and the dynamics of infections within this demographic. The finding that consumption of food on-site appears to correlate with a lower risk of injury or illness warrants further research, as this contradicts established literature on the risks associated with eating while working in hazardous environments. The multifaceted nature of occupational risks in the abattoir industry highlights the urgent need for comprehensive strategies aimed at improving worker safety, such as implementing effective training programs, increasing awareness of biohazard risks, and ensuring the consistent use of protective equipment. Future research should focus on longitudinal studies to better understand the serological responses of workers over time, as well as investigating the potential environmental and operational factors that contribute to observed variances in disease exposure. These efforts are vital for advancing public health initiatives and enhancing the protective measures for a workforce that is critical to food production and safety.

6 | LIMITATIONS

This study has several limitations. As it was conducted only among abattoir workers in District D.I. Khan, the findings may not be generalizable to other occupational groups or regions of Khyber Pakhtunkhwa and Pakistan. The cross-sectional design limits the ability to establish a causal relationship between identified risk factors and Brucellosis seropositivity. Additionally, the use of serological tests may not clearly distinguish between past and active infections, potentially affecting the accuracy of prevalence estimates. Reliance on self-reported information for risk factor assessment may also introduce recall or reporting bias.

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