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PREVALENCE OF HUMAN BRUCELLOSIS IN PAKISTAN SINCE 2021 TO 2024

Original Research

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ABSTRACT

Background: Brucellosis is a highly infectious zoonotic disease caused by *Brucella* species, affecting both humans and animals globally. It remains a significant public health concern, particularly in regions with extensive livestock farming and close human-animal interactions. The disease manifests as fever, fatigue, joint pain, and severe complications such as endocarditis and neurological disorders. Despite being endemic in many developing countries, brucellosis often remains underreported due to inadequate surveillance and diagnostic challenges. Pakistan, with its large livestock population, is at high risk, necessitating comprehensive epidemiological assessment.

Objective: This study aimed to determine the prevalence and distribution of human brucellosis in Pakistan from 2021 to 2024, utilizing national surveillance data to identify high-burden regions and inform future control strategies.

Methods: A retrospective study was conducted using secondary data obtained from the National Institute of Health – Integrated Disease Surveillance and Response (NIH-IDSR). All reported human brucellosis cases from January 2021 to May 2024 were included. Data were analyzed to determine prevalence trends across different provinces. Statistical assessments included descriptive analysis, prevalence calculations, and trend evaluation over time.

Results: A total of 1,171 cases of brucellosis were reported across Pakistan from 2021 to 2024. Khyber Pakhtunkhwa had the highest burden with 678 cases (57.9%), followed by Balochistan with 376 cases (32.1%) and Sindh with 111 cases (9.5%). Minimal cases were recorded in Gilgit Baltistan (3 cases) and Azad Jammu & Kashmir (3 cases). No cases were reported in Punjab. The highest annual incidence was in 2023, with 913 cases, accounting for 78% of all reported cases.

Conclusion: This study highlights the significant burden of human brucellosis in Khyber Pakhtunkhwa and Balochistan, emphasizing the need for improved surveillance, vaccination programs, and public health interventions. The absence of reported cases in Punjab may indicate effective control measures or potential underreporting. Strengthening disease monitoring and preventive strategies is essential to reducing brucellosis transmission in high-risk regions.

Keywords: Brucellosis, Epidemiology, Pakistan, Prevalence, Serological Testing, Surveillance, Zoonotic Disease.

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INTRODUCTION

Brucellosis is a zoonotic disease of significant public health concern, affecting both humans and animals globally, including Pakistan. It ranks as the second most important zoonotic disease worldwide, with over 500,000 cases reported annually, according to the World Health Organization (WHO) (1). The causative agent, Brucella, is a genus of aerobic, non-motile, facultative intracellular, Gram-negative bacteria that can persist in epithelial cells, macrophages, dendritic cells, and placental trophoblasts, facilitating its survival and replication within the host (2). Various Brucella species exhibit host preferences; *Brucella melitensis* predominantly infects small ruminants, *Brucella abortus* targets cattle, *Brucella suis* affects pigs, and *Brucella canis* is specific to dogs (3,4). The infection leads to significant clinical consequences in humans, including fever, fatigue, joint pain, and in severe cases, complications such as endocarditis and neurological disorders (5). In animals, brucellosis contributes to reproductive issues such as miscarriages, stillbirths, reduced milk production, and infertility, resulting in substantial economic losses for the livestock industry (6). The disease primarily spreads through direct contact with infected animals, their bodily fluids, or by consuming unpasteurized dairy products (7). Laboratory testing is crucial for diagnosing brucellosis, with various serological and molecular techniques utilized. The Rose Bengal Test (RBT), IgG/IgM ELISA, and PCR are among the most reliable methods for detecting Brucella infections (8). Studies across different countries have highlighted variations in prevalence based on species, diagnostic methods, and geographic regions. For instance, research in Northern Iraq reported brucellosis seroprevalence rates of 3.1% in cattle, 0.7%-4.4% in sheep and goats, and up to 50% in buffalo, depending on the diagnostic method used (9,10). Similarly, studies in India have demonstrated a prevalence of brucellosis ranging from 4.96% to 17.64% based on ELISA and PCR methods (11). Research in Saudi Arabia has also indicated varying seroprevalence rates among camels, sheep, and goats, with higher rates observed in older and female animals (12). The persistence of brucellosis in many regions underscores its complex epidemiology and the challenges associated with its control (13).

Pakistan, with its large livestock population and limited brucellosis control measures, remains vulnerable to the widespread transmission of this disease. The prevalence of brucellosis in Pakistan has been reported in both humans and animals, with seroprevalence rates varying across different regions. Previous reports indicated a 16% infection rate in humans (3), while more recent studies have documented an overall prevalence of 4.35% among high-risk workers in Lahore and Kasur (14,15). Another study in Malakand reported a significantly higher prevalence of 27.47% using ELISA, with distinct variations between different Tehsils (16). Further research in Gilgit and Nagar districts identified notable seroprevalence rates in cattle, yaks, and zos (17). Camel brucellosis studies conducted in Sibi district revealed infection rates ranging from 6.6% to 22.8%, depending on the district and diagnostic method used (18). Seasonal patterns have also been observed in brucellosis incidence, with peaks occurring in spring and summer, as seen in a decade-long study from China (19). Brucellosis poses a significant threat to pregnant women, with studies highlighting its association with spontaneous abortions. A case-control study conducted in Haripur District revealed a seroprevalence of 23.63% among women who had miscarriages, with molecular testing confirming Brucella DNA in the majority of cases (2). Additional studies from Pakistan's Abbottabad, Lahore, and Punjab regions have also documented varying prevalence rates, reinforcing the occupational and dietary risk factors associated with brucellosis transmission (20-22). The disease disproportionately affects individuals with direct exposure to livestock, such as farmers, veterinarians, and butchers, as well as those consuming unpasteurized dairy products. Moreover, demographic factors, including education level and socioeconomic status, have been linked to infection rates, with higher prevalence observed among uneducated and lower-income populations (22).

Despite its profound public health and economic implications, brucellosis remains an underreported and under-researched disease in Pakistan. Limited surveillance and diagnostic facilities contribute to its persistence, necessitating urgent measures to improve awareness, diagnostic capabilities, and control strategies. The present study aims to assess the prevalence of human brucellosis across various provinces of Pakistan from 2021 to 2024. By analyzing recent epidemiological data, the study seeks to provide a comprehensive understanding of brucellosis trends in the country, identify high-risk populations, and contribute to the development of effective prevention and control policies.

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METHODS

This retrospective study was conducted across all provinces and territories of Pakistan, including Balochistan, Khyber Pakhtunkhwa, Punjab, Sindh, Gilgit Baltistan, Islamabad, and Azad Jammu and Kashmir. The study aimed to assess the prevalence of human brucellosis between 2021 and 2024 using secondary data obtained from the National Institute of Health – Integrated Disease Surveillance and Responses (NIH-IDSR) database. A non-probability purposive sampling technique was employed to select relevant data, ensuring the inclusion of reported cases from different regions (18). The study population comprised individuals diagnosed with brucellosis as recorded in the NIH-IDSR database. Inclusion criteria involved all confirmed human cases of brucellosis documented in the national surveillance system, while cases lacking definitive laboratory confirmation or incomplete records were excluded to maintain data reliability. The diagnosis of brucellosis in the included data was based on serological and molecular testing, including the Rose Bengal Plate Test (RBPT), Enzyme-Linked Immunosorbent Assay (ELISA), and Polymerase Chain Reaction (PCR), ensuring accuracy in case identification (12).

Data collection involved extracting relevant epidemiological variables such as patient demographics, geographical distribution, laboratory-confirmed diagnostic results, and reported risk factors. The extracted data were systematically organized and analyzed using appropriate statistical methods. Descriptive statistics were applied to determine the prevalence rates across different provinces and demographic groups. Chi-square tests and logistic regression models were utilized to assess associations between risk factors and disease prevalence, where applicable (8). Ethical approval for the study was sought from the Research Committee of Bashir Institute of Health Sciences. Since secondary data were used, the study did not involve direct patient interaction, and informed consent was not applicable. Nonetheless, all data were anonymized, and confidentiality was maintained in accordance with ethical research guidelines.

RESULTS

A total of 1,171 cases of human brucellosis were reported across Pakistan from 2021 to 2024. The highest number of cases was documented in 2023, with 913 cases, followed by 2024 with 156 cases, 2022 with 69 cases, and the lowest number in 2021 with 33 cases. Khyber Pakhtunkhwa was the most affected province, accounting for 678 cases (57.9%) during this period. Balochistan reported 376 cases (32.1%), Sindh recorded 111 cases (9.5%), while Gilgit Baltistan and Azad Jammu & Kashmir each had 3 cases (0.25%). In 2021, a total of 33 cases were reported, with Khyber Pakhtunkhwa accounting for 26 cases (78.8%), followed by Balochistan with 5 cases (15.2%) and Sindh with 2 cases (6.1%). The distribution of cases within Khyber Pakhtunkhwa showed a peak in August (10 cases), followed by October (5 cases) and December (7 cases).

The number of cases increased in 2022, with 69 cases reported nationwide. Khyber Pakhtunkhwa remained the most affected province, reporting 39 cases (56.5%), followed by Balochistan with 26 cases (37.7%) and Sindh with 4 cases (5.8%). A sharp increase in Khyber Pakhtunkhwa was observed in March (25 cases) and April (12 cases), while Balochistan had the highest incidence in January (24 cases). A significant surge was observed in 2023, with 913 cases reported. Khyber Pakhtunkhwa reported the highest number of cases, with 515 cases (56.4%), followed by Balochistan with 288 cases (31.5%), Sindh with 104 cases (11.4%), Gilgit Baltistan with 3 cases (0.3%), and Azad Jammu & Kashmir with 3 cases (0.3%). The highest incidence was recorded in June, with 356 cases in Khyber Pakhtunkhwa, followed by May (42 cases) and July (25 cases). Similarly, in Balochistan, the peak was observed in August with 81 cases, followed by May (50 cases) and June (43 cases). Sindh reported the highest cases in November (49 cases) and October (21 cases).

By the first 18 weeks of 2024, 156 cases had been reported, with Khyber Pakhtunkhwa contributing 98 cases (62.8%), Balochistan 57 cases (36.5%), and Sindh 1 case (0.6%). The highest incidence in Khyber Pakhtunkhwa occurred in March (25 cases) and February (21 cases), while in Balochistan, April showed the highest count (25 cases), followed by January (15 cases). The overall prevalence of brucellosis in Pakistan between 2021 and 2024 was estimated at 48 cases per 100,000 population. Khyber Pakhtunkhwa had the highest burden, with 678 reported cases, followed by Balochistan with 376 cases, Sindh with 111 cases, and minimal cases in Gilgit Baltistan and Azad Jammu & Kashmir. The findings highlight a significant increase in cases in 2023, particularly in Khyber Pakhtunkhwa and Balochistan, with seasonal variations observed across provinces.

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Table 1 Year-wise Reported Cases of Human Brucellosis in Pakistan (2021-2024)

Year	Total Cases	Khyber Pakhtunkhwa	Balochistan	Sindh	Gilgit Baltistan	Azad Jammu & Kashmir
2021	33	26	5	2	0	0
2022	69	39	26	4	0	0
2023	913	515	288	104	3	3
2024	156	98	57	1	0	0

Table 2 Monthly Distribution of Brucellosis Cases in Khyber Pakhtunkhwa (2023-2024)

Month	Cases in 2023	Cases in 2024
January	0	17
February	0	21
March	0	25
April	3	14
May	42	21
June	356	0
July	25	0
August	19	0
September	19	0
October	16	0
November	14	0
December	21	0

Table 3 Prevalence of Brucellosis in Pakistan (2021-2024) per 100,000 Population

Metric	Value
Total Population (Million)	240.5
Total Cases Reported	1171
Prevalence per 100,000	486.9

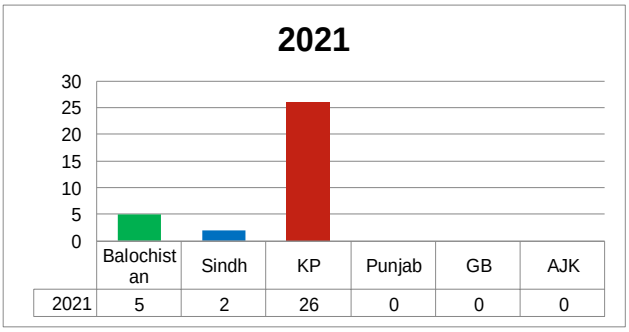

Figure.1.1: Total reported cases of Brucellosis in 2021 in regions of Pakistan

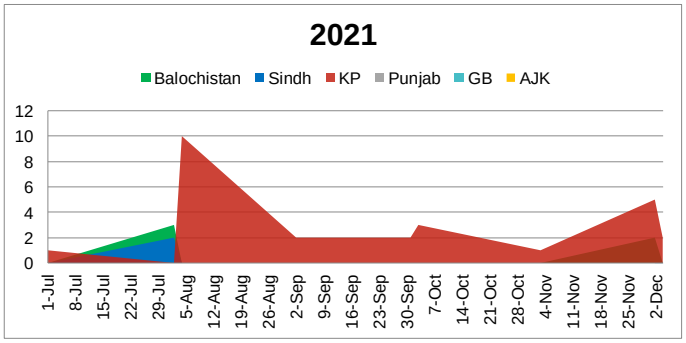

Figure.1.2: Weekly trend of Brucellosis cases in 2021

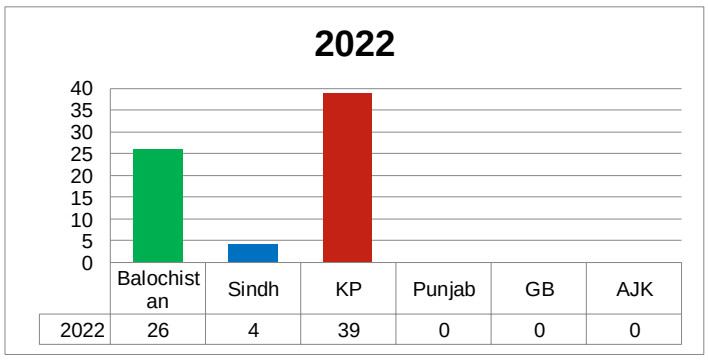

Figure.2.1: No. of cases of brucellosis in regions of Pakistan in 2022

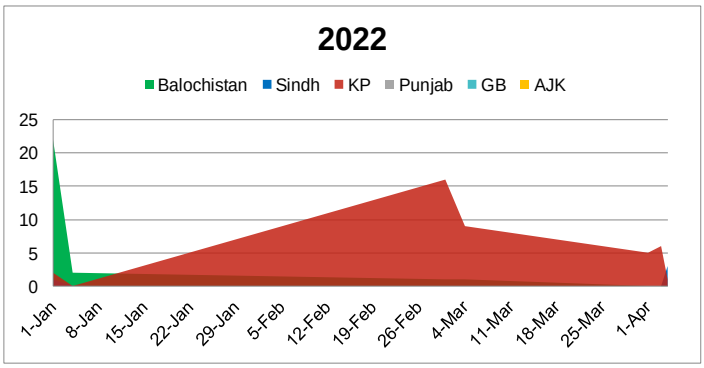

Figure.2.2: Weekly trend of Brucellosis cases in 2022

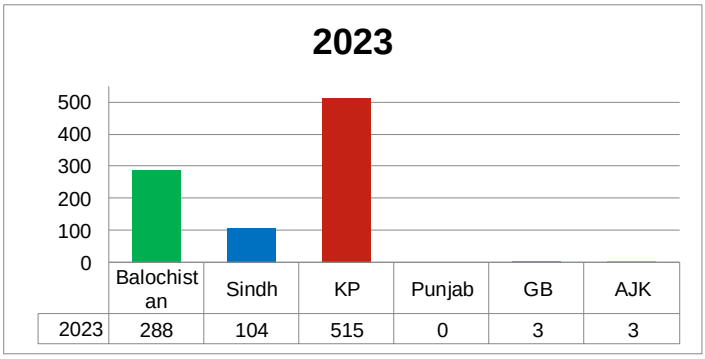

Figure.3.1: No. of cases of brucellosis in regions of Pakistan in 2023

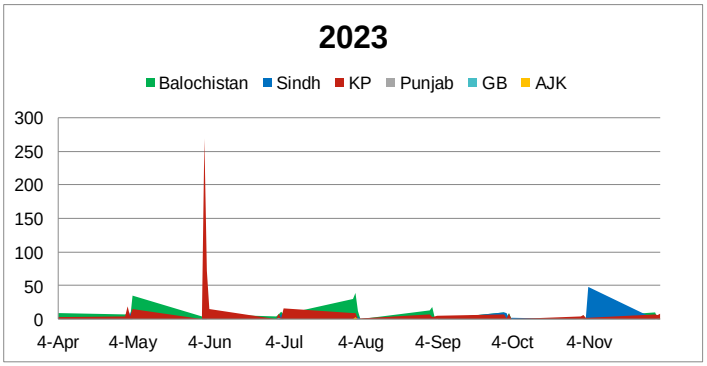

Figure.3.2: Monthly trend of Brucellosis cases in 2023

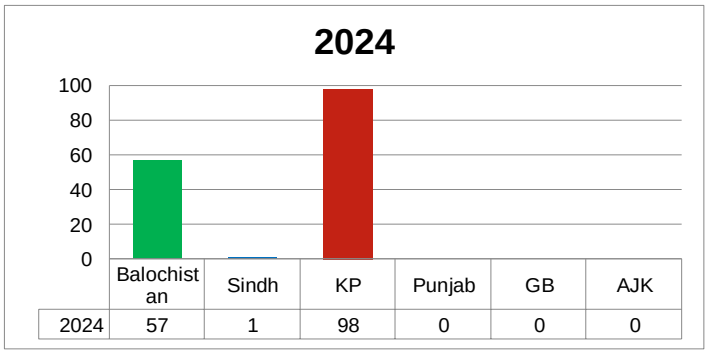

Figure.4.1: No. of cases of brucellosis in regions of Pakistan in 2022

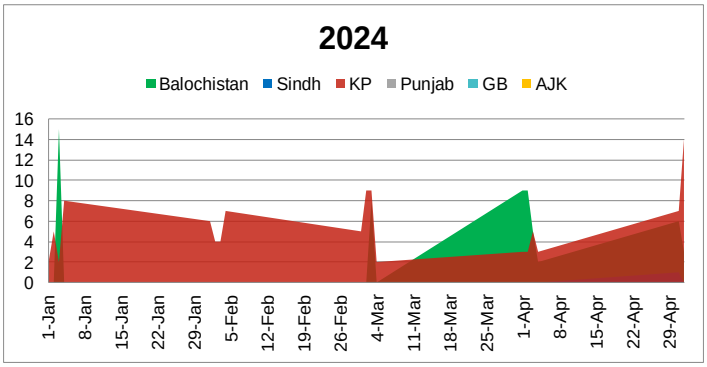

Figure.4.2: Weekly trend of Brucellosis cases in 2024

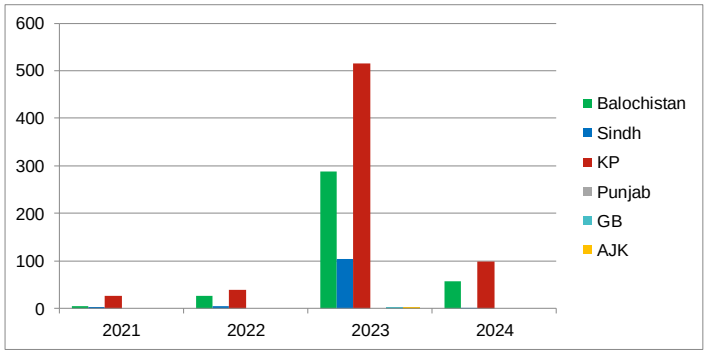

Figure.5.1: Total prevalence of Brucellosis since 2021-2024

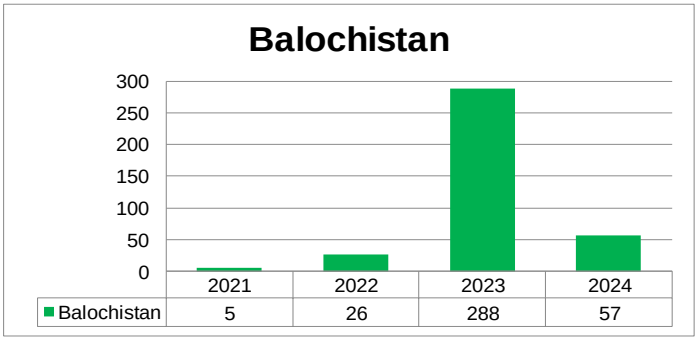

Figure.5.2: Prevalence of Brucellosis in Balochistan since 2021-2024

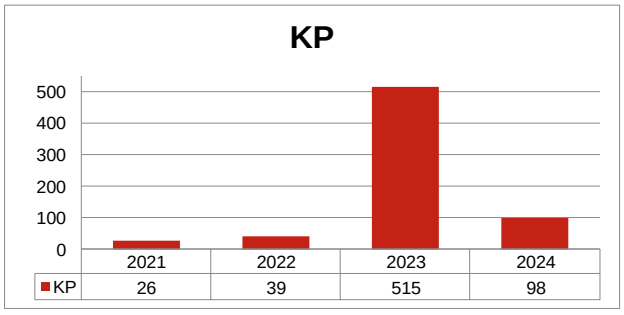

Figure.5.3: Prevalence of Brucellosis in Khyber Pakhtunkhwa since 2021-2024

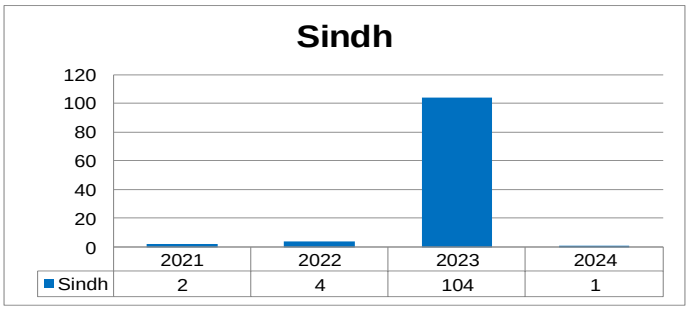

Figure.5.4: Prevalence of Brucellosis in Sindh since 2021-2024

DISCUSSION

Brucellosis remains one of the most neglected zoonotic diseases globally, posing a significant burden on human and animal health. The findings of this study highlight the epidemiological trends of human brucellosis in Pakistan from 2021 to 2024, demonstrating a marked increase in cases in 2023. The overall prevalence of brucellosis in Pakistan was found to be 48 cases per 100,000 population, with Khyber Pakhtunkhwa and Balochistan being the most affected regions. This distribution aligns with global trends, where regions with a high dependence on livestock, unregulated dairy consumption, and limited disease control measures exhibit elevated brucellosis prevalence. Studies from the Eastern Mediterranean, South Asia, and Latin America have also reported significant disease burdens, particularly in areas with extensive livestock farming and insufficient public health interventions (23). The data obtained from the National Institute of Health - Integrated Disease Surveillance and Response (NIH-IDSR) provided valuable insight into disease trends across different regions of Pakistan. Khyber Pakhtunkhwa consistently exhibited the highest number of cases throughout the study period, with a substantial peak in 2023. Balochistan followed as the second most affected province, reflecting a similar trend. The surge in cases in 2023 may be attributed to improved surveillance, increased awareness, or a genuine rise in infection rates due to

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environmental and epidemiological factors. Studies in other endemic regions have identified seasonal variations, with brucellosis cases peaking in warmer months, a pattern that was also observed in this study, where incidence spiked during the summer months (9).

A significant factor contributing to the high prevalence in Khyber Pakhtunkhwa and Balochistan is the extensive livestock-rearing practices and close human-animal interactions. The unregulated consumption of raw dairy products, including unpasteurized milk and soft cheese, remains a primary route of transmission. The majority of cases in endemic regions are linked to occupational exposure, particularly among farmers, veterinarians, and slaughterhouse workers. Previous studies have confirmed the role of occupational risk in brucellosis transmission, with higher infection rates observed in individuals working closely with livestock (23). The findings of this study further support these observations, indicating that the disease burden is more pronounced in rural and agrarian communities. The decline in reported cases in 2024 may suggest improvements in disease management, strengthened surveillance, or underreporting due to limitations in diagnostic accessibility. Despite the reduction, the persistence of brucellosis in Pakistan underscores the need for sustained public health interventions. Countries that have successfully controlled brucellosis have implemented stringent animal vaccination programs, pasteurization of dairy products, and robust surveillance systems. The introduction of these measures in Pakistan could significantly reduce the disease burden. However, limited healthcare infrastructure in rural areas poses a challenge to effective disease control, as diagnostic facilities and treatment options remain inadequate in many affected regions (24).

One of the strengths of this study is its reliance on national surveillance data, which provides a comprehensive overview of the disease burden across multiple years. The use of laboratory-confirmed cases enhances the reliability of the findings, minimizing the risk of overestimation. Additionally, the inclusion of multiple provinces allows for a broader understanding of regional variations and risk factors associated with brucellosis in Pakistan (25,26). Despite its strengths, the study has several limitations. The reliance on secondary data restricts the ability to control for potential biases in case reporting. Underreporting remains a significant concern, particularly in regions with limited access to healthcare facilities. Many cases of brucellosis may go undiagnosed due to the nonspecific clinical presentation of the disease, which often mimics other febrile illnesses. Furthermore, the study did not account for demographic and occupational risk factors, which are crucial for understanding disease transmission dynamics. Future research should focus on assessing the socio-economic determinants of brucellosis, including gender distribution, occupational risks, and access to healthcare services (27-30. The findings of this study reinforce the need for targeted public health interventions to mitigate the spread of brucellosis in Pakistan. Enhancing disease surveillance, promoting vaccination of livestock, and improving awareness regarding safe dairy consumption are critical components of an effective control strategy. Strengthening laboratory diagnostic capabilities, particularly in high-risk regions, could further aid in timely case detection and management. Addressing these challenges through a multidisciplinary approach involving veterinarians, healthcare providers, and policymakers is essential for reducing the burden of brucellosis and preventing future outbreaks.

CONCLUSION

This study highlights the persistent burden of human brucellosis in Pakistan from 2021 to 2024, with a notable concentration of cases in Khyber Pakhtunkhwa, Balochistan, and Sindh. The findings emphasize the significance of brucellosis as a public health concern, particularly in regions with extensive livestock farming and close human-animal interactions. The absence of reported cases in certain areas does not necessarily indicate the absence of the disease but may reflect gaps in surveillance and reporting. Strengthening national surveillance systems, raising public awareness, and implementing preventive measures are crucial for controlling the spread of brucellosis. The study underscores the need for targeted interventions, including improved diagnostic facilities, vaccination programs, and enhanced biosecurity measures, to reduce transmission risks. Future research should focus on understanding the socio-economic and occupational factors contributing to disease prevalence and refining control strategies to mitigate its impact on human health and livestock productivity.

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AUTHOR CONTRIBUTIONS

Author	Contribution
Abrar Ahmed Hasni*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Farah Shaikh	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Sadaf Sarfraz	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Dania Farooq	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Muhammad Sohail	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Muryyum Dilshad	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Fatima Ijaz	Contributed to study concept and Data collection Has given Final Approval of the version to be published
Mohammad Wasiq Waseem	Writing - Review & Editing, Assistance with Data Curation

REFERENCES

1. Jamil T, Khan AU, Saqib M, Hussain MH, Melzer F, Rehman A, et al. Animal and human brucellosis in Pakistan. Frontiers in public health. 2021;9:660508.

2. Iqbal M, Fatmi Z, Khan MA. Brucellosis in Pakistan: a neglected zoonotic disease. JPMA The Journal of the Pakistan Medical Association. 2020;70(9):1625.

3. Qureshi KA, Parvez A, Fahmy NA, Abdel Hady BH, Kumar S, Ganguly A, et al. Brucellosis: epidemiology, pathogenesis, diagnosis and treatment–a comprehensive review. Annals of medicine. 2023;55(2):2295398.

4. Khairullah AR, Kurniawan SC, Puspitasari Y, Aryaloka S, Silaen OSM, Yanestria SM, et al. Brucellosis: Unveiling the complexities of a pervasive zoonotic disease and its global impacts. Open Veterinary Journal. 2024;14(5):1081.

5. Dadar M, Maurin M. Commentary on: Brucellosis in Iraq: A comprehensive overview of public health and agricultural challenges. Ger. J Microbiol. 2025;5(1):1-3.

6. Dadar M, Alamian S, Zowghi E. Comprehensive study on human brucellosis seroprevalence and Brucella species distribution in Iran (1970–2023). Microbial Pathogenesis. 2025;198:107137.

7. Freire ML, Machado de Assis TS, Silva SN, Cota G. Diagnosis of human brucellosis: Systematic review and meta-analysis. PLOS Neglected Tropical Diseases. 2024;18(3):e0012030.

8. Xu N, Wang W, Chen F, Li W, Wang G. ELISA is superior to bacterial culture and agglutination test in the diagnosis of brucellosis in an endemic area in China. BMC infectious diseases. 2020;20:1-7.

9. Almuzaini AM. An epidemiological study of brucellosis in different animal species from the Al-qassim region, Saudi Arabia. Vaccines. 2023;11(3):694.

10. Almashhadany DA, Zefenkey ZF, Odhah MNA. Epidemiological study of human brucellosis among febrile patients in Erbil-Kurdistan region, Iraq. The Journal of Infection in Developing Countries. 2022;16(07):1185-90.

11. Awais MM, Khadim B, Akhtar M, Anwar MI, Khadim G, Shirwany ASAK, et al. Epidemiology of Brucellosis in Small Ruminants of Rural and Peri-Urban Areas of Multan, Pakistan. Canadian Journal of Infectious Diseases and Medical Microbiology. 2024;2024(1):8898827.

12. Akhtar R, Ali MM, Ullah A, Muttalib A, Mehboob K, Ullah A, et al. Genotyping of Brucella strains isolated from humans and cattle of different geographical regions of Pakistan using MLVA-15. Veterinary Medicine and Science. 2021;7(5):1688-95.

13. Laine CG, Johnson VE, Scott HM, Arenas-Gamboa AM. Global estimate of human brucellosis incidence. Emerging Infectious Diseases. 2023;29(9):1789.

14. Mustafa AH, Khaleel HA, Lami F. Human brucellosis in Iraq: spatiotemporal data analysis from 2007-2018. JMIRx Med. 2024;5:e54611.

15. Abbas F, Ali S, Muhammad A, Azam A, Moawad AA, Ejaz M, et al. Human Brucellosis in the Rural and Urban Population of Pakistan: Seroprevalence, Risk Factors, and Clinical Manifestations. Current Microbiology. 2025;82(2):80.

16. Kumari R, Kalyan RK, Jahan A, Jain A, Kumar P, Gupta K, et al. Human Brucellosis: An Observational Study From a Tertiary Care Centre in North India. Cureus. 2023;15(8).

17. Akpabio U, Edward I. Public health importance of brucellosis: a review. Journal of Sustainable Veterinary & Allied Sciences. 2024;6(2).

18. Nawaz Z, Shafique M, Zahoor M, Siddique A, Ali S, Arshad R, et al. RESEARCH ARTICLE Sero-epidemiology and risk factor analysis of human brucellosis in Punjab, Pakistan: a cross sectional study. Tropical Biomedicine. 2021;38(3):413-9.

19. Hassan L, Ali S, Syed MA, Shah AA, Abbasi SA, Tabassum S, et al. Risk factors for acute brucellosis in patients on the day of admission at selected hospitals of Abbottabad, Pakistan. Frontiers in Public Health. 2022;9:669278.

20. Niaz S, Hussain S. Serological Detection, Risk Factor Analysts and Statistical Mapping of Brucellosts in Females of KP Pakistan. IJLAI Transactions on Science and Engineering. 2024;2(2):59-73.

21. Ejaz M, Ali S, Syed MA, Melzer F, Faryal R, Dadar M, et al. Seroprevalence and molecular detection of brucellosis among Pakistani women with spontaneous abortion. Frontiers in Public Health. 2024;12:1372327.

22. Yousaf R, Khan I, Shehzad W, Hussain R, Ali S, Neubauer H, et al. Seroprevalence and molecular detection of brucellosis in hospitalized patients in Lahore hospitals, Pakistan. Infectious Disease Reports. 2021;13(1):166-72.

23. Abbas W, Kalhoro DH, Baloch H, Abubakar M, Kalhoro MS, Wali N, et al. Seroprevalence of Brucella abortus in Yak, Zo and Cows in Gilgit and Nagar Districts of Gilgit-Baltistan, Pakistan. 2022.

24. Almuzaini AM, Aljohani AS, Alajaji AI, Elbehiry A, Abalkhail A, Almujaidel A, et al. Seroprevalence of brucellosis in camels and humans in the Al-Qassim region of Saudi Arabia and its implications for public health. AMB Express. 2025;15(1):22.

25. Rahman H, Kamboh A, Korejo N, Memon A, Korejo R, Chandio M. Seroprevalence of brucellosis in camels in district sibi, balochistan. J Anim Health Prod. 2022;10(2):153-7.

26. Ali S, Saeed U, Rizwan M, Hassan L, Syed MA, Melzer F, et al. Serosurvey and risk factors associated with Brucella infection in high risk occupations from district Lahore and Kasur of Punjab, Pakistan. Pathogens. 2021;10(5):620.

27. Fathabadi A, Khorashadizadeh F, Darrudi R, Maroosi M. Spatio-temporal analysis of human brucellosis distribution in Neyshabur, Iran from 2015 to 2022, a cross-sectional study. PloS one. 2025;20(2):e0318503.

28. Liang P, Zhao Y, Zhao J, Pan D, Guo Z. The spatiotemporal distribution of human brucellosis in mainland China from 2007-2016. BMC Infectious Diseases. 2020;20:1-11.

29. Niaz S, Raqeeb A, Khan A, Amir S, Zhu L, Kumar S. Status of human brucellosis in district Malakand, Khyber Pakhtunkhwa, Pakistan. Journal of Infection and Public Health. 2021;14(3):423-7.

30. Mallappa A, Suresh KP, Shome R, Patil SS, Amachawadi RG, Mohan KS, et al. Systematic review, Meta-analysis, and Pan-genome analytics predict the surging of Brucella melitensis by China and India-specific strains, elucidating the demand for enhanced preparedness. Journal of Infection and Public Health. 2025:102693.

