Volume 4, Issue 1, 2026

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

FOODBORNE DISEASE RISK PATTERNS IN SUKKUR, SINDH: INSIGHTS FROM A CROSS-SECTIONAL POPULATION STUDY

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DOI: https://doi.org/10.5281/zenodo.18323011

Keywords

Foodborne infections, Risk mapping, Cross-sectional study, Sukkur, Public health

Article History

Received: 26 November 2025
Accepted: 07 January 2026
Published: 21 January 2026

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Abstract

Foodborne diseases remain a major public health concern in low- and middle-income countries such as Pakistan, where unsafe food consumption and inadequate hygiene practices contribute to a high disease burden. This cross-sectional study was conducted in Sukkur, Sindh, to assess dietary habits, water and sanitation practices, and the prevalence of foodborne illnesses among the local population. Data were collected from 300 participants using a structured questionnaire. The results indicated widespread engagement in high-risk behaviors, including consumption of unpasteurized milk (77%), street-vended juices (71%), and undercooked animal products (23%). Poor water and sanitation conditions were also common, with only 15% of respondents reporting boiling drinking water and 63% lacking access to proper toilet facilities. Diarrhea (70%) and typhoid fever (18%) were the most frequently reported illnesses. Younger individuals and those from lower-income households were identified as particularly vulnerable to foodborne infections. The findings highlight the urgent need for targeted public health interventions that address both behavioral risk factors and infrastructural deficiencies. Strengthening integrated food safety and Water, Sanitation, and Hygiene strategies is essential to reduce the burden of foodborne diseases in high-risk settings such as Sukkur, Sindh.

INTRODUCTION

Foodborne diseases result from the consumption of food or water contaminated with pathogenic microorganisms, toxins, or chemical hazards and represent a substantial global public health challenge (WHO, 2015; Havelaar et al., 2015; Gambhir et al., 2025). Globally, an estimated 600 million cases of foodborne illness and 420,000 deaths occur annually, with children under five years of age being disproportionately affected due to underdeveloped immunity and poor nutritional status (WHO, 2015; Kirk et al., 2017). Beyond health impacts, foodborne diseases impose significant economic burdens through healthcare expenditures, loss of productivity, and long-term disability (Havelaar et al., 2015; Soomro et al., 2025).

The burden of foodborne diseases is particularly severe in low- and middle-income countries (LMICs), including Pakistan, where weak regulatory frameworks, informal food supply chains, inadequate hygiene practices, and limited access to safe drinking water exacerbate disease transmission (Grace, 2015; Qamar et al., 2023). Rapid urbanization and the widespread consumption of street-vended foods further increase exposure to foodborne pathogens, especially among low-income populations (Bhatti et al., 2019; Newell et al., 2010). In Pakistan, foodborne

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ISSN: (e) 3007-1607 (p) 3007-1593

infections such as diarrhea, typhoid fever, and other enteric diseases remain endemic and continue to strain already limited public health resources (Rasheed et al., 2019; Qamar et al., 2023).

The scientific understanding of foodborne infections is rooted in the germ theory of disease, developed by Louis Pasteur and Robert Koch, which established microorganisms as causative agents of infectious diseases (Madigan et al., 2021). Despite advances in food processing, microbiological surveillance, and public health interventions, foodborne diseases continue to emerge and re-emerge due to globalization of food trade, climate change, environmental degradation, and the growing threat of antimicrobial resistance (Newell et al., 2010; Maitlo et al., 2024; Khan et al., 2025).

In modern public health practice, risk mapping has emerged as a critical tool for assessing the spatial and temporal distribution of foodborne disease risks. By integrating epidemiological, environmental, and socio-economic data, risk mapping enables the identification of geographic hotspots and vulnerable populations, supporting targeted interventions and evidence-based policymaking (Clements et al., 2014; Qin et al., 2025). Recent applications of spatiotemporal analysis and predictive modeling have demonstrated the value of risk mapping in detecting disease clusters and forecasting outbreaks, thereby strengthening early warning systems and resource allocation (Qin et al., 2025; Eisenberg et al., 2016). Against this background, the present study aimed to identify key behavioral and environmental risk factors associated with foodborne infections in the Sukkur region of Sindh, Pakistan, to support targeted public health interventions and integrated food safety and Water, Sanitation, and Hygiene (WASH) strategies.

Materials and Methods

Study Design

A cross-sectional study was conducted in Sukkur and Khairpur, Sindh, Pakistan, following the methodology described by Bhayo et al. (2025).

Sample Size and Sampling

A non-probability purposive sampling technique was employed to recruit 300 confirmed patients, following the protocol described by Samo et al. (2020).

Data Collection and Questionnaire

A structured survey questionnaire was employed to collect data from study participants. Demographic characteristics included age, gender, marital status, occupation, and level of education. Information on food consumption habits, water and sanitation practices, and self-reported clinical symptoms of foodborne illness was also recorded to summarize potential exposure and health outcomes (Shaikh et al., 2024; Soomro et al., 2025; Bhayo et al., 2025). Data were coded and analyzed using Microsoft Excel 2013 for data entry and preliminary analysis, while statistical analyses were performed using Statistix version 8.0.

Results

Demographic Characteristics

A total of 300 participants were included in the study. The gender distribution showed a predominance of males (55%), followed by females (40%) and individuals identifying as other genders (5%). More than half of the participants (54%) belonged to the 16–30 year age group, while 26% were aged 31–45 years. Participants aged 0–15 years accounted for 17%, whereas only 3% were older than 45 years. Educational attainment varied among respondents, with the majority having completed secondary education (42%), followed by graduate-level education (36%). Smaller proportions had primary education (13%) or post-graduate qualifications (6%). From an economic perspective, a substantial majority of participants (81%) reported a monthly household income below PKR 40,000, indicating a predominantly low-income study population. Regarding occupational status, 45% of respondents were engaged in business-related activities, 36% were formally employed, 13% were housewives, and 6% were unemployed. Detailed sociodemographic characteristics of the study population are summarized in Table 1.

Food Consumption Habits and Risk Behaviors

High-risk dietary practices were common among participants (Table 2). Consumption of unpasteurized milk was reported by 77% of respondents, while 71% regularly consumed street-vended juices or sliced fruits. Undercooked meat or eggs were consumed by 23%, and 36% reported using leftovers the next day.

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ISSN: (e) 3007-1607 (p) 3007-1593

Frequent eating outside the home was reported by 25%. These behaviors indicate substantial exposure to potential foodborne pathogens. Figure 1 illustrates the main sources of outside food consumption, highlighting street vendors as the predominant source, followed by small eateries and home-delivered food.

Water and Sanitation Practices

Water and sanitation behaviours revealed potential exposure risks (Table 3). Only 15% of participants reported boiling drinking water, and 37% used the same water for drinking and washing vegetables. While 63% had access to proper toilet facilities, a high proportion practiced handwashing, with 86% washing hands before meals and 89% after toilet use. Figure 2 depicts drinking water sources, showing a reliance on municipal supply and wells, with minimal use of treated bottled water.

Symptoms and Infections

Self-reported symptoms and diagnosed infections reflected the burden of foodborne disease in the study population (Table 4). Diarrhea was the most common symptom (70%), followed by abdominal pain (18%) and vomiting (9%). Fever was reported by 3% of participants. Laboratory-confirmed or clinically diagnosed infections included typhoid (18%), H. pylori (9%), and cholera (3%).

Overall, the results demonstrate that high-risk dietary behaviors, inadequate water treatment, and partial access to sanitation facilities are associated with a significant burden of foodborne illness in the Sukkur region

Table 1. Demographic characteristics of participants (N=300)

Characteristic	Category	Percentage
Gender	Male Female Other	55% 45% 5%
Age Group	0–15 16-15 31–45 45+	17% 54% 26% 3%
Education Level	Primary Secondary Graduate Post-graduate	13% 42% 36% 6%
Monthly Income (PKR)	< 40,000 40,000–100,000 > 100,000	81% 13% 6%
Occupation	Unemployed Housewife Employed Business	6% 13% 36% 45%

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Table 2. Food consumption habits and risk behaviors

Behavior	Yes	No
Consume unpasteurized milk	77%	23%
Eat undercooked meat/eggs	23%	77%
Consume street juices/sliced fruits	71%	29%
Use leftovers the next day	36%	64%
Frequent eating outside	25%	75%

Table 3. Water and Sanitation Practices

Practice	Yes	No
Use same water for drinking and washing vegetables	37%	63%
Boil drinking water	15%	85%
Access to proper toilet facilities	63%	37%
Wash hands before meals	86%	14%
Wash hands after toilet use	89%	11%

Table 4. Sign and Symptoms and Infections

Symptom	Percentage
Diarrhea	70%
Abdominal pain	18%
Vomiting	9%
Fever	3%
Type Infection	
Diarrhea	70%
Typhoid	18%
H. pylori	9%
Cholera	3%

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ISSN: (e) 3007-1607 (p) 3007-1593

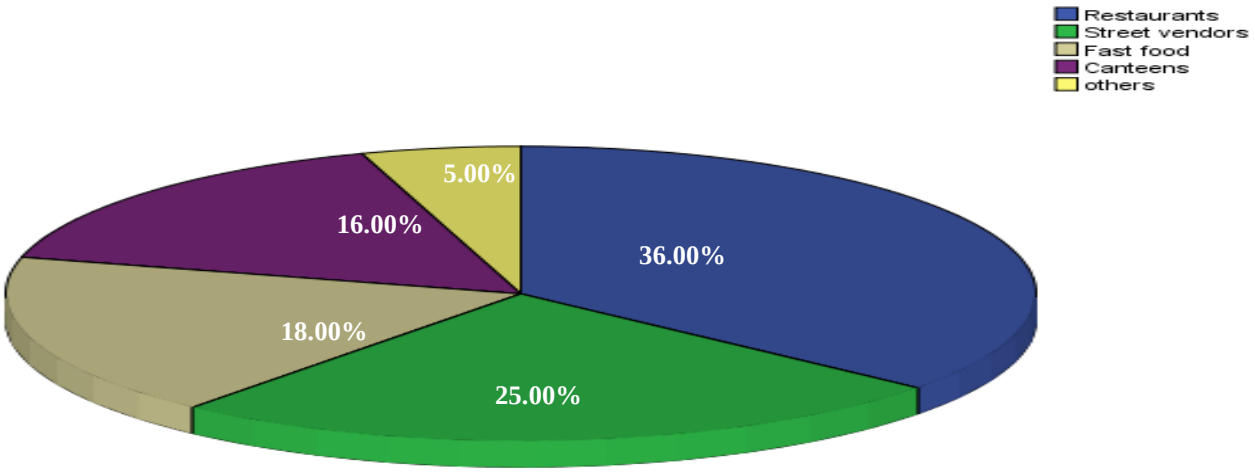

Figure 1. Sources of food consumption

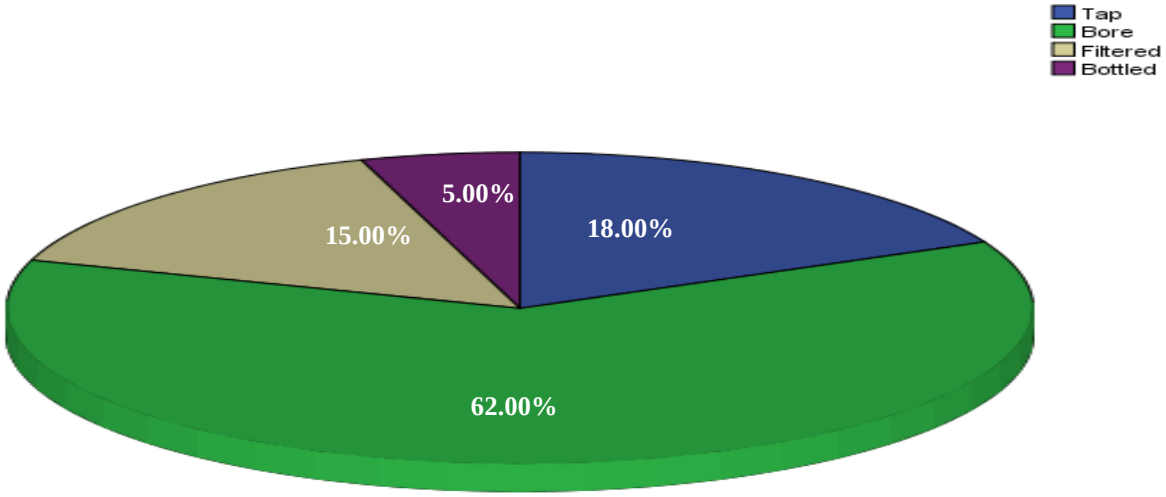

Figure 2. Source of water

Discussion

This study provides a comprehensive, community-based assessment of foodborne infection risks in the Sukkur region of Sindh, Pakistan, offering critical insights into the behavioral, environmental, and socio-economic drivers of disease transmission in a low-resource urban setting. The findings reveal a convergence of unsafe dietary practices, inadequate water and sanitation behaviors, and socio-demographic vulnerabilities that collectively amplify the burden of foodborne and enteric infections. Unsafe food consumption behaviors were highly prevalent among the study population. The widespread intake of unpasteurized milk (77%) represents a major public health concern, as raw dairy products are well-documented reservoirs of pathogens such as *Salmonella* spp., *Brucella spp., Campylobacter jejuni*, and Listeria monocytogenes (Grace et al., 2021;

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Nadira et al., 2024). Similarly, the frequent consumption of street-vended juices and sliced fruits (71%) underscores the role of informal food systems in disease transmission. These foods are often prepared under unhygienic conditions, exposed to environmental contaminants, and handled with unsafe water and poor personal hygiene, creating ideal conditions for microbial proliferation (Islam et al., 2022; Grace, 2023).

Consumption of undercooked meat or eggs (23%) and reuse of leftovers (36%) further elevate the risk of exposure to foodborne pathogens such as *Escherichia coli, Salmonella*, and *Staphylococcus aureus*. In LMIC settings, limited access to refrigeration and inadequate food storage practices exacerbate these risks, particularly during hot climatic conditions common to Sindh (Kirk et al., 2017; Qamar et al., 2023). These findings collectively highlight the need for targeted food safety education emphasizing safe cooking, storage, and reheating practices at the household and community levels.

Water and sanitation practices emerged as critical determinants of infection risk. Only 15% of participants reported boiling drinking water, while a substantial proportion relied on untreated municipal or well water sources. The use of the same water for drinking and washing vegetables (37%) significantly increases the likelihood of cross-contamination, particularly in environments where microbial water quality is compromised (WHO, 2019). Although handwashing practices were reported at relatively high levels (86–89%), the protective effect of hand hygiene is substantially diminished when safe water and sanitation infrastructure are lacking (Freeman et al., 2020).

Access to proper toilet facilities was reported by 63% of respondents, indicating persistent gaps in sanitation coverage. Open defecation or poorly maintained sanitation systems contribute to environmental contamination and fecal–oral transmission pathways, reinforcing the cyclical nature of foodborne and waterborne diseases (Prüss-Ustün et al., 2019). These findings support global evidence that behavioral interventions alone are insufficient without concurrent improvements in WASH infrastructure.

Socio-economic status emerged as a key modifier of foodborne disease risk. The predominance of low-income households (81% earning < PKR 40,000 per month) reflects economic constraints that limit access to safe food, clean water, and adequate sanitation. Financial limitations often compel households to rely on cheaper, informal food sources and untreated water, despite awareness of potential health risks (Grace, 2015; Shaikh et al., 2025).

Young adults aged 16–30 years constituted the largest demographic group (54%) and exhibited higher exposure to foodborne risks, likely due to increased consumption of foods prepared outside the home. Similar age-related patterns have been documented in Pakistan and other LMICs, where younger populations demonstrate greater mobility, occupational exposure, and reliance on street foods (Bhatti et al., 2019; Qamar et al., 2023). These findings suggest that interventions targeting youth, including workplace and university-based food safety programs, may yield substantial public health benefits.

The high prevalence of diarrhea (70%), typhoid fever (18%), and *Helicobacter pylori* infection (9%) observed in this study aligns with regional and global burden estimates. The World Health Organization has consistently identified unsafe food and water as leading contributors to diarrheal morbidity in South Asia (WHO, 2015, 2019). Similarly, the Global Burden of Disease studies attribute a significant proportion of enteric infections to contaminated food, particularly in settings with weak regulatory oversight (Kirk et al., 2017).

The presence of typhoid fever remains a critical concern in Pakistan, where antimicrobial-resistant *Salmonella typhi* strains have further complicated disease management (Khan et al., 2025). The observed prevalence of *H. pylori* infection is also consistent with previous reports linking poor sanitation and contaminated food and water to chronic gastrointestinal infections (Maitlo et al., 2025).

The findings of this study underscore the interconnected nature of food safety, water quality, sanitation, and socio-economic conditions in shaping foodborne disease risk. Addressing these challenges requires integrated, multi-sectoral public health strategies that extend beyond individual behavior change. Strengthening food safety regulations for informal food vendors, promoting affordable household water treatment technologies, and

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ISSN: (e) 3007-1607 (p) 3007-1593

improving urban WASH infrastructure are critical priorities.

Risk mapping at the community level, as demonstrated in this study, offers a valuable tool for identifying high-risk populations and geographic hotspots, enabling more efficient allocation of limited public health resources. Tailored interventions targeting young adults and economically disadvantaged households are particularly important for reducing disease burden and improving health equity in the Sukkur region and similar urban settings across Pakistan.

Conclusion

This study highlights major gaps in food safety and hygiene in Sukkur, Sindh. High consumption of unpasteurized milk, street-vended foods, and undercooked animal products, along with inadequate water treatment and limited sanitation, contributes to foodborne infections. Diarrhea and typhoid were particularly prevalent. These findings underscore the need for urgent, integrated public health interventions. Strengthening community awareness, improving water and sanitation infrastructure, and enforcing food safety regulations are essential. Targeted measures for young adults and low-income populations are critical. Multi-level interventions can reduce the incidence and impact of foodborne diseases in this vulnerable region.

Recommendations

Community-based programs should be implemented to promote hygiene and food safety education, alongside efforts to improve access to clean water and encourage household water treatment. Strengthening food safety monitoring and regulation, particularly for street vendors, is essential, while enhancing diagnostic and treatment facilities for foodborne infections will improve health outcomes. Additionally, conducting longitudinal studies is recommended to monitor trends and assess the effectiveness of interventions.

Conflict of Interest

The authors declare no conflict of interest.

Acknowledgments

Authors acknowledge the staff members of GMMC Sukkur, Hira Medical Centre, Sukkur and KMC Civil Hospital, Khairpur. Additionally authors are thankful to Mr Faiq Narejo, Mr. Shakeel and Dr Syed Amir Hyder for their help in conducting research.

REFERENCES

Bhatti, R. S., Sarfraz, S., & Raza, S. (2019). Foodborne Diseases: Causative Agents, Prevalence and Control. *Lahore Garrison University Journal of Life Sciences*, *3*(2), 108-120. DOI: 10.54692/lgujls.2019.030263

Bhatti, S. A., Shah, A. H., & Hussain, A. (2019). Foodborne diseases and associated risk factors in developing countries. *Journal of Infection and Public Health, 12*(6), 765–772. https://doi.org/10.1016/j.jiph.2019.05.012

Bhayo, F.A., Soomro, A.A, Moazzam Hussain Hajano, M.H., Bhatti, Z. Z., Soomro, M.B., Maitlo, M.A. (2025). Prevalence and associated risk factors of viral hepatitis in the Khairpur region, Pakistan. (2025). *Frontier in Medical and Health Research*, *3*(10), 2132-2138.

Clements, A. C. A., Pfeiffer, D. U., & Martin, V. (2014). Application of Bayesian spatial analysis methods for disease mapping. *International Journal of Health Geographics*, 13, 10. https://doi.org/10.1186/1476-072X-13-10

Eisenberg, J. N. S., Desai, M. A., Levy, K., Bates, S. J., Liang, S., Naumoff, K., & Scott, J. C. (2016). Environmental determinants of infectious disease: A framework for tracking causal links. *Environmental Health Perspectives*, 115(8), 1216–1223. https://doi.org/10.1289/ehp.9659

Freeman, M. C., Garn, J. V., Sclar, G. D., Boisson, S., Medlicott, K., Alexander, K. T., ... Clasen, T. (2020). The impact of sanitation on infectious disease and nutritional status: A systematic review. *International Journal of Hygiene and Environmental Health, 220*, 928–949. https://doi.org/10.1016/j.ijheh.2017.05.007

Gambhir, M. R., Lal, S., Shaikh, S. H., Zaidi, S. A. S., Khuhro, F. A., Kanhar, A. R., & Mailto, M. A. (2025). Unsafe sips: Prevalence of pathogenic bacterial diversity in drinking water of Khairpur City, *Pakistan. Insights-Journal of Health and Rehabilitation*, 3(3), 141–148.

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

Grace, D. (2015). Food safety in low and middle income countries. *International Journal of Environmental Research and Public Health, 12*(9), 10490–10507. https://doi.org/10.3390/ijerph120910490

Grace, D. (2023). Food safety in South Asia: Status, challenges and the way forward. *Global Food Security, 36*, 100678. https://doi.org/10.1016/j.gfs.2023.100678

Havelaar, A. H., Kirk, M. D., Torgerson, P. R., et al. (2015). World Health Organization global estimates and regional comparisons of the burden of foodborne disease. *PLoS Medicine, 12*(12), e1001923. https://doi.org/10.1371/journal.pmed.1001923

Islam, M. S., Rahman, M. M., & Kabir, M. H. (2022). Risk factors and prevalence of foodborne infections in urban Bangladesh: A cross-sectional study. *Journal of Infection and Public Health, 15*(5), 512–518. https://doi.org/10.1016/j.jiph.2022.03.006

Jatt, T., Maitlo, M. A., Shaikh, S. H., & Catanho, D. P. Z. (2023). Application of Flow Cytometry in Biological Sciences. In *Genome Size and Genetic Homogeneity of Regenerated Plants: Methods and Applications* (pp. 232-271). Bentham Science Publishers.

Khan, M. I., Ahmed, R., & Ali, S. (2025). Climate change and emerging foodborne infections in South Asia. *Environmental Health Perspectives, 133*(2), 027001.

Khan, M., Khan, S., & Basharat, S. (2025). Exacerbating Crises: The Devastating Impact of Climate Change and Antibiotic Resistance on Human and Animal Health in Pakistan. *Journal of the College of Physicians and Surgeons-Pakistan: JCPSP, 35*(9), 1203-1206. DOI: 10.29271/jcpsp.2025.09.1203

Kirk, M. D., Pires, S. M., Black, R. E., et al. (2017). World Health Organization estimates of the global burden of foodborne diseases. *Clinical Infectious Diseases, 63*(1), 1–11. https://doi.org/10.1093/cid/ciw695

Madigan, M. T., Bender, K. S., Buckley, D. H., Sattley, W. M., & Stahl, D. A. (2021). *Brock biology of microorganisms* (16th ed.). Pearson.

Maitlo, M. A., Qazi, M. A., & Shar, A. H. (2024). Exploring the potential of biosurfactant-producing endophytic Pseudomonas aeruginosa SF1R in medical therapeutics. *Journal of Population Therapeutics and Clinical Pharmacology*, 31(9), 4378–4386.

Maitlo, M. A., Qazi, M. A., Shaikh, S. H., Phulpoto, I. A., Maitlo, R. R., Bhatti, M. S. I., & Shar, A. H. (2025). Microbial Biosurfactants: A review of their Classification and Multidimensional Applications. *Planta Animalia*, *4*(2), 155-163.

Nadira, F., Ahmad, S., & Riaz, M. (2024). Socioeconomic determinants of unpasteurized milk consumption in rural Punjab, Pakistan. *Food Control, 158*, 110245. https://doi.org/10.1016/j.foodcont.2023.110245

Newell, D. G., Koopmans, M., Verhoef, L., et al. (2010). Food-borne diseases—The challenges of 20 years ago still persist while new ones continue to emerge. *International Journal of Food Microbiology, 139*(Suppl. 1), S3–S15. https://doi.org/10.1016/j.ijfoodmicro.2010.01.021

Prüss-Ustün, A., Wolf, J., Bartram, J., Clasen, T., Cumming, O., Freeman, M. C., Johnston, R. (2019). Burden of disease from inadequate water, sanitation and hygiene. *Tropical Medicine & International Health, 24*(2), 153–169. https://doi.org/10.1111/tmi.13161

Qamar, F. N., Yousafzai, M. T., Khalid, M., & Rasheed, S. (2023). Burden and prevention of foodborne illnesses in Pakistan. *Eastern Mediterranean Health Journal, 29*(4), 289–297.

Qamar, K., Nchasi, G., Yousuf, J., Mirha, H. T., Kumar, P., Islam, Z., & Malikzai, A. (2023). Food toxicity in Pakistan: a mini-review on foodborne diseases. *IJS Global Health*, *6*(6), e0333. DOI: 10.1097/GH9.0000000000000333

Qin, K., Dai, X., Wu, L., & Gao, M. (2025). Spatiotemporal analysis and risk prediction of foodborne diseases based on meteorological risk factors: a case study of Wuxi city, China. *BMC Infectious Diseases*, *25*(1), 1206. https://doi.org/10.1186/s12879-025-11686-9

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

Qin, Y., Zhang, L., Wang, J., & Li, X. (2025). Spatiotemporal risk mapping and prediction of foodborne diseases. *International Journal of Environmental Research and Public Health, 22*(3), 2145. https://doi.org/10.3390/ijerph22032145

Rasheed, S., Qadir, A., & Hussain, M. (2019). Street food consumption patterns and food safety awareness in urban Pakistan. *Food Control, 98*, 270–277. https://doi.org/10.1016/j.foodcont.2018.11.014

Shaikh, S. H., Khuhro, F. A., Zardari, J. A., Khuhro, R., Zaidi, S. A. S., Solangi, J. A., & Mailto, M. A. (2024). Prevalence of diabetes mellitus type II and usefulness of HbA1c as a diagnostic criterion. *Journal of Health and Rehabilitation Research, 4*(3), 1–6.

Shaikh, S., Soomro, A., & Bhayo, M. (2024). Behavioral determinants of foodborne infections in Sindh province. *Pakistan Journal of Public Health, 14*(2), 45–53.

Soomro, A. A., Shaikh, S. H., Maitlo, M. A., Muhummad, D., Lutufullah Bhayo, L., & Kumar, S. (2025). Gender and age-specific distribution of anti-CCP antibodies in rheumatoid arthritis: A single-center study. *Review Journal of Neurological & Medical Sciences Review, 3*(8), 12–18.

Soomro, A., Bhayo, M., & Shaikh, S. (2025). Food safety knowledge, attitudes, and practices among urban populations in Pakistan. *Journal of Food Protection, 88*(1), 112–120. https://doi.org/10.4315/JFP-22-123

World Health Organization. (2015). WHO estimates of the global burden of foodborne diseases: foodborne disease burden epidemiology reference group 2007–2015. *Geneva, Switzerland*.