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Original Article

Prevalence of Foodborne Diseases and the Role of Hygiene Practices in Prevention

Muhammad Talha Aziz[1], Tajwer Shahana[2], Uzma Abbasi[3], Dua Ayoob Zardari[4], Mehreen Nisha Abbasi[4], Aleena Jamshaid[5]

[1] Doctor of Veterinary Medicine and Master of Public Health, St. Francis College, Brooklyn, New York, United States of America
[2] Public Health Specialist, Liaquat University of Medical and Health Sciences, Jamshoro, Pakistan
[3] Health Education Officer and Lecturer, Institute of Public Health, Peoples University of Medical and Health Sciences for Women, Nawabshah, Pakistan
[4] Master of Science in Public Health, Peoples University of Medical and Health Sciences for Women, Nawabshah, Pakistan
[5] PMAS Arid Agriculture University, Rawalpindi, Pakistan

***Corresponding author: Muhammad Talha Aziz, maziz4@sfc.edu**

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ABSTRACT

Background: Foodborne illness remains an important public-health problem in settings with unsafe water, inadequate food storage, and inconsistent household hygiene. Community-level evidence from Nawabshah is limited. Objective: To estimate the prevalence of self-reported probable foodborne illness and examine its association with sociodemographic characteristics and household food-hygiene practices among urban and rural residents. Methods: A community-based cross-sectional study included 420 adults selected through multistage household sampling from urban and rural Nawabshah. Data were collected using an interviewer-administered questionnaire covering gastrointestinal symptoms, handwashing, drinking-water safety, separation of raw and cooked food, leftover storage, and street-food consumption. Associations were examined using chi-square tests and multivariable logistic regression. Results: Probable foodborne illness was reported by 138 participants, giving a prevalence of 32.9% (95% CI, 28.5%–37.5%). Prevalence was higher among rural than urban residents (39.0% versus 26.7%; p=0.007) and decreased with increasing educational attainment (p=0.001). Poor handwashing was the strongest independently associated factor (adjusted OR, 2.31; 95% CI, 1.47–3.63), followed by unsafe drinking water (adjusted OR, 1.88; 95% CI, 1.18–2.98), delayed refrigeration of leftovers (adjusted OR, 1.83; 95% CI, 1.13–2.96), and failure to separate raw and cooked food (adjusted OR, 1.72; 95% CI, 1.07–2.76). Frequent street-food consumption was not significant after adjustment. Conclusion: Probable foodborne illness was common and was associated with several modifiable household water and food-hygiene practices. Keywords: Foodborne illness; food hygiene; food safety; handwashing; drinking water; cross-contamination; rural health; Nawabshah; Pakistan.

INTRODUCTION

Foodborne diseases comprise a broad range of illnesses resulting from the consumption of food or water contaminated with pathogenic bacteria, viruses, parasites, toxins, or hazardous chemicals. Their clinical manifestations commonly include diarrhoea, vomiting, nausea, abdominal pain, and fever, although severe infections may lead to dehydration, systemic infection, renal complications, prolonged disability, or death. Children, pregnant women, older adults, and immunocompromised individuals are particularly susceptible to serious outcomes. Beyond their immediate clinical consequences, foodborne illnesses impose substantial social and economic burdens through healthcare expenditure, nutritional impairment, loss of productivity, school absenteeism, and reduced household income.

Foodborne diseases remain a major global public-health concern. Estimates from the World Health Organization indicate that foodborne hazards cause a substantial number of illnesses and considerable loss of healthy life worldwide, with children younger than five years carrying a disproportionate share of the burden (1,2). Norovirus is among the leading causes of acute gastroenteritis, whereas non-typhoidal Salmonella remains an important bacterial cause of diarrhoeal illness globally (3,4). Even countries with well-established surveillance systems report a high incidence of foodborne illness (5). The burden is likely to be underestimated in low- and middle-income countries because many affected individuals self-medicate, do not seek formal healthcare, or are not investigated through laboratory testing. Consequently, routine surveillance records capture only a proportion of the actual community burden.

Food safety remains a persistent challenge in Pakistan because contamination can occur throughout the food chain, including production, transportation, storage, preparation, serving, and household consumption. Published evidence has identified inadequate surveillance, limited laboratory capacity, unsafe water, poor temperature control, inappropriate food storage, food adulteration, weak regulatory enforcement, and inconsistent inspection practices as major contributors to foodborne illness in the country (6–8). Studies conducted in institutional and commercial food settings have documented deficiencies in food-handler knowledge, hand hygiene, sanitation, and food-storage practices, together with microbial contamination of ready-to-eat foods and food-contact surfaces (9–12). Salmonella species, including antimicrobial-resistant isolates, have also been detected in street-vended foods in Pakistan, indicating that contaminated ready-to-eat food may represent an important public-health hazard (10).

Several foodborne pathogens are epidemiologically relevant in Pakistan. Norovirus has been detected in human clinical samples through a One Health investigation conducted in Punjab, while contaminated food, water, fresh produce, and inadequately cooked animal products may contribute to transmission of enteric and parasitic infections (13,14). Extensively drug-resistant Salmonella Typhi presents an additional concern because treatment failure, prolonged illness, and increased healthcare costs may occur when effective antimicrobial options are limited (15). Nevertheless, gastrointestinal symptoms alone cannot identify the responsible pathogen or confirm that an illness originated from food. Community surveys therefore measure probable foodborne illness through predefined symptom-based criteria while recognising that such cases are not equivalent to clinically or microbiologically confirmed disease.

Many determinants of foodborne illness are potentially modifiable through appropriate household and community practices. Handwashing with soap, use of microbiologically safe drinking water, adequate cooking, separation of raw and cooked food, cleaning of utensils and preparation surfaces, protection of prepared food from environmental contamination, prompt refrigeration, and thorough reheating of leftovers are fundamental food-safety measures. Research from developing settings has shown that food-safety knowledge and practices are frequently inadequate and that satisfactory knowledge does not necessarily translate into safe behaviour (16–19). Education, food-safety training, access to clean water, workplace conditions, sanitary facilities, and availability of appropriate storage equipment can influence food-handling practices (20–22). Household food handlers are particularly important because a considerable proportion of food is prepared, served, and stored within the home (23). Street-vended food may present additional risks when vendors have limited access to clean water, waste disposal, refrigeration, pest control, and protection from dust or environmental contamination (20,21,24). Regular cleaning and sanitation therefore remain essential components of foodborne disease prevention (25).

Patterns of food exposure and access to preventive resources may differ between urban and rural populations. Urban residents may consume more commercially prepared and ready-to-eat food and may experience greater exposure to restaurants, markets, canteens, and street vendors. Rural households may rely more heavily on locally produced foods, untreated water sources, household preparation, and storage arrangements that differ from those available in urban settings. Differences in education,

sanitation, refrigeration, health information, food inspection, and access to healthcare may further influence the occurrence and reporting of gastrointestinal illness. These contextual differences require direct investigation rather than assuming that food-safety risks are uniform across populations.

Nawabshah, officially known as Shaheed Benazirabad District, includes densely populated urban communities and surrounding rural settlements with potentially different food-handling environments and water, sanitation, and storage conditions. Despite the public-health relevance of foodborne illness, community-level evidence from the district remains limited, particularly regarding differences between urban and rural residents and the relationship between illness and routine household hygiene practices. Most available Pakistani studies have focused on food handlers, institutional food services, university cafeterias, or microbiological contamination of selected foods rather than symptom-defined illness within the general community.

The present study therefore aimed to estimate the prevalence of self-reported probable foodborne illness among adults residing in selected urban and rural communities of Nawabshah and to examine its association with sociodemographic characteristics and food-hygiene practices. The principal practices assessed included handwashing with soap, drinking-water safety, separation of raw and cooked food, storage of cooked leftovers, and frequency of street-food consumption. It was hypothesised that unsafe water and food-handling practices would be associated with greater odds of probable foodborne illness after adjustment for relevant demographic and residential characteristics.

MATERIALS AND METHODS

A community-based cross-sectional study was conducted among adults residing in selected urban and rural communities of Nawabshah, officially designated Shaheed Benazirabad District, Sindh, Pakistan. The cross-sectional design was selected to estimate the prevalence of self-reported probable foodborne illness and evaluate its association with contemporaneously reported household food-handling and hygiene practices. Data were collected from residential areas of Nawabshah city and surrounding rural communities to permit comparison between settings that could differ in water sources, sanitation, food-storage facilities, food-consumption patterns, and access to health information.

The target population comprised adults aged 18 years or older who had resided in the selected community for at least six months. One eligible adult was recruited from each selected household. Because the study focused on household food practices, priority was given to an adult who was principally involved in purchasing, preparing, cooking, storing, or serving food. When more than one household member met the relevant eligibility conditions, one participant was selected through a simple random procedure. Temporary visitors, individuals who were seriously ill at the time of data collection, persons unable to participate in the interview, and those who declined consent were excluded.

The required sample was estimated using the single-population proportion formula, (n=Z^2p(1-p)/d^2). A 95% confidence level, an anticipated prevalence of 50%, and a 5% absolute margin of error were used. An expected prevalence of 50% was selected because a reliable community-level estimate for Nawabshah was unavailable and this assumption generated the maximum required sample for the specified precision. The initial estimate was 384 participants. After allowing approximately 10% for nonresponse or incomplete questionnaires, the recruitment target was approximately 423 participants. During fieldwork, 438 eligible residents were approached, of whom 420 completed the survey and were included in the final analysis, corresponding to a response rate of 95.9%. Equal numbers of participants were recruited from urban and rural settings, with 210 individuals included from each stratum to support direct comparison between the two residential groups.

Participants were selected through a multistage sampling procedure. Urban neighbourhoods and rural union councils were first selected from within the district, after which streets and villages were selected from the respective sampling areas. Households within each selected locality were approached

systematically. The estimated number of households in each locality was divided by the required locality-specific sample to determine the household sampling interval. A random starting household was identified, after which every household corresponding to the predetermined interval was approached. When a selected household was locked or no eligible participant was available, the data-collection team made a repeat visit. If recruitment remained unsuccessful, the next eligible household was approached.

Data were collected using a structured, interviewer-administered questionnaire developed after reviewing published studies concerning foodborne illness, consumer food-safety behaviour, household food handling, and hygiene practices (16–23). The questionnaire covered sociodemographic characteristics, recent gastrointestinal symptoms attributed by participants to suspected unsafe food, personal hygiene, drinking-water sources, household food preparation and storage, kitchen sanitation, waste disposal, environmental contamination, and street-food consumption. Sociodemographic information included age, sex, education, occupation, residential setting, and household size.

Participants were asked about diarrhoea, vomiting, nausea, abdominal pain, and fever occurring in temporal association with consumption of food they considered potentially unsafe. For the purposes of the survey, probable foodborne illness was operationally defined as self-reported diarrhoea or vomiting after consumption of suspected unsafe food, with or without accompanying nausea, abdominal pain, or fever. This operational classification represented a symptom-based epidemiological outcome rather than a clinically or microbiologically confirmed diagnosis. Symptoms clearly attributed during the interview to pregnancy, medication use, or an established chronic medical condition were not classified as probable foodborne illness.

Personal hygiene was assessed through questions regarding handwashing before preparing food, before eating, after using the toilet, and after handling raw meat. Participants were also asked whether soap and clean water were routinely used. Handwashing practice was classified as adequate when the participant reported washing with soap and water at essential times, including before food preparation and after toilet use; practices that did not satisfy these criteria were classified as poor handwashing.

Food-handling practices included washing fruits and vegetables, cooking meat thoroughly, checking expiry dates, reheating leftovers, refrigerating cooked food, cleaning preparation surfaces, and keeping raw foods separate from cooked or ready-to-eat foods. Failure to separate raw and cooked food included storing or handling these foods together or using the same utensils or preparation surfaces without adequate cleaning between tasks. Cooked leftovers retained at room temperature for more than two hours were classified as being stored unsafely. Street-food consumption was classified as frequent when participants reported consuming street-vended food three or more times per week.

Drinking-water sources were assessed according to their reported source and treatment. Water obtained from protected sources or subjected to filtration, boiling, or another household treatment method was classified as safe, whereas untreated groundwater, unprotected wells, and other uncontrolled sources were classified as unsafe. Additional environmental observations and self-reported practices included kitchen cleanliness, waste disposal, food covering, and the presence of flies or other insects in food-preparation areas.

The questionnaire was reviewed for content and comprehensibility by individuals with expertise in public health, epidemiology, and food safety. It was translated from English into Urdu and Sindhi and independently back-translated into English to assess conceptual consistency across language versions. A pilot assessment was conducted among adults from a community not included in the main survey. Questions identified as unclear or difficult to interpret were revised before the principal data collection. Data collectors received standardised training in household selection, participant recruitment, interview administration, informed consent, confidentiality, operational definitions, and completion of the questionnaire. Field supervisors reviewed completed questionnaires each day to identify incomplete,

inconsistent, or implausible responses. Questionnaires with substantial missing information that prevented determination of the primary outcome or principal exposures were excluded from analysis.

Data were entered and analysed using IBM SPSS Statistics version 26.0. Continuous variables were summarised using means and standard deviations, whereas categorical variables were presented as frequencies and percentages. The prevalence of probable foodborne illness was calculated by dividing the number of participants meeting the operational case definition by the total number included in the analysis, and the corresponding 95% confidence interval was estimated. Associations between probable foodborne illness and categorical demographic, residential, water, hygiene, and food-handling variables were initially examined using Pearson's chi-square test.

Multivariable binary logistic regression was subsequently used to estimate adjusted associations between the selected hygiene practices and probable foodborne illness. The dependent variable was the presence or absence of probable foodborne illness. Independent variables included handwashing practice, drinking-water safety, separation of raw and cooked food, storage of cooked leftovers, and frequency of street-food consumption. Age, sex, educational level, and urban or rural residence were included as covariates because of their potential relationships with both food-hygiene practices and illness. Results were expressed as adjusted odds ratios with 95% confidence intervals and p-values. The categories representing adequate handwashing, safe water use, separation of raw and cooked food, timely refrigeration of cooked leftovers, and less frequent street-food consumption served as the respective comparison categories. Statistical significance was defined as a two-sided p-value below 0.05.

Participation was voluntary, and informed consent was obtained before each interview. Interviews were conducted in a manner that protected participant privacy, and collected information was handled confidentially. No names or directly identifying personal information were used in the statistical analysis or presentation of findings.

RESULTS

Of the 438 eligible residents approached, 420 completed the survey and were included in the analysis, resulting in a response rate of 95.9%. The study included equal numbers of urban and rural participants, with 210 participants recruited from each residential setting. The mean age was 37.6 ± 13.8 years, with an age range of 18–76 years. Women comprised 274 (65.2%) participants, while 146 (34.8%) were men.

Table 1. Sociodemographic Characteristics and Prevalence of Probable Foodborne Illness

Participant characteristic	Total, n (%)	Probable foodborne illness, n (%)	χ^2	p-value
Residence			7.30	0.007
Urban	210 (50.0)	56 (26.7)		
Rural	210 (50.0)	82 (39.0)		
Age group, years			6.17	0.104
18–29	132 (31.4)	35 (26.5)		
30–44	154 (36.7)	49 (31.8)		
45–59	88 (21.0)	34 (38.6)		
≥60	46 (11.0)	20 (43.5)		
Sex			0.42	0.517
Female	274 (65.2)	93 (33.9)		
Male	146 (34.8)	45 (30.8)		
Educational level			13.27	0.001
No formal education	96 (22.9)	43 (44.8)		
Primary or secondary	218 (51.9)	73 (33.5)		
Above secondary	106 (25.2)	22 (20.8)		

Percentages in the total column were calculated using the complete sample as the denominator. Percentages in the probable foodborne illness column were calculated within each row category. Pearson's chi-square test was used.

Among the 420 participants, 138 met the operational definition of probable foodborne illness, corresponding to an overall prevalence of 32.9% (95% CI, 28.5%–37.5%). The prevalence was higher among rural participants than among urban participants, at 39.0% (95% CI, 32.7%–45.8%) and 26.7% (95% CI, 21.1%–33.0%), respectively. Rural participants had 1.76 times the crude odds of probable foodborne illness compared with urban participants (95% CI, 1.17–2.66; p=0.007).

The proportion of participants reporting probable foodborne illness increased across the age categories, from 26.5% among those aged 18–29 years to 43.5% among those aged 60 years or older; however, the overall association between age group and illness did not reach statistical significance (p=0.104). The prevalence was also similar between women and men (33.9% versus 30.8%; p=0.517). In contrast, educational level was significantly associated with probable foodborne illness (p=0.001). Participants with no formal education had the highest prevalence at 44.8%, whereas those educated beyond secondary level had the lowest prevalence at 20.8%.

Among the 138 participants classified as probable cases, abdominal pain was the most frequently reported symptom, affecting 101 (73.2%) participants. Diarrhoea was reported by 89 (64.5%), while nausea was reported by 75 (54.3%). Participants could report more than one symptom during the same illness episode.

Table 2. Crude and Adjusted Associations Between Hygiene Practices and Probable Foodborne Illness

Hygiene or food-handling practice	Total with practice, n	Probable illness, n (%)	Crude OR (95% CI)	Crude p-value	Adjusted OR (95% CI)	Adjusted p-value
Poor handwashing with soap	164	76 (46.3)	2.70 (1.78–4.11)	<0.001	2.31 (1.47–3.63)	<0.001
Unsafe or untreated drinking water	150	68 (45.3)	2.37 (1.55–3.61)	<0.001	1.88 (1.18–2.98)	0.008
Raw and cooked food not separated	137	62 (45.3)	2.25 (1.47–3.45)	<0.001	1.72 (1.07–2.76)	0.025
Cooked leftovers unrefrigerated for >2 hours	129	60 (46.5)	2.37 (1.54–3.66)	<0.001	1.83 (1.13–2.96)	0.014
Street food consumed ≥3 times weekly	148	62 (41.9)	1.86 (1.22–2.83)	0.004	1.39 (0.87–2.21)	0.164

OR: odds ratio; CI: confidence interval. Reference categories were adequate handwashing with soap, safe or treated drinking water, separation of raw and cooked food, refrigeration of cooked leftovers within two hours, and street-food consumption fewer than three times weekly. Adjusted odds ratios were controlled for age, sex, educational level, urban or rural residence, and all hygiene practices shown in the table.

All five hygiene and food-handling practices were associated with probable foodborne illness in the crude analyses. Poor handwashing showed the largest crude association, with participants reporting inadequate handwashing having 2.70 times the odds of illness compared with those reporting adequate handwashing (95% CI, 1.78–4.11; p<0.001). Unsafe drinking water and storage of cooked leftovers without refrigeration for more than two hours were each associated with approximately 2.4-fold higher crude odds of illness. Failure to separate raw and cooked food was associated with 2.25 times the crude odds of illness, while frequent street-food consumption was associated with 1.86 times the crude odds.

After adjustment for age, sex, education, residence, and the other hygiene practices included in the model, poor handwashing remained the strongest independently associated factor. Participants reporting poor handwashing had more than twice the odds of probable foodborne illness compared with those reporting adequate handwashing (adjusted OR, 2.31; 95% CI, 1.47–3.63; p<0.001). Use of unsafe or untreated drinking water was independently associated with 88% higher odds of illness (adjusted OR, 1.88; 95% CI, 1.18–2.98; p=0.008).

Failure to separate raw and cooked food also remained independently associated with illness (adjusted OR, 1.72; 95% CI, 1.07–2.76; p=0.025), as did retaining cooked leftovers without refrigeration for more than two hours (adjusted OR, 1.83; 95% CI, 1.13–2.96; p=0.014). Frequent street-food consumption was

associated with illness in the crude analysis, but the estimate was attenuated after adjustment and was no longer statistically significant (adjusted OR, 1.39; 95% CI, 0.87–2.21; p=0.164).

Overall, probable foodborne illness affected approximately one-third of the study population and was more frequently reported among rural residents and participants with lower educational attainment. Poor handwashing, unsafe drinking water, failure to separate raw and cooked food, and delayed refrigeration of cooked leftovers remained independently associated with greater odds of probable foodborne illness. The attenuation of the street-food estimate after adjustment indicated that its crude association may have been partly explained by correlated demographic, water, and household hygiene factors.

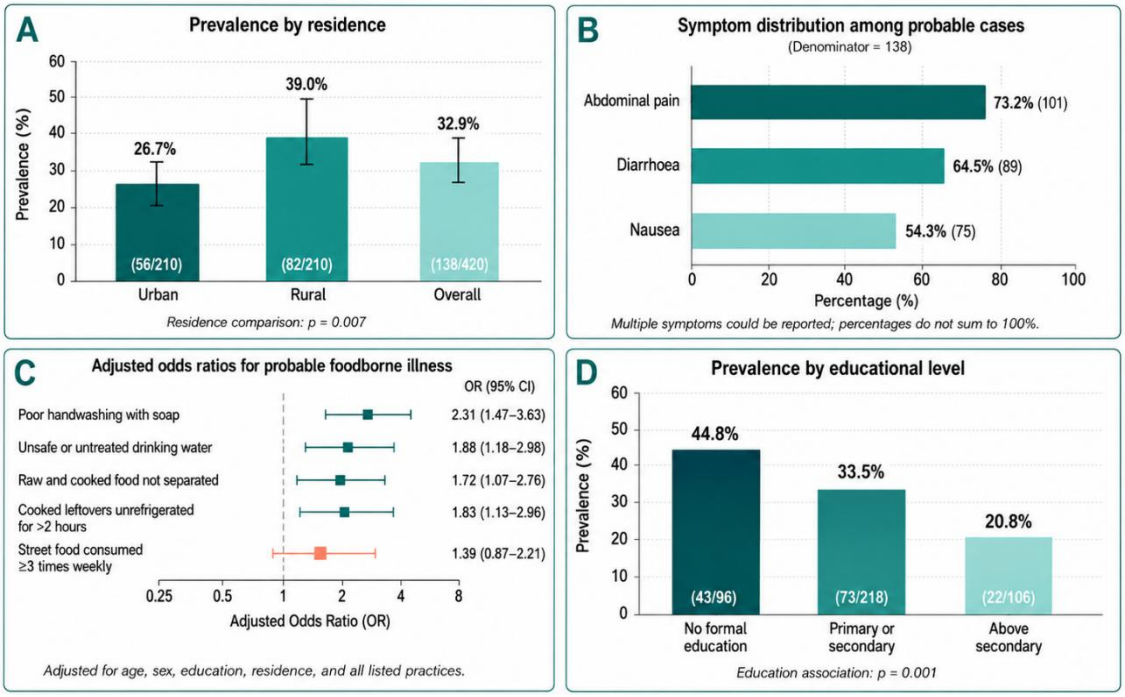

Figure 1 presents the epidemiological profile and hygiene-related correlates of probable foodborne illness among 420 participants in Nawabshah. Prevalence was higher in rural than urban residents (39.0% vs 26.7%; p=0.007) and decreased with increasing educational attainment (44.8% with no formal education to 20.8% above secondary level; p=0.001). Among 138 probable cases, abdominal pain, diarrhoea, and nausea were the most common symptoms. Poor handwashing showed the strongest adjusted association with illness (aOR 2.31), followed by unsafe drinking water, delayed refrigeration of leftovers, and failure to separate raw and cooked food, whereas frequent street-food consumption was not significant after adjustment.

DISCUSSION

This community-based cross-sectional study found that approximately one-third of the surveyed adults met the symptom-based definition of probable foodborne illness. The prevalence was higher among rural residents and participants with lower educational attainment. Poor handwashing with soap, unsafe or untreated drinking water, failure to separate raw and cooked food, and retention of cooked leftovers without refrigeration for more than two hours remained independently associated with greater odds of probable foodborne illness after adjustment for demographic and residential characteristics. Frequent street-food consumption was associated with illness in the crude analysis, but the association was attenuated and no longer statistically significant after multivariable adjustment.

The observed prevalence of 32.9% indicates that acute gastrointestinal symptoms attributed to suspected unsafe food were common within the surveyed population. Direct comparison with other studies is difficult because community surveys vary in their symptom definitions, recall periods, populations, and methods of attributing illness to food. Some investigations rely on medically attended disease or laboratory confirmation, whereas others measure self-reported gastrointestinal symptoms. Nevertheless, international burden estimates consistently identify foodborne illness as an important cause of

morbidity and loss of healthy life, particularly in settings where surveillance and laboratory confirmation are limited (1,2). Evidence from Pakistan has similarly described a substantial but incompletely documented burden associated with contaminated water, inappropriate food storage, weak temperature control, inadequate inspection, and limited foodborne disease surveillance (6–8).

Rural participants had a significantly higher prevalence of probable foodborne illness than urban participants. The crude odds of illness were approximately 76% higher among rural residents, although the available results did not provide a separate adjusted odds ratio for residence. The observed difference may reflect variation in water sources, sanitation, refrigeration, food-storage conditions, health literacy, and access to food-safety information. Rural residence should not, however, be interpreted as an independent causal exposure because it may represent a combination of socioeconomic and environmental conditions. Previous reviews from Pakistan have identified unsafe water, inadequate cold-chain systems, poor storage practices, and weak regulatory monitoring as interconnected food-safety concerns (6–8). Further studies should examine which specific household and environmental factors account for urban–rural differences rather than treating place of residence as a single explanatory variable.

Educational attainment was also associated with probable foodborne illness. Participants without formal education had the highest prevalence, whereas those educated beyond secondary level had the lowest prevalence. Education may influence the ability to understand food labels, expiry dates, health messages, water-treatment instructions, and recommendations concerning cooking and storage. Studies among consumers and food handlers have reported associations between education, food-safety knowledge, training, and hygiene practices (16,18,22). However, knowledge alone may not ensure safe behaviour when clean water, soap, refrigeration, suitable utensils, or adequate kitchen facilities are unavailable. Educational interventions should therefore be accompanied by improvements in the material conditions required to practise food safety.

Abdominal pain, diarrhoea, and nausea were the most frequently reported symptoms among probable cases. This clinical pattern is compatible with acute gastroenteritis caused by numerous bacterial, viral, parasitic, and toxic foodborne hazards. Norovirus is a major cause of acute vomiting and diarrhoeal illness globally, whereas non-typhoidal Salmonella is an important bacterial cause of gastroenteritis (3,4). Norovirus has been identified in human clinical samples in Punjab, and Salmonella species have been detected in ready-to-eat street foods in Pakistan (10,13). Nevertheless, the symptom profile reported in the present study could not identify a particular pathogen or establish food as the definitive source of illness. Similar symptoms may arise from person-to-person transmission, contaminated water, medications, chronic gastrointestinal disorders, or other infectious and noninfectious causes.

Poor handwashing with soap showed the strongest independent association with probable foodborne illness. Participants reporting inadequate handwashing had more than twice the adjusted odds of illness compared with those reporting adequate practice. Hands can transfer microorganisms from toilets, raw meat, waste, animals, contaminated water, and unclean surfaces to cooked or ready-to-eat food. Research has shown that self-reported food-safety practices do not always correspond with microbiological hand cleanliness, indicating that reported awareness may overestimate actual practice (17). Studies conducted in Pakistani university canteens have also identified deficiencies in handwashing and food handling alongside microbial contamination of prepared foods (9). These findings support practical hygiene education that demonstrates when and how hands should be washed, while also ensuring reliable access to soap and clean water.

Use of unsafe or untreated drinking water remained independently associated with probable foodborne illness after adjustment for the other measured factors. Contaminated water may transmit enteric pathogens directly and may also contaminate hands, utensils, vegetables, preparation surfaces, and cooked meals. Repeated household use of unsafe water can therefore create several opportunities for exposure. Water treatment through boiling, appropriate filtration, or another effective method may

reduce contamination, but treated water may be recontaminated during storage when containers are uncovered or water is removed using unclean utensils. The observed association supports integrating household water treatment and safe storage into food-hygiene programmes rather than addressing drinking water and food preparation as separate concerns.

Failure to separate raw and cooked food was associated with increased adjusted odds of illness. Raw meat, poultry, vegetables, and other uncooked products may carry microorganisms that can be transferred to prepared foods through shared knives, cutting boards, plates, hands, and storage containers. Because cross-contamination may occur without visible deterioration of food, households may underestimate this route of exposure. Studies in Pakistani institutional food settings have documented microbial contamination and procedural weaknesses involving preparation surfaces and food handling (9,11,12). International reviews likewise identify separation of raw and ready-to-eat foods as a central component of food-safety practice (18,25).

Keeping cooked leftovers unrefrigerated for more than two hours was also independently associated with probable foodborne illness. Cooked food may become contaminated during serving or subsequent handling, and prolonged storage at ambient temperature can permit microbial multiplication. This issue may be particularly important in hot environments and in households with limited refrigeration capacity or unreliable electricity. The finding supports advice to prepare quantities appropriate for immediate consumption, cover cooked food, refrigerate leftovers promptly, and reheat stored food thoroughly. Nevertheless, because storage practices and illness were assessed simultaneously, the observed relationship should be interpreted as an association rather than evidence that delayed refrigeration directly caused the reported episodes.

Frequent street-food consumption was associated with probable foodborne illness in the crude analysis but not after adjustment for demographic characteristics, residence, and household hygiene practices. The attenuation from a crude odds ratio of 1.86 to an adjusted odds ratio of 1.39 suggests that part of the initial association may have been explained by correlated water, hygiene, storage, educational, or residential factors. This finding should not be interpreted as evidence that street-vended food is uniformly safe. Studies from Pakistan and other developing settings have identified Salmonella contamination, inadequate water supplies, poor waste disposal, insufficient refrigeration, and limited protection of food from insects and dust at street-vending sites (10,20,21,24). The safety of street food is likely to depend on vendor-specific preparation, storage, water, and sanitation conditions rather than consumption frequency alone.

The study had several strengths. It included both urban and rural communities, recruited a comparatively large sample, achieved a high response rate, and examined multiple modifiable food-hygiene practices. The multivariable analysis allowed the principal associations to be assessed after adjustment for selected demographic and behavioural factors. The findings therefore provide useful local evidence for food-safety education and future epidemiological investigation in Nawabshah.

Several limitations must also be considered. The cross-sectional design measured hygiene practices and illness history at the same time and could not establish temporal sequence or causality. Participants who had recently experienced illness may have changed their hygiene behaviour, creating the possibility of reverse causation. Both exposures and outcomes were self-reported and were therefore susceptible to recall error, misclassification, and socially desirable responses. The case definition depended partly on participants attributing gastrointestinal symptoms to suspected unsafe food, which may have introduced attribution bias. No clinical examination or laboratory testing of stool, food, or water samples was performed; therefore, the outcome represented probable rather than confirmed foodborne illness.

Residual confounding may also have affected the estimates because household income, refrigeration availability, sanitation infrastructure, food-source characteristics, electricity reliability, comorbidities, and healthcare access were not included in the reported model. Equal recruitment from urban and rural

areas facilitated comparison but may not have reflected the population distribution of the district, limiting interpretation of the overall prevalence as a district-wide population estimate. The multistage sampling procedure may also have introduced clustering within selected neighbourhoods and villages, and the reported analysis did not indicate whether cluster-adjusted standard errors or sampling weights were applied. In addition, the prevalence estimate is highly dependent on the exact symptom-recall period and season of data collection, which should be reported clearly in the final manuscript.

Despite these limitations, the findings consistently identified handwashing with soap, safe water use, separation of raw and cooked food, and prompt refrigeration of cooked leftovers as important correlates of lower reported illness. Prospective studies using clearly defined recall periods, representative sampling, cluster-adjusted analysis, direct observation of household practices, and laboratory examination of clinical, food, and water samples are needed to clarify temporal relationships and identify the pathogens and exposure pathways responsible for gastrointestinal illness in the district.

CONCLUSION

Probable foodborne illness was reported by approximately one-third of the surveyed adults in Nawabshah and was more common among rural residents and participants with lower educational attainment. Poor handwashing with soap, unsafe or untreated drinking water, failure to separate raw and cooked food, and delayed refrigeration of cooked leftovers were independently associated with greater odds of illness, whereas the association with frequent street-food consumption was not statistically significant after adjustment. These findings identify practical household water, hygiene, and food-handling behaviours that may inform locally appropriate food-safety interventions, while the cross-sectional and symptom-based nature of the study requires that the observed relationships be interpreted as associations rather than causal effects.

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