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ORIGINAL ARTICLE

Public perception and assessment of microbial and heavy metal contamination of commonly consumed street foods in Cumilla City, Bangladesh: a multicenter, observational, and cross-sectional study

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Abstract

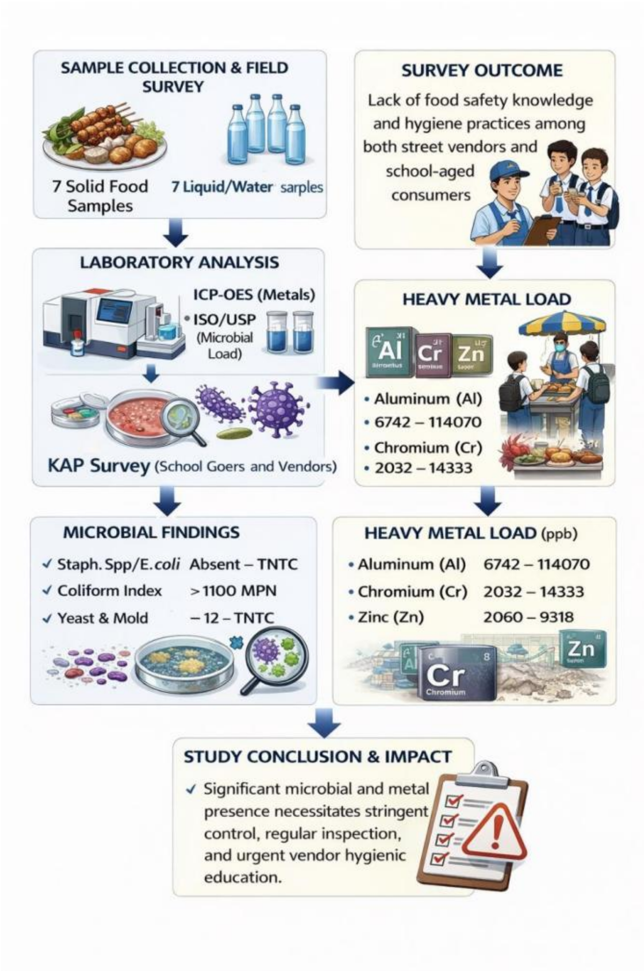
Substandard and improper food hygiene of street food can lead to human ailments by dangerous pathogens and heavy metals. 33% of commonly consumed street food samples including pickles, sauces, chips, puffed rice, fruit drinks, mustard oil, butter, soybean oil, dalda, and honey have been tested unsafe in Bangladesh. The objective of this study is to evaluate the microbiological quality and heavy metal level of several street items predominantly consumed by school-aged children in Cumilla city, Bangladesh. Collected street food samples were promptly processed and dispatched to the laboratory. The microbial load and heavy metal concentration were evaluated using standard microbiological testing techniques and the Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) method, respectively. The knowledge, behaviors, and attitudes of food vendors and consumers on street foods were assessed with a questionnaire derived from prior research. The survey results showed that both street food vendors and consumer lack food safety knowledge. The microbial test revealed the presence of different microorganisms in the range of: *Staphylococcus* spp (absent- too numerous to count, TNTC), *Pseudomonas* spp (absent- TNTC), *Coliform* (>1100 MPN index/100g), *E.coli* (absent- TNTC), Yeast and Mold (12 cfu/g -TNTC). In solid food items, concentration (ppb) of selected metals was: Al (6742-114070), Zn (2060- 9318), Cr (2032-14333), Cd (<dL, dL=5), Cu (999-3773), Ni (1501-2024). Drinking jar water contained microbial load and heavy metals within the permissible range. It is imperative to instruct and teach our merchants on proper hygienic standards at the local level. The substantial microbiological and heavy metal presence necessitates stringent control through regular inspection and monitoring.

Keywords: Street food. Microbial load. Heavy metal quantity. ICP-OES. Food safety.

Highlights

- Public perception regarding the street food safety varies considerably
- This study provides the first confirmed report of street food safety of the Cumilla region of Bangladesh
- Microbial and heavy metal content of the selected street foods are of questionable extent
- Scarcity of sanitation knowledge and practice have been observed among the street food vendors

Graphical Abstract



Source: Own authorship.

Introduction

Foodborne diseases represent a critical global health burden, resulting in an estimated 1.8 million fatalities annually **[1]**. This crisis is particularly acute in developing regions; Africa and South-East Asia report the highest per capita incidence of foodborne infections globally **[2]**. Within these regions, school-aged children are identified as a high-risk demographic, frequently suffering from gastrointestinal manifestations such as nausea, vomiting, and abdominal discomfort due to microbial and heavy metal contamination **[3,4]**. Despite these risks, street foods are indispensable to urban ecosystems. They significantly contribute to the nutritional needs of lower and middle-income consumers by providing ready-to-eat, affordable, and palatable meals **[5]**. For working individuals and students, street-vended snacks offer rapid accessibility in public spaces where conventional dining is unavailable **[6]**.

This dual nature of street food - as both a nutritional lifeline and a potential health hazard - necessitates rigorous scientific scrutiny. However, a significant information gap exists regarding the intersection of microbiological safety, heavy metal toxicity, and the socio-economic drivers of food handling in specific regional hubs. While general studies on food safety are available, there is a lack of integrated data connecting the heavy metal concentrations (such as Pb, Cd, and Cr) and specific bacterial pathogens (like *L. monocytogenes* and *Salmonella spp.*) directly to the demographic of school-based street vendors in secondary urban centers. Dey (2018) emphasizes that while foodborne infections are prevalent in developing nations, specific localized data on vendor practices in emerging cities remains fragmented **[7]**.

Das and Das (2018) highlight that heavy metal contamination in street foods is an escalating but under-monitored global health issue, particularly in densely populated urban zones **[8]**. Khairuzzaman et al. (2014) point out that the correlation between a vendor's socio-economic attributes—such as educational attainment—and the actual microbiological quality of their food is often theorized but rarely quantified in regional studies **[5]**. To address this void, the present study was aimed to assess the microbiological and heavy metal quality of food products supplied by school-based street food vendors in Cumilla City, Bangladesh.

Furthermore, this research wanted to determine the correlation between the level of food safety knowledge among vendors and the incidence of foodborne illness among secondary school students, ultimately providing the empirical evidence needed to enhance public health safety protocols in the region.

Materials and Methods

Study location and sampling

This multicenter, observational, and cross-sectional study was conducted to evaluate food safety in Cumilla City, Bangladesh. The study followed the STROBE guidelines for reporting observational research. Twenty high schools in Cumilla city were chosen for the study to guarantee representation from various zones. A single food sample was obtained from each randomly selected food vendor, culminating in a total of 14 predominantly consumed food samples (e.g., Singara, Samosa, Jhalmuri, Belpuri, Fuska, Achar, Jar water) from 65 school-based street food vendors. We collected some information from street food vendors on their background characteristics, practices, and food safety awareness. During the study period, we identified food sellers located on the streets and in places next to the selected schools. We secured consent, and they consented to provide food samples for laboratory analysis. We also collected street food consumers' background characteristics, street food taking habits, food safety knowledge, awareness, and practice information from 198 street food consumers. We used purposive sampling methods for collecting data from street food consumers and vendors.

Ethics and consent

Ethical approval for this study was obtained from Biosafety, Biosecurity & Ethical Committee, Faculty of Biological Sciences, Jahangirnagar University, Savar, Dhaka-1342, Bangladesh (Ref No: BBEC,JU/M 2024/08 (127)). As this study involves interviewing secondary school goers (mainly of 12-18 years age group) and adult food vendors, verbal consent from the students as well as their parents and vendors as well was taken before conducting the survey.

Questionnaire by face-to-face interviews

Data were gathered via face-to-face interviews with students who regularly consume these food items and the vendors who were seen to run street food business adjacent to the schools, employing a pre-tested questionnaire. Each interview endured for roughly 5 to 10 minutes. It comprised both closed and open-ended questions. The questionnaire variables included the socioeconomic background of school-based street food vendors, such as gender, age, educational attainment, and daily income, as well as general characteristics of school-based street food vending, including the vending location, types of food sold, daily child customer count, and duration of vending near the school. The consumer questionnaire evaluated data regarding age, gender, current educational status, frequency of street food consumption, and levels of food safety knowledge, practices, and awareness.

Statistical analysis

Microsoft Access 2003 (Microsoft, Redmond, WA) was necessary for data entry, whereas SPSS 26 for Windows (SPSS, Chicago, IL) was utilized for data analysis. Background characteristics, food safety awareness, and practice of vendors and consumers are presented by descriptive statistics. In addition to consumers' food-taking habits and knowledge of food safety, these are presented in frequency and percentages.

Laboratory procedures for food samples

Subsequent to collection, the samples were principally processed at the laboratories of the Department of Pharmacy, Comilla University, and readied for further analysis. The microbial load and heavy metal concentrations of the samples were assessed at the Bangladesh Reference Institute for Chemical Measurements (BRiCM).

Microbial Analysis

Determination of Salmonella

The ISO 6579 method was employed to enumerate *Salmonella* species (ISO 6579-1: 2017) **[9]**. Food samples weighing 25 g were homogenized in 225 mL of buffered peptone water and incubated at 35 C for 24 hours. For swab samples collected from knives, display surfaces, hands, and storage containers, 10 mL of the soaked swab and diluent were utilized. The inoculums were moved from pre-enrichment broth to Rappaport-Vassiliadis broth at 41.5±1°C for 24 hours for selective enrichment. A loopful of the selective enrichment was inoculated onto solid selective media: xylose lysine deoxycholate agar (XLD). XLD agar was incubated at 37 ± 1°C and examined after 24±3 hours for the characteristic translucent red halo and black center indicative of Salmonella. The colony count method was employed to enumerate the microbial population.

Presence of Staphylococcus aureus

Baired Parker Agar (BPA) was utilized to quantify *S. aureus*, with round, convex, and black colonies identified morphologically in the preliminary stage. Specific colonies exhibiting positive results underwent Gram staining to distinguish between gram-positive and gram-negative bacteria. The coagulase test was conducted with human plasma to verify the presence of *S. aureus* in the collected street food samples **[10]**.

Presence of Shigella

The ISO 21567:2004(E) method was utilized for the enumeration of Shigella (ISO 21567, 2004) **[11]**. About 10g/10mL solid/liquid sample was homogenized in shigella broth containing 0.5µg/mL novobiocin. The broth with homogenized solid sample was incubated at 41,5 ° C for 16-20 hrs. The enrichment culture was inoculated in Hektoen Enteric Agar. The agar plates were incubated for 20-24 hrs. Following that, observation was made for typical colonies that seemed convex, transparent and green.

Determination of Pseudomonas aeruginosa

This quantitation was based on USP 62 method. About 10g/10 mL of solid/liquid sample was homogenized in 90 mL saline solution (0.9%). Dilution of the solution was done from 10^{-2}-10^{-10}. Then 1 mL from each dilution inoculated in 9 mL Soybean Casein Digest Broth. The broth was incubated at (30-35)°C for 18-20 hrs. Then 100µL was subcultured on a plate of Cetrimide Agar and incubated for 18-72 hrs at (30-35)°C temperature. Following that, observation was made for typical colonies that seemed round and green.

Presence of *E.coli*

A loopful of positive BGB (Brilliant Green Bile broth) tubes was streaked onto Eosin Methylene Blue (EMB) agar (HIMEDIA- M317-500G) and incubated at 44 - 44.5°C for 24-48 hours. Plates exhibiting colonies with distinct physical traits (metallic luster, dark purple cores) were identified as probable *E. coli*. The indole test was conducted utilizing Kovac's indole reagent following 24 hours of incubation at 44 °C. Favorable outcomes were obtained utilizing the red ring configuration at the apex of the test tube **[10]**.

Determination of Total Coliform Count

The Total Coliform Count (TCC) was assessed utilizing the Most Probable Number (MPN) three-tube approach as per A0AC 966.24. To ascertain the presumptive TCC, tubes with Lauryl Tryptose Broth or Lauryl Sulfate Broth (LSTB) and Durham tubes were inoculated and incubated at 35°C for 24-48 hours. Gas production was observed. From each gas positive tube, a loopful of suspensions were transferred into BGLB (Brilliant Green Bile Broth) tubes and incubated at 35°C for 24-48 hours. The tubes exhibiting gas production were recorded as a positive outcome **[10]**.

Determination of Total Plate Count and Yeast & Mold Count in street foods

Aseptic conditions were upheld during the analysis to prevent external contamination. Samples were homogenized, and tenfold serial dilutions were prepared using 1% peptone water up to 10^{-3}. The total plate count of street food samples was assessed using Plate Count Agar (HIMEDIA – M091-500G) and incubated at 37 ±2°C for 24-48 hours, as stipulated in the Sri Lankan Standard (SLS) code 516; Section 1, Part 1; 2013. The yeast and mold counts were assessed using Dichloran Rose Bengal Chloramphenicol Agar (DRBC) and incubated at 25-27°C for 5 days **[10]**.

Heavy metal analysis

For heavy metal analysis, the samples were initially labeled properly. The laboratory equipment was cleaned using 50% HNO_3, rinsed with water, soaked in 50% HCl for 2 hours, and then rinsed again with water. Subsequently, the Inductively Coupled Plasma Optical Emission spectroscopy (ICP-OES) instrument was calibrated using assigned heavy metal standards, creating calibration curves with standard solutions of different concentrations. In the sample preparation phase, 1-2 grams of thoroughly mixed substances were transferred into a 250 mL beaker and weighed to the closest 0.01 grams. Analysis of the dried part was avoided due to potential loss or changes in extractability during drying. The non-dried portion was mixed with 10 mL of 50% HNO_3. Concentrated HNO_3 was added at intervals, and the solution was heated and refluxed. The solution was then evaporated without letting the beaker dry. After cooling, 3 mL of 30% H_2O_2 and 2 mL of water were added. The beaker was heated until effervescence stopped, and additional 30% H_2O_2 was added incrementally to ensure sample uniformity. After cooling, 10 mL of water and 5 mL of concentrated HCl were added, followed by a 15-minute reflux. Post-reflux, the solution was diluted to 100 mL with water and mixed. The solution was filtered or centrifuged, and adjustments were made within the linear range through dilution with calibration blank solution when necessary (AOAC 990.08) **[12]**. For liquid sample i.e. jar water, collected samples were acidified with HNO_3 (pH < 2) and further assessment was done in ICP-OES (APHA Method 3120) **[13]**.

Results

The study's results revealed a significant bacterial presence in each food sample, notably Staphylococcus spp. in solid food samples, which were too numerous to count. A similar pattern was observed in liquid samples, except for Jar Water (SM2), Jar Water (SM3), and Jar Water (SM7), where it was absent. Pseudomonas spp. levels exceeded the recommended limit of < 100 CFU/g in four samples but were moderately high in others like Belpuri (SM1Y), Fuska (SM6Y), and Chickenpeas (SM7Y) (Table 1). These findings underscore serious health concerns.

Table 1. Microbial load in commonly consumed street foods and jar water.

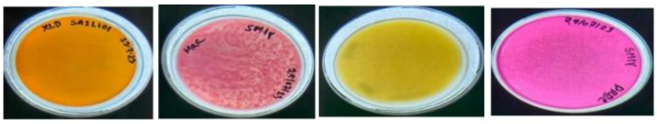
Sample ID	Sample matrix	*Staphylococcus spp*	*Pseudomonas spp*	Coliform	*Salmonella spp*	*E. coli*	*Shigella spp*	Yeast and Mold
Solid Samples								
SM1Y	Belpuri	TNTC	310 cfu/g	>1100 MPN index/100 g	Absent/25 g	TNTC	Absent	TNTC
SM2Y	Singara	TNTC	TNTC	>1100 MPN index/100 g	Absent/25 g	15 cfu/g	Absent	12 cfu/g
SM3Y	Samosa	TNTC	TNTC	>1100 MPN index/100g	Absent/25 g	33 cfu/g 1	Absent	TNTC
SM4Y	Jhal Muri	TNTC	TNTC	>1100 MPN index/100g	Absent/25 g	Absent /g	Absent	31 cfu/g
SM5Y	Mixed Achar	TNTC	TNTC	>1100 MPN index/100g	Absent/25 g	Absent /g	Absent	TNTC

SM6Y	Fuska	TNTC	40 cfu/g	>1100 MPN index/100g	Absent/25 g	TNTC	Absent	TNTC
SM7Y	Chickpeas	TNTC	Absent cfu/g	>1100 MPN index/100g	Absent/25 g	80 cfu/g	Absent	TNTC
Liquid Samples								
SA [1]	Belpuri Tok	TNTC	Absent cfu/g	<3 MPN index/100 mL	Absent/25 mL	Absent / mL	Absent	TNTC
SM2	Jar Water	Absent/mL	Absent/mL	<3 MPN index/100 mL	Absent/25 mL	Absent / mL	Absent	Absent/mL
SM3	Jar Water	Absent/mL	Absent/mL	<3 MPN index/100 mL	Absent/25 mL	1 cfu/mL	Absent	Absent/mL
SM4	Jar Water	TNTC	Absent/mL	23 MPN index/100 mL	Absent/25 mL	1 cfu/mL	Absent	Absent/mL
SM5	Jar Water	TNTC	Absent/mL	<3 MPN index/100 mL	Absent/25 mL	Absent / mL	Absent	Absent/mL
SM6	Puska Tok	TNTC	Absent/mL	<3 MPN index/100 mL	Absent/25 mL	Absent / mL	Absent	TNTC
SM7	Jar Water	Absent/mL	Absent/mL	23 MPN index/100 mL	Absent/25 mL	10 cfu/mL	Absent	Absent/mL

N.B. Each sample was taken in triplicates and results are expressed as the mean of them. Source: Own authorship.

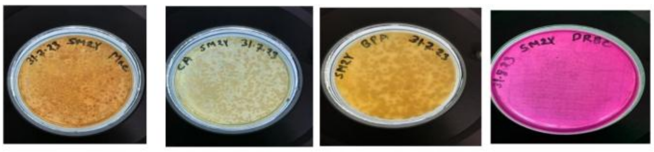
TNCT = Too numerous to count

The microbial content in liquid samples varied. While *Pseudomonas spp* was absent in all liquid samples, the Coliform count, which should be < 30 MPN/100g for solid samples, exceeded recommended limits in all solid samples and was present in significant amounts in liquid samples, surpassing the standard value of 0/100mL. However, *Shigella spp.* and *Salmonella spp*. were entirely absent in both solid and liquid samples. *E. coli* levels varied among samples, surpassing reference standards in Jhal Muri (SM4Y) and Mixed Achar (SM5Y) to varying extents. Liquid samples, except Jar Water (SM7), showed the absence of all microbes. Yet, the yeast and mould levels, which should be < 300 cfu/g, exceeded the standard in all solid samples to different extents (Table 1). Conversely, except for Belpuri Tok (SM1) and Fuska Tok (SM6), yeast and mould were absent in liquid samples. Grown colonies for different food samples are shown in Figures 1 to 8.



(a) (b) (c)

Figure 1. Colonies formed in petri dishes for belpuri (SM1Y) samples a) *Salmonella spp* and *Shigella spp;* b) *E.coli;* c) yeast and mold. Source: Own authorship.



(a) (b) (c) (d)

Figure 2: Colonies formed *in petri* dishes for singara (SM2Y) samples *E. coli* b) Pseudomonas c) *Staphylococcus aureas* d) yeast and mold. Source: Own authorship.

(a) (b) (c)

Figure 3: Colonies formed *in petri* dishes for samosa (SM3Y) samples a) Yeast and mold b) *E. coli* c) Pseudomonas. Source: Own authorship.

(a) (b)

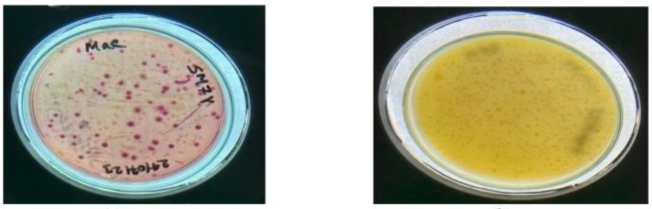
Figure 4: Colonies formed *in petri* dishes for jhal muri (SM4Y) samples a) Yeast and mold b) *E. coli* . Source: Own authorship.

(a) (b)

Figure 5. Colonies formed *in petri* dishes for mixed achar (SM5Y) samples a) *E. coli* b) *Staphylococcus aureas.* Source: Own authorship.

(a) (b) (c)

Figure 6. Colonies formed *in petri* dishes for Fuska (SM6Y) samples a) Yeast and mold b) *Pseudomonas* c) *E. coli.* Source: Own authorship.



(a) (b)

Figure 7. Colonies formed in petri dishes for Chickpeas (SM7Y) samples a) *E. coli* b) Yeast and mold. Source:

Own authorship.

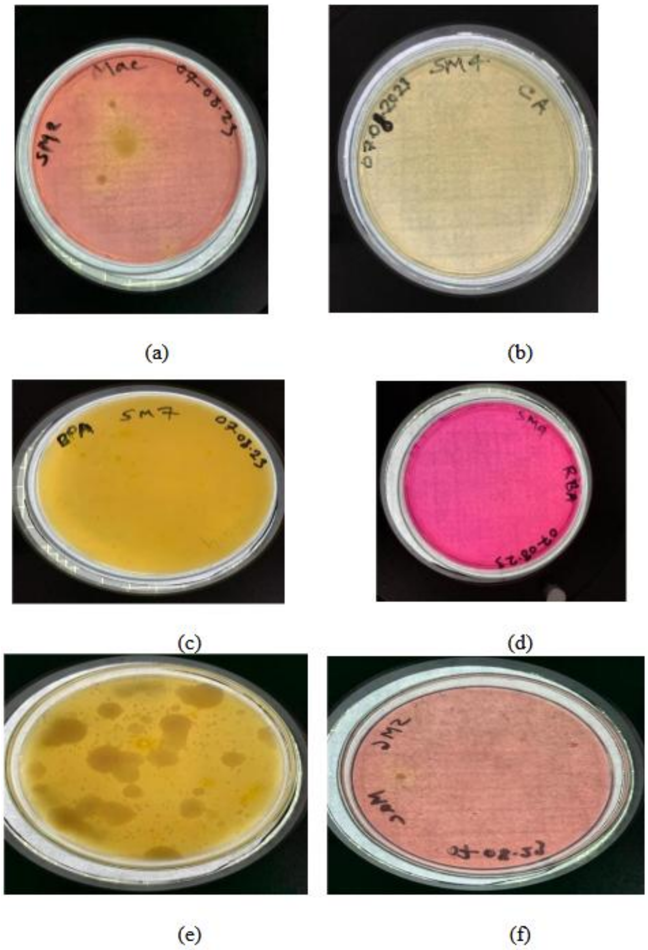


Figure 8. Colonies formed in petri dishes for liquid food sample a) *E.coli* colonies for jar water b) Pseudomonas colonies for jar water c) *Staphylococcus aureus* colonies for jar water d) yeast and mold colonies for jar water; e) yeast and mold colonies for fuska tok water f) *E.coli* colonies for fuska tok water. Source: Own authorship.

Table 2. Heavy metal level in food samples.

Sample ID	Sample matrix	Al (ppb)	Cu (ppb)	Pb (ppb)	Cd (ppb)	Cr (ppb)	Zn (ppb)	Ni (ppb)
Solid Sample								
SM1Y	Belpuri	8934.79	2662.31	2289.42	<dL, dL = 5	7366.19	8168.30	2040.55
SM2Y	Singara	13848.7	3773.15	3692.44	1524.22	7581.45	9211.16	1898.44
SM3Y	Samosa	5300.11	2075.2	3574.88	<dL, dL = 5	10141.79	4507.85	1959.10
SM4Y	Jhal Muri	14070.37	1625.79	2901.91	<dL, dL = 5	2337.5	4616.13	1512.37
SM5Y	Mixed Achar	9677.9	999.5	3168.3	<dL, dL = 5	2032.5	2060.40	1422.5
SM6Y	Fuska	6496.87	2047.09	3126.58	<dL, dL = 5	11524.02	5626.26	1501.74
SM7Y	Chickpeas	6742.10	1686.68	2705.54	369.16	14333.48	9318.56	1695.32
Liquid Sample								
SA [1]	Belpuri Tok	33508.85	<dL, dL = 5	1766.89	<dL, dL = 5	5828.2	2228.3	5105.7
SA2	Jar Water	<dL, dL = 5	<dL, dL = 5	<dL, dL = 5	<dL, dL = 5	<dL, dL = 5	<dL, dL = 5	<dL, dL = 5
SA3	Jar Water	<dL, dL = 5	<dL, dL = 5	<dL, dL = 5	<dL, dL = 5	<dL, dL = 5	<dL, dL = 5	<dL, dL = 5
SA4	Jar Water	<dL, dL = 5	<dL, dL = 5	<dL, dL = 5	<dL, dL = 5	<dL, dL = 5	100.8	<dL, dL = 5
SM5	Jar Water	<dL, dL = 5	<dL, dL = 5	<dL, dL = 5	<dL, dL = 5	<dL, dL = 5	100.8	<dL, dL = 5
SM6	Fuska Tok	4033.5	<dL, dL = 5	714.2	<dL, dL = 5	2804.9	3703.8	1064.4
SM7	Jar Water	<dL, dL = 5	<dL, dL = 5	<dL, dL = 5	<dL, dL = 5	<dL, dL = 5	100.8	<dL, dL = 5

Source: Own authorship.

The excessive consumption of street food poses potential health risks due to heavy metal toxicity. Heavy metals, known for their persistence, accumulation, and toxicity to organisms, are significant contributors to food contamination from the environment. This research reports on the extent of heavy metals, including Aluminium (Al), Copper (Cu), Lead (Pb), Cadmium (Cd), Chromium (Cr), Zinc (Zn), and Nickel (Ni), in commonly consumed street food in Cumilla. Aluminium (Al) lacks a considerable biological role but can be toxic at higher levels, though it is generally less toxic than other heavy metals. However, this study found moderately high Al levels in almost all food samples, ranging from 6742 to 14070 ppb, still below the permissible limit of 1 mg/kg. Zinc (Zn) content in all food samples exceeded WHO/FAO limits (1-1.5 mg/kg), ranging from 2060 to 9318 ppb. Similarly, Chromium (Cr) levels surpassed the reference value (5 mg/kg) in most samples, except for two satisfactory results, ranging from 2032 to 14333 ppb. Lead was detected in all street food samples, surpassing the WHO/FAO-set maximum allowable limit of 0.01 mg/kg. Cadmium levels were mostly within permitted limits (0.05 mg/kg) according to US EPA, WHO, and EU standards, except for one sample with a notably high value. Copper (Cu) levels were satisfactory in approximately half of the samples (standard: 1-2 mg/kg), ranging from 999 to 3773 ppb. Nickel (Ni) content in all food samples exceeded the standard level (0.01 mg/kg), ranging from 1501 to 2040 ppb.

Contrarily, the heavy metal content in all jar water samples was within acceptable limits, with levels lower than 5 ppb for Al (standard: 0.9 mg/kg), Cu (standard: 1-2 mg/kg), Pb (standard: 0.05 mg/kg), Cd (standard: 0.005 mg/kg), Zn (standard: 5 mg/kg), Cr (standard: 5 mg/kg), and Ni (standard: 0.01 mg/kg), except for samples SM1 and SM6, which differed from the rest (Table 2). The order of heavy metal contamination observed was Al > Zn > Cr > Pb > Cu > Ni > Cd.

Vendors' and consumers' (school going children) perception about street foods:

In total, 65 school-side vendors and 198 high school going children were interviewed (Table 3). Collected data were analyzed and presented as the following:

Table 3. Profile of the Street Food Vendors (N= 65).

Variables	Frequency	Percentage (%)
Gender		
Male	48	73.8
Female	17	26.2
Age of Vendors (years)		
15-24	25	38.5
25-34	30	46.2
35-45	10	15.4

Source: Own authorship.

The study involved 65 street food vendors, with a gender distribution of 73.8% male and 26.2% female. Most vendors (46.2%) were between the 25-34 age group, while the fewest were in the 35-45 age group. Regarding education, most vendors (41.5%) had completed primary education, 26.2% secondary, and 20% tertiary, while 12.3% were illiterate. Notably, only 7.7% of vendors had received food safety training (Table 4).

Table 4. Education qualification of the Street Food Vendors (N=65).

Variables	Frequency	Percentage (%)
Vendors Levels of Education		
Illiterate	8	12.3
Primary	27	41.5
Secondary	17	26.2
Tertiary	13	20
Food Safety Training		
Yes	5	7.7
No	60	92.3

Source: Own authorship.

In terms of food safety practices, 44.6% of vendors always washed their hands before processing food, but only 24.6% always used soap or detergents for handwashing. The frequency of hand washing after touching food and before/after handling unwrapped food items was lower, with 36.9% and 29.2% of vendors always doing so, respectively (Table 5).

Table 5. Food safety practices among Street Food Vendors (N=65).

Observation	Response		
	Never	Sometimes	Always
	N (%)	N (%)	N (%)
Do you wash your hands before processing food?	17 (26.2)	19 (29.2)	29 (44.6)
Do you wash your hands after touching food?	24 (36.9)	17 (26.2)	24 (36.9)
Do you wash your hands before and after touching unwrapped food items?	26 (40)	20 (30.8)	19 (29.2)
Do you use soaps/detergents to wash your hands?	30 (46.2)	19 (29.2)	16 (24.6)

Source: Own authorship.

Concerning food safety awareness, 53.8% of vendors were aware that some microorganisms could cause foodborne diseases, while 46.2% were unaware (Tabel 6).

Table 6. Food safety awareness about foodborne diseases of Street Food Vendors (N=65).

Observation	Response	
	Yes	No
	N (%)	N (%)
Are you aware that some microorganisms can cause foodborne diseases?	35 (53.8)	30 (46.2)

Source: Own authorship.

The Table 7 presents demographic information for 198 street food consumers. Regarding gender distribution, 57.1% (113) of the consumers were female, while 42.9% (85) were male. The age distribution shows that the largest group was the 12-14 age group, comprising 39.9% (79) of the sample, followed by the 14-16 age group at 33.8% (67), and the 16-18 age group at 26.3% (52).. Regarding education levels, the consumers were distributed across classes 6 to 10, with Class 10 having the highest representation at 26.8% (53), followed by Class 9 at 21.2% (42). Classes 6, 7, and 8 had similar representations, each accounting for approximately 17% of the sample.

Table 7. Profile of the Street Food Consumers (N= 198).

Variables	*Frequency*	*Percentage (%)*
Gender		
Male	85	42.9
Female	113	57.1
Age of Consumers (years)		
12-14	79	39.9
14-16	67	33.8
16-18	52	26.3
Consumers Levels of Education		
Class 6	34	17.2
Class 7	35	17.7
Class 8	34	17.2
Class 9	42	21.2
Class 10	53	26.8

Source: Own authorship

The street food consumer's eating patterns, with 60.1% enjoying 2-3 times weekly and 28.3% eating daily. Only 11.6% consume street food 4-5 times a week, indicating a combination of moderate and frequent consumers. There is a strong demand for street food in surrounding areas of schools, with the majority (41.4%) of street food consumers purchasing street food from near school areas. While 22.7% frequent street corners, 25.3% buy from other places, and only 10.6% of the group purchase street food from footpaths, indicating that the most popular places to eat street food are near schools. Most choose to eat on-site as well as takeout, demonstrating a flexible attitude to consuming (63.1%). While a lesser percentage, 7.1%, only select food delivery, 29.8% of customers prefer eating on-site, recommending that most consumers appreciate the flexibility of choosing food service when they visit street food vendors (Table 8).

Table 8. Street Food consumer's food taking habits.

Observation	*Frequency*	*Percentage (%)*
How many times do you take street food in a week?		
2-3 times	119	60.1
4-5 times	23	11.6
Everyday	56	28.3
Where do you buy street food?		
Near School	82	41.4
Street corner	45	22.7
Footpath	21	10.6
Others	50	25.3
Which of the following types of food service do you take at a street food vending facility?		
Eating on site	59	29.8
Take away foods	14	7.1
Booth takeaway and eating on-site	125	63.1

Source: Own authorship.

Source: Own authorship.

The Table 9 presents data on various aspects of food safety knowledge, practices, and awareness among 198 street food consumers. According to the findings, about twenty-five percent of respondents had heard of Salmonella (23.7%), Clostridium (26.3%), and Staphylococci (23.2%), indicating a lack of knowledge about specific bacteria. Regarding hygiene practices, 39.9% reported washing their hands before eating street food, and only 29.8% observed vendors washing their hands frequently. Environmental factors varied, with 54.5% noting the presence of garbage bins with lids, but only 30.8% reporting healthy refuse disposal facilities. A significant 70.2% observed food left at room temperature, and 64.1% reported flies at vending sites. On a positive note, 61.1% were aware that some microorganisms can cause potentially fatal foodborne diseases. The use of protective gear by vendors (masks, caps, or gloves) was observed by 58.1% of consumers. Overall, these statistics indicate a need for improved food safety practices and increased consumer awareness in the street food sector.

Table 9. Food safety knowledge, practice, and awareness among school going street food consumers (N= 198).

Statements	Response	
	No N (%)	Yes N (%)
Have you ever heard of Salmonella?	151 (76.3)	47 (23.7)
Have you ever heard of Clostridium?	146 (73.7)	52 (26.3)
Have you ever heard of Staphylococci?	152 (76.8)	46 (23.2)
Is there adequate cleaning equipment at the food shop?	119 (60.1)	79 (39.9)
Are the windows and doors cleaned and free from dirt or damage?	118 (59.6)	80 (40.4)
Is there a dedicated garbage disposal bin with a lid at the vending site?	90 (45.5)	108 (54.5)
Are hand washing facilities available?	121 (61.1)	77 (38.9)
Do you wash your hands before taking the street food?	119 (60.1)	79 (39.9)
Do your vendors wash their hands frequently?	139 (70.2)	59 (29.8)
Is the food left at room temperature?	59 (29.8)	139 (70.2)
Is there a healthy refuse disposal facility?	137 (69.2)	61 (30.8)
Is the environment around the stall clean?	110 (55.6)	88 (44.4)
Are the flies available at the vending site?	71 (35.9)	127 (64.1)
Are you aware that some microorganisms can cause foodborne diseases that may lead to death?	77 (38.9)	121 (61.1)
Are utensils adequately covered and cleaned every time after use?	128 (64.6)	70 (35.4)
Do you notice that food vendors wear masks, caps, or gloves?	83 (41.9)	115 (58.1)

Source: Own authorship.

This pie chart shows that whereas 47.5% of people reported problems after eating street food, 52.5% of people did not encounter any problems. The close symmetry between the two groups shows that although many people eat street food without any problems, many of them face difficulties (Figure 9).

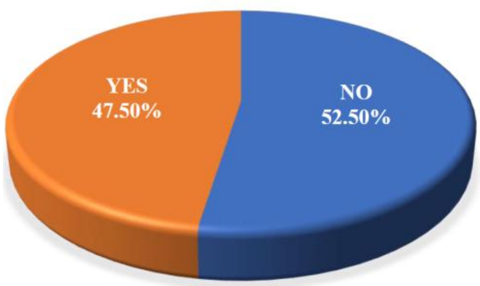


Figure 9. Incidence of consumers' complications after street food consumption. Source: Own authorship.

Discussion

The affordability of street foods sold by vendors often leads to concerns about microbial contamination if not managed properly. In many developing countries, such precautions are overlooked, resulting in severe contamination by various microbes **[14-16]**. Generally, most street food sellers lack access to adequate hygienic facilities, including potable water and restrooms. Furthermore, our survey revealed that they lack enough facilities to keep food covered during preparation and sale. Inadequate hygiene practices during food preparation and handling, together with insufficiently sterilized utensils, may contribute to the substandard heavy metal and microbiological quality of vended foods. Comparable deficiencies in infrastructure for street food vending have been noted by numerous individuals globally **[17]**. A prevalent hygiene error made by these vendors is the inadequate cleaning of utensils, including cutting boards, spoons, knives, glasses, and cups, during food preparation or service. Prior research from Bangladesh, Pakistan, and India indicated that street food sellers in these nations exhibit inadequate sanitary measures **[18-20]**.

Comparing our study to a Brazilian study, our findings indicate significantly higher food contamination by microbes, as only 35% of their food was deemed unsuitable for consumption **[21]**. Like previous study, we have found the presence of considerable amount of heavy metal contamination of selected food items **[22]**. Another similar study provides direct comparative data for popular street foods like *Fuchka* and *Chotpoti*. It highlights high counts of *Staphylococcus aureus* (38.29%) and *E. coli* (17.02%) in similar street food varieties in Bangladesh, reinforcing our further exploration on a large scale **[23]**.

Insufficient food safety knowledge, inadequate personal hygiene prior to food consumption, and a lack of health awareness are the primary factors contributing to various gastrointestinal issues among school-aged children. Consumers expressed significant issues with sanitation, microbial contamination, and inadequate food preparation and handling. A study conducted in Malaysia revealed that consumers are apprehensive about their health when buying street food and consider it detrimental if consumed in excess. Consumers exhibit a more favorable perception of street food that is lower in fat and higher in vegetables **[24]**.

The majority of street food vendors in Comilla City are male (95.45%), which is a common pattern in other studies **[6,25-28]**. The biggest percentage of vendors (46.2%) were between the ages of 25 to 34 years age group which is the same as some of the previous study **[25-28]**. Nearly half of the vendors (41.5%) had finished their primary schooling also similar findings were found in some previous studies **[25-31]** whereas other studies came to different conclusions. Unexpectedly, just a tiny percentage of vendors had received food safety training which is the same in some previous published studies **[25,26,31]**.

In our study, we found that the majority of street food consumers are female. A study found the same types of findings **[26]** whereas some studies found males and females had almost similar consumption rates **[30,31]**. The majority of consumers belonged to the younger age group and this finding was similar to different study **[6,30,31]**.

Limitation of the study

This investigation encountered several constraints. Initially, the sample was collected from merely 20 designated locations inside Cumilla city; hence, the study's findings may not accurately reflect the entirety of Cumilla district. The participants in this study are aged 12 to 18 years, primarily consisting of high school students. Different age groups may offer varying perspectives on street food. Although we chose predominantly popular food products, we had to exclude other street food options due to our laboratory's restricted analytical capabilities.

Conclusion

Due to their affordability and ubiquitous availability, street foods are preferred by people of all ages and walks. School going children especially of high school level are more enchanted by the drooling taste, aroma and look of these items. But their microbial and metal content status are posing great threat to the public health issue. As evidence, our study has identified *Staphylococcus spp, Pseudomonas spp, Coliform, E.coli*, Yeast and Mold in a high extent in the selected food items that can be regarded as the potential food safety concern. A considerable level of heavy metal concentration except Cd in all food items has been detected. At the same time proper training and awareness measures should be arranged to educate our food vendors, if needed, financial support can be provided to them to ensure proper sanitation and cleaning set up beside their food stalls. The implementation of stringent standards regarding proper manufacturing and sanitary practices among street food sellers is essential. Common public especially our school going children should be taught about food safety knowledge and practice.

CRediT

Author contributions: Conceptualization, Funding acquisition: **TA, BKS**.; Sample/laboratory analysis and data collection: **TA, BKS, SA, MAH, FA, MRI, NNC;** Statistical analysis: **MA, MSZ**; data interpretation: **MA, NAN, BKS**; writing the first draft: **TA, BKS**.; Manuscript editing and reviewing: **MA, MSZ;** Project administration: **SKK.**

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Ethical Approval

Ethical approval for this study was obtained from Biosafety, Biosecurity & Ethical Committee, Faculty of Biological Sciences, Jahangirnagar University, Savar, Dhaka-1342, Bangladesh (Ref No: BBEC,JU/M 2024/08 (127)). As this study involves interviewing secondary school goers (mainly of 12-18 years age group) and adult food vendors, verbal consent from the students as well as their parents and vendors as well was taken before conducting the survey, in accordance with the Declaration of Helsinki and its 2024 update.

Informed Consent

Informed consent was obtained from all participants involved in the study, with all procedures explained in detail before participation.

Funding

Not applicable.

Data Sharing Statement

The data that support the findings of this study will be available from the corresponding author upon reasonable request.

Conflict of Interest

The authors declare no competing interests.

Similarity Check

It was applied by Ithenticate@.

Application of Artificial Intelligence (AI)

Not applicable.

Peer Review Process

It was performed.

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References

1. Muchuweti M, Birkett JW, Chinyanga E, Zvauya R, Scrimshaw MD, Lester JN. Heavy metal content of vegetables irrigated with mixtures of wastewater and sewage sludge in Zimbabwe: Implications for human health. Agric Ecosyst Environ. 2006;112(1):41-8.
2. Lucky NA, Nur IT, Ahmed T. Microbiological quality assessment for drug resistant pathogenic microorganisms from the fresh vended fruit juices. Stamford J Microbiol. 2017;6(1):7-10.
3. Aluko O, Ojeremi T, Olaleke D, Ajidagba E. Evaluation of food safety and sanitary practices among food vendors at car parks in Ile Ife, southwestern Nigeria. Food Control. 2014;40:165-71.
4. Madhur V, Yadav V. Microbial analysis of street food. Int J Home Sci. 2019;5(3):20-2.
5. Khairuzzaman MD, Chowdhury FM, Zaman S, Al Mamun A, Bari M. Food safety challenges towards safe, healthy, and nutritious street foods in Bangladesh. Int J Food Sci. 2014;2014:483519.
6. Mamun S, Alam S, Zaher MA, Huq AO. Food Safety Knowledge, Attitudes and Behavior of Street Food Vendors and Consumers in Dhaka City. Bangladesh J Microbiol. 2020;37(2):48-51.
7. Dey TK. Urbanization and the prevalence of foodborne infections in emerging economies. J Public Health Policy. 2018;39(4):455-68.
8. Das A, Das A. Heavy metals in common food items in Kolkata, India. Euro-Mediterr J Environ Integr. 2018;3:31.
9. International Organization for Standardization. Microbiology—General Guidance on Methods for the Detection of Salmonella (ISO 6579:2002). 4th ed. Geneva: ISO; 2002.
10. Dharmarathne G, De P, Abeysundara A. Assessment of microbial quality of street foods sold in Nugegoda, Sri Lanka. [Source details missing, e.g., Journal Name]. 2022.
11. International Organization for Standardization. Microbiology of food and animal feeding stuffs — Horizontal method for the detection of Shigella (ISO 21567:2004). 1st ed. Geneva: ISO; 2004.
12. Association of Official Analytical Chemists. AOAC Official Method 990.08. [Source details missing].
13. American Public Health Association. Method 3120. In: Standard Methods for the Examination of Water and Wastewater. Washington, DC: APHA; [Year].
14. Samad D, Abbas F, Ahmad Z, Tanveer Z, Ahmad I, Nawaz N, et al. Multiplex polymerase chain reaction detection of Shiga toxin genes and antibiotic sensitivity of Escherichia coli O157:H7 isolated from beef meat in Quetta, Pakistan. J Food Saf. 2018;e12540.
15. Samad D, Abbas F, Tanveer Z, Ahmad Z, Ahmad I, Nawaz N, et al. Prevalence of Salmonella spp. in chicken meat from Quetta retail outlets and typing through multiplex PCR. Rom Biotechnol Lett. 2019;24:271-9.
16. Samad D. Isolation and Identification of Listeria monocytogenes from Raw Vegetables and Meat Sold in Quetta Pakistan. Pak J Zool. 2019;52.
17. Sabuj AAM, Haque ZF, Barua N, Islam MA, Saha S. Assessment of Bacteriological Quality of Street Vended Fast Foods and Their Antimicrobial Resistance. Int J Curr Microbiol Appl Sci. 2018;7(11):3049-59.
18. Uddin M, et al. Microbial Safety of Street Vended Fruit Juices in Dhaka City of Bangladesh. J Adv Microbiol. 2017;3(2):1-7.
19. Gupta M, Tomar RS, Kaushik S, Mishra R. Bacteriological Quality of Panipuri in Historical Gwalior City (MP), India. Asian J Pharm. 2018;12:S328.
20. Bi S, et al. Street Vended Foods and Associated Environment in Two Major Cities of India: Microbial Safety Concern. Int J Livest Res. 2018;8(5):312.
21. Hanashiro A, Morita M, Matté GR, Matté MH, Torres EAFS. Microbiological quality of selected street foods from a restricted area of São Paulo city, Brazil. Food Control. 2005;16(5):439-44.
22. Haque M, Islam MMT, Hassan T, Shekhar H. Determination of Heavy Metal Contents in Frequently Consumed Fast Foods of Bangladesh. Proc Natl Acad Sci, India, Sect B Biol Sci. 2018;89.
23. Moli SR, Shovo TR, Khan RA, Islam MZ, Miah MS. Microbiological quality of street foods and antimicrobial resistance pattern of bacterial isolates including assessment of food hygiene knowledge of respective food handlers. Am J Pure Appl Biosci. 2025;7(2):221-34.
24. Chang FS. Consumer's Perception Towards Street Food In Malaysia. EPRA Int J Res Dev. 2020;5(2).
25. Abid MT, Banna MHA, Hamiduzzaman M, Seidu

A, Kundu S, Rezyona H, et al. Assessment of food safety knowledge, attitudes and practices of street food vendors in Chattogram city, Bangladesh: A cross-sectional study. Public Health Chall. 2022;1(3):e16.

26. Farhana Z, Sutradhar N, Mustafa T, Naser MN. Food Safety and Environmental Awareness of Street Food Vendors of the Dhaka University Campus, Bangladesh. Bangladesh J Zool. 2020;48(1):181-8.

27. Islam S, Tanjia N, Mitra AK, Hossain A, Jasika MT, Suhi SS, et al. Inadequate food safety knowledge and hygiene practices among street food vendors in Dhaka, Bangladesh. Sci Rep. 2024;14(1):17349.

28. Meher MM, Afrin M, Talukder AK, Haider MG. Knowledge, attitudes and practices (KAP) of street food vendors on food safety in selected areas of Bangladesh. Heliyon. 2022;8(12):e12166.

29. Hossen MT, Ferdaus MJ, Hasan MM, Lina NN, Das AK, Barman SK, et al. Food safety knowledge, attitudes and practices of street food vendors in Jashore region, Bangladesh. Food Sci Technol. 2021;41(suppl 1):226-39.

30. Ma L, Chen H, Yan H, Wu L, Zhang W. Food safety knowledge, attitudes, and behavior of street food vendors and consumers in Handan, a third tier city in China. BMC Public Health. 2019;19(1):1128.

31. Samapundo S, Cam Thanh TN, Xhaferi R, Devlieghere F. Food safety knowledge, attitudes and practices of street food vendors and consumers in Ho Chi Minh city, Vietnam. Food Control. 2016;70:79-89.

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