



Food Safety Knowledge and Microbial Status of Food Contact Surfaces in Primary Schools in Morogoro Municipal, Tanzania

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Abstract

Introduction: Several outbreaks of foodborne illnesses to school children have been reported in different countries where food service workers are questioned to be responsible due to poor knowledge and practices. The purpose of this study was to evaluate the food safety knowledge among food service workers and microbial status of food contact surfaces in private primary school in Morogoro Municipal, Tanzania.

Methods: This study involved 60 food service workers who were purposively selected from 8 private primary schools. A structured questionnaire and checklist were employed to assess their food safety knowledge, and a total of 75 samples from food contact surfaces (cups, spoons, and plates) were collected from school kitchens for microbiological analysis.

Results: The study involved 60 food service workers, with the majority being female (73.3%) and married (65%). Education levels ranged from primary to secondary school (41.7%), with the least illiterate (3.3%). The survey demonstrated a significant level of food safety knowledge, with an average score of 81%. The study indicates that food service workers recognize the need for hand hygiene, with 96.6% washing their hands before and after food preparation, and 96.6% asserting that it mitigates the risk of food contamination. The study found moderate contamination levels in cups and plates, with mean total viable count (TVC) values ranging from 2.19 to 2.67 log CFU/ml, and total coliform count (TCC) in various schools (0 to 1.23 log CFU/ml). *E. coli* contamination in food service indicates gaps in hygienic practices, despite workers' awareness of cleanliness and personal hygiene. *E. coli* contamination was detected in cups in school A and E, with 20% contamination in cups and 40% contamination in plates, indicating possible faecal contamination.

Conclusion: The study found that while school food service personnel have a moderate food safety knowledge, they still struggle with microbial contamination on food contact surfaces. The detection of *E. coli* on certain surfaces highlights deficiencies in hygiene protocols, possibly due to insufficient training, resources, or incentives.

Keywords: Food service workers, Food safety knowledge, Food contact surfaces, Microbial status

Introduction

Food safety assurance has been of high public concern worldwide (Jubayer *et al.*, 2020). The knowledge of food safety and microbial status of the food contact surfaces is a clear indication of the food hygienic quality (Illés *et al.*, 2018). The World Health Organisation (WHO) underscores the importance of safe food handling and preparation, emphasising that lapses in food safety can lead to a myriad of health issues (Organisation). Disadvantages of poor food safety include, foodborne

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illnesses caused by microbial contamination and ingesting the food contaminated with pathogenic microbes (Hald *et al.*, 2016). Foodborne illnesses caused by *Salmonella typhi*, *Listeria spp*, *Taenia solium*, *Hepatitis A virus*, *Clostridium perfringens* and aflatoxins have been a major cause of millions of deaths each year worldwide whereby nearly 800,000 deaths of children under 5 years are reported each year (Havelaar *et al.*, 2015).

Food can be contaminated during production in the farms by unsafe water utilization or soil, in handling, storage or by the methods used in preparation and cooking (Aluh *et al.*, 2021). Higher chances of contamination have reported due to unhygienic food handling and preparation from food service providers and lack of hygiene in food contact surfaces (Abd Lataf Dora-Liyana *et al.*, 2018). Food service workers are tasked with ensuring that food is free from contamination and safe for consumption, whether at home or in public settings (Lee *et al.*, 2017). These workers utilize various surfaces in contact with food, including cutting boards, tables, plates, knives, utensils, spoons, forks, and washing sinks during food handling and preparation. These surfaces pose a persistent risk of cross-contamination to food products, where mesophilic aerobes, including *E. coli* and other microorganisms, may contaminate the food (Mgqibandaba *et al.*, 2020).

According to the findings of Havelaar *et al.* (2015), Odeyemi *et al.* (2019) and Aluh *et al.* (2021), developing countries exhibit a higher incidence of foodborne illnesses in schools, attributed to the inadequate food knowledge of food service personnel, insufficient food handling facilities, and cultural practices. In contrast, developed countries have adopted enhanced food safety protocols, including prerequisite programs and Hazard Analysis Critical Control Point (HACCP) systems, which are implemented by food handlers in school kitchens. However, the foodborne outbreaks in these kitchens with HACCP plan are still reported (Pagotto *et al.*, 2018).

Primary schools in Tanzania, which educate students younger than fourteen and are either publicly or privately funded, are required by the country's 2014 national education and training policy to provide meals to their students (Appietu & Amuquandoh, 2020). These foods are handled and prepared within school boundaries by the appointed food service workers by school boards (Webb & Morancie, 2015). Safety of the food for children is very vital as they are easily and highly affected by foodborne illness because they do not have much developed immune system or can be already threatened by other diseases (Sibanyoni & Tabit, 2019). The significance of ensuring impeccable food safety practices within these educational settings is underscored by the potential impact on the health and development of students.

Lack of adequate knowledge among food service workers on food safety, including good hygiene practices (GHP) on preparation and handling of food and food contact surfaces, poses a significant threat to students' health, including the risk of foodborne illnesses and their impact on students' health (Nyawo *et al.*, 2021). Studies have shown that there have been serious outbreaks of foodborne illnesses that have been reported in various schools across the globe (Alemayehu *et al.*, 2021; Ameme *et al.*, 2016; Bujang *et al.*, 2023; Pretty, 2020). However, there was absence in authentic information about knowledge among food service workers and the hygiene of the food contact surfaces in primary schools in Tanzania and Morogoro at particular.

Moreover, Häsler *et al.* (2014) indicated that African nations, such as Tanzania, exhibit a deficiency in baseline surveys, surveillance systems, and peer-reviewed literature, hindering the acquisition of a comprehensive understanding of foodborne infections. In Dar es Salaam, Tanzania, Moyo *et al.* (2007) reported that 22.9% of diarrhea cases were attributed to *E. coli*. Other findings indicate that Tanzania's dairy value chain may be associated with various zoonotic and food-borne diseases, including tuberculosis, brucellosis, anthrax, antibiotic residues and resistance, salmonellosis,

and campylobacteriosis (Häsler et al., 2014). Prior studies indicate that school food safety has been overlooked in developing countries (FAO, 2019; Nicholaus, 2023).

Recent research indicates a lack of information regarding food safety in school feeding programs, particularly concerning aflatoxins and pesticide exposure from the regular consumption of sensitive crops (Nicholaus, 2023). School food safety is not monitored due to limited awareness and knowledge of safety issues, as well as insufficient resources, infrastructure, and equipment (Roothaert et al., 2021). This study aimed to assess the food safety knowledge among food service workers and microbial status of food contact surfaces in private primary school in Morogoro Municipal, Tanzania. This research is vital for stakeholders like parents, school administrators, health authorities, and policy makers to improve food safety practices, prevent outbreaks, and create a safer learning environment.

Materials and methods

Research design and sampling

This was a cross-sectional research study conducted in private primary schools in Morogoro Municipal, Tanzania, from February 2024 to May 2024. The study was conducted at 8 Private Primary Schools in Morogoro Municipal, which were purposively selected from 5 wards: Kihonda (2 schools), Bigwa (1 school), Kichangani (2 schools), Lukobe (1 school), and Tungi (2 schools), based on the availability of schools in each ward. The private schools in Morogoro were selected for this study because they all provide meals for their students and can effectively evaluate food safety, in contrast to public primary schools, most of which do not engage in a school feeding program and do not offer food to their students. In specific schools, parents provide food items directly to their children. Additionally, a total of 60 food service workers were randomly chosen from the designated schools to participate in the study, and their food safety knowledge was then evaluated using a structured questionnaire and checklist. Furthermore, a total of 75 swab samples were collected from the selected school kitchens to assess the microbiological status of food contact surfaces (spoons, plates and cups).

Data collection

Structured questionnaire

The results about food safety awareness among food service workers were collected using structured questionnaires developed from a comprehensive literature study and group discussions (Nkosi et al., 2021; Sobuj et al., 2022). The questionnaire was pre-tested in a pilot study at one private school in Morogoro to ascertain its reliability and validity prior to comprehensive data collecting utilizing this instrument. The questionnaire comprised two sections: the first addressed demographic characteristics including gender, age, educational attainment, and duration of employment, while the second section featured questions pertaining to food safety knowledge, crafted for clarity and ease of response for participants.

The questionnaires were translated from English to Swahili for clarity and subsequently distributed to interested food service workers in the corresponding schools following a brief introduction to the issue and a guarantee of confidentiality about the obtained information. Each participant completed the questionnaire, resulting in the collection of 60 questionnaires from all sampled schools for analysis. The checklists for observing the fundamental specified indicators for basic qualities were utilized. Data about hygienic practices and environmental conditions, including hygienic facilities, food handling practices, and personal hygiene of food service workers, were obtained to assess the status of food contact surfaces.

Microbial analysis

Microbial analysis was conducted to determine Total Viable Count (TVC) and Total Coliform Count (TCC) on the food contact surfaces. Food contact surfaces were assessed by randomly collecting five (5) samples of spoons, plates, and cups in five school kitchens, resulting in a total of 75 samples for microbiological examination. Although eight private schools participated in this study, only five school kitchens were used, as three were excluded due to ongoing repairs and maintenance, rendering them unsuitable for sample collection. Sampling was performed on serving spoons, plates and cups, by swabbing using rotational protocols with sterile collection swabs previously moistened with sterilized normal saline water according to Maes et al. (2017) method with modification. A premoistened sponge stick was used to sample the food contact surface (spoons, plates and cups). Subsequent to sampling, the sponge stick was inserted into the bag, and the stick was flexed to break it, permitting the cellulose sponge to fall into the sterile plastic bag. Subsequently, 10 mL of normal saline solution was introduced into the bag. The samples within the stomacher bags, each containing 10 mL of diluent, were homogenized in a stomacher for 2 minutes. The samples were placed in tubes, labeled with identification codes, and stored in a cool container (2 to 8°C) before being promptly transported to the laboratory for microbial analysis.

Total Viable Count (TVC)

Serial ten-fold dilutions were prepared from 10^{-1} to 10^{-6} in 0.1% BPW; duplicate pour plates were prepared using 1 ml from each dilution and mixed with about 20-25 ml tempered (44-47°C) Plate Count Agar (OXOID® Ltd., Basingstoke, U.K.). The plates were incubated aerobically at 37 ± 1 °C for 24 ± 3 h. Colony forming units were counted on at least two critical dilution plates by the aid of colony counter. Two consecutive plates with 30-300 colonies were considered for record. The number of colonies were converted into the weighted mean colony forming units per millilitre or total number of bacteria (cfu/ml) using a formula;

$$\text{No. of bacteria in } \frac{\text{CFU}}{\text{ml}} = \frac{\text{number of colonies} \times \text{reciprocal of dilution factor}}{\text{inoculum size(ml)}} \dots\dots\dots \text{Eqn. 1}$$

Total Coliform Count (TCC) and Isolation of *Escherichia coli*

The total coliform count (TCC) was evaluated using MacConkey agar media, whereby 1 ml from each diluted sample was inoculated onto sterile Petri dishes containing about 15 ml of solidified MacConkey agar, followed by incubation at 37 °C for 24 hours. Plates with 15-150 colonies were considered for record. The number of colonies were converted into the weighted mean colony forming units per millilitre or total number of bacteria (cfu/ml) using equation No.1

For isolation and identification of *Escherichia coli*, the enrichment of the sample was done using sterilized peptone buffer water (PBW) where swabs were inoculated and then incubated for 24 hours. Subsequently, culture was performed by streaking a loopful onto MacConkey agar for the isolation of *Escherichia coli* at 37°C for 24 hours. Following incubation, the plates were assessed for distinctive colonies of *Escherichia coli*, employing two methodologies for identification: macro-morphology and micromorphology. In macro morphology, the presence of pinkish coloration, lactose fermentation, a pungent odor, and smooth, shiny colonies indicated a positive reaction. In micromorphology, the Gram stain technique revealed the characteristics of *Escherichia coli*, which included Gram-negative, rod-shaped bacteria occurring singly.

Data Analysis

Food safety knowledge

Microsoft Excel 2021 was used for data entry and analysis, with descriptive statistics calculated. Knowledge scores were coded and converted to percentages. Data was imported into IBM SPSS for statistical analysis, with ANOVA tests conducted to determine if age, marital status, and education level significantly impacted knowledge scores. Results were presented in tables and figure.

Microbial status of food contact surfaces

The microbiological test data were compiled in a Microsoft Excel 2021 spreadsheet and subsequently imported into IBM SPSS version 20, where a one-way ANOVA was conducted to analyze the microbial condition of different food contact surfaces. A post hoc (Tukey) analysis was conducted to assess the microbiological status of food contact surfaces and the food safety knowledge of food service workers across the five examined schools, with the aim of identifying the relationship between these variables.

Results

Demographic Information and Food Safety Knowledge of Respondents

The demographic characteristics of the respondents are represented in Table 1. The majority of food service workers who took part in the survey were women (73.3%). The majority of respondents (66.7%) were aged between 21 and 40, while a small proportion were elderly individuals over 60 years (1.7%), with most being married (65%). The findings indicate that the educational attainment of numerous food service workers varies from elementary school (41.7%) to secondary school (40.0%), with a minimal proportion being illiterate (3.3%). A majority were involved in full-time service (71.7%), with their experience ranging from 3 to 10 years (58.3%).

Table 1: Demographic characteristics of respondents

| Parameters | Choices | Percentage % |
|--------------------|------------------------|--------------|
| Gender | Female | 73.3 |
| | Male | 26.7 |
| Age | <20 | 6.7 |
| | 21-40 | 66.7 |
| | 41-60 | 25 |
| | >60 | 1.7 |
| Education level | Can sign | 3.3 |
| | Up to primary school | 41.7 |
| | Up to secondary school | 40 |
| Marital status | Above primary school | 15 |
| | Single | 33.3 |
| | Married | 65 |
| Employment status | Widow | 1.7 |
| | Full time | 71.7 |
| | Part time | 28.3 |
| Working experience | <2 years | 25 |
| | 3-10 years | 58.3 |

| | |
|--------------|------|
| 11- 20 years | 13.3 |
| >20 years | 3.3 |

Total number of respondents (n = 60)

The average knowledge score in relation to demographic characteristics of the respondents are represented in Table 2. Approximately 53.33% of the respondents, exceeding half, achieved knowledge scores above the computed average of 81%, whilst a minority, including 28 respondents (46.67%), scored below this average. The findings indicated a substantial influence of education level on the average knowledge score (Table 2). The Bonferroni post hoc test showed that individuals with education above secondary school had a significant high knowledge score (88.89%) than those individuals who had their education up to secondary school (81.61%) with $p < 0.05$. Other demographic factors had no significant effect on knowledge score ($p > 0.05$).

Table 2: Relationship between knowledge and demographic data of respondents

| Demographic | Factor | N | Mean \pm SD | P-value |
|-------------------------------|------------------------|----|--------------------------------|---------|
| Gender | Female | 43 | 80.77 ^a \pm 9.21 | 0.965 |
| | Male | 17 | 80.92 ^a \pm 16.73 | |
| Marital status | Single | 19 | 80.99 ^a \pm 11.99 | 0.921 |
| | Married | 40 | 80.61 ^a \pm 11.79 | |
| | Widow | 1 | 85.37 ^a \pm 0 | |
| Education | up to primary school | 25 | 76.58 ^a \pm 12.71 | 0.034 |
| | up to secondary school | 24 | 81.61 ^{ab} \pm 9.78 | |
| | above secondary school | 9 | 88.89 ^c \pm 9.99 | |
| Age group | < 20 | 3 | 70.73 ^a \pm 32.27 | 0.332 |
| | 21- 40 | 40 | 81.89 ^a \pm 10.69 | |
| | 41-60 | 16 | 79.42 ^a \pm 8.26 | |
| | >60 | 1 | 90.24 ^a \pm 0 | |
| Employment Status | Full time | 44 | 80.38 ^a \pm 9.38 | 0.636 |
| | Part time | 16 | 82.01 ^a \pm 16.78 | |
| Working experience (in years) | < 2 years | 14 | 83.97 ^a \pm 10.16 | 0.15 |
| | 3-10 years | 35 | 78.05 ^a \pm 12.69 | |
| | 11-20 years | 9 | 86.72 ^a \pm 7.91 | |
| | Above 20 years | 2 | 80.49 ^a \pm 0 | |

Means with different superscript letters are significant different ($p < 0.05$)

Food Hygiene Knowledge among Food service workers.

Results for hand washing and hygiene knowledge among food service workers are presented in Table 3. Ensuring cleanness of hands of the food service workers is important for assuring safety of the food. In the current study, most of respondents know their role to wash their hands both before and after the food preparation work (96.6%) and accept that washing the hands properly can reduce the risk of food contamination (96.6%). About 57.6% of respondents wash their hands after visiting the toilets and after picking the nose, where majority of them are aware on the correct way to clean hands by using

either cold water (16.9%) or warm water (37.3%) or both (33.9%) with soap and cleaning hands with only water is not enough (93.2%).

However, most of them do not know that it is harmful handling food while touching money (61%) or when sick from flu, colds, cough while 94.6% of them know the correct way to handle an injured hand during food handling by covering the wound with water proof bandage.

Table 3: Hand washing and hygiene knowledge of food service workers

| Parameters | Answer choice | Percentage% |
|---|--|-------------|
| As a food handler, which of the following compels you to wash your hands when you are involved in preparations and serving of food? | After visiting toilet only | 28.8 |
| | After picking your nose | 5.1 |
| | None of above | 8.5 |
| | Both 1 and 2 | 57.6 |
| As a food handler, I must not handle food and money and when I have Flu, colds, cough or catarrh | True | 39 |
| | False | 61 |
| As a food handler, I must not handle food when I have Diarrhoea, even when I was my hands regularly | True | 64.4 |
| | False | 35.6 |
| Washing hands regularly before work is a part of personal hygiene | Yes | 96.6 |
| | No | 3.4 |
| Washing hands regularly after work is one part of personal hygiene | Yes | 96.6 |
| | No | 3.4 |
| Washing hands properly reduce risk of food contamination | Yes | 96.6 |
| | No | 3.4 |
| Which is of the following is the correct way to wash your hands during the preparation and serving of foods? | Wash hands with soap and cold running water and then wipe dry with clean cloth | 16.9 |
| | Wash hands with soap and warm running water and then wipe dry with a clean cloth | 37.3 |
| | Both 3 and 4 above are correct | 33.9 |
| | Wash hands with warm running water and wipe dry with a clean cloth | 10.2 |
| | Wash hands with cold running water and wipe dry with clean cloth | 1.7 |
| Washing hands with only water can't clean enough | Yes | 93.2 |
| | No | 6.8 |
| As a food handler, which of the following is a correct thing to do if you have a wound on your hands? | Cover the wound with a water proof dressing /bandage | 94.9 |

| Parameters | Answer choice | Percentage% |
|------------|----------------------------------|-------------|
| | Do nothing, if it is not painful | 5.1 |

Several questions were used to evaluate the knowledge of food workers on food hygiene which directly affect food safety as shown on the table 4. About 98.3% of respondents agreed on ensuring that the kitchen is clean before starting the work and most of them 90% agree that personal hygiene can prevent food contamination. To prevent food contamination, most respondents (93%), agreed that using bare hands to taste or distribute food is unhealthy, and that covering one's mouth when coughing or sneezing is a good precaution (96%). Additionally, they agreed that using clean tools, like knives, to clean contaminated foods, like raw meat, is also important (96%). However, 48.3% were not aware on the risk of contact between wet and dry foods.

Table 4: Food hygiene knowledge of food service workers

| Parameter | Choice | Percentage % |
|---|----------|--------------|
| Prior to beginning the work, the work area should be clean | Agree | 98.3 |
| | Neutral | 1.7 |
| | Disagree | 0.0 |
| Personal hygiene can prevent food contamination | Agree | 90.0 |
| | Neutral | 5 |
| | Disagree | 5 |
| Several types of hazards cause contamination | Agree | 93.3 |
| | Neutral | 1.7 |
| | Disagree | 5 |
| Taste or distributing food with unprotected hands is harmful to health | Agree | 93.3 |
| | Neutral | 1.7 |
| | Disagree | 5 |
| While coughing or sneezing, it is necessary to use protective measures to cover your mouth | Agree | 96.7 |
| | Neutral | 1.7 |
| | Disagree | 1.7 |
| Food handlers with wounds or symptoms of diseases/ infections should not work on the activities | Agree | 81.7 |
| | Neutral | 3.3 |
| | Disagree | 15 |
| Cleaning all food contact surfaces with water and soap before using is important | Agree | 86.7 |
| | Neutral | 3.3 |
| | Disagree | 10 |
| Using different types of instruments to process different types of food is essential | Agree | 91.7 |
| | Neutral | 1.7 |
| | Disagree | 6.7 |
| Washing the knife used to cut wet foods such as meat with water and soap is important before using it | Agree | 96.7 |
| | Neutral | 1.7 |
| | Disagree | 1.7 |
| Washing food contact surfaces with water and sanitizer every day is important | Agree | 98.3 |
| | Neutral | 1.7 |
| | Disagree | 0 |
| Wet food come in contact with processed/dry food | Agree | 48.3 |
| | Neutral | 3.3 |

| Parameter | Choice | Percentage % |
|-----------|----------|--------------|
| | Disagree | 48.3 |

Food safety knowledge of food service workers

The food safety knowledge and health characteristics of food service workers are shown in Table 5. Results indicate that most of them are aware of wearing apron, mask, gloves and hair net during food preparations (95%), avoid touching hairs (96.7%), no long or coloured nails (98.3%), proper cleaning of equipments after work (98.3%) and separating clean and dirty zones can reduce the risk of food contamination, contaminated food has always some changes in colour, odor and taste (98.3%) also re use of oil is dangerous for health (83.3%). However, more than half were not aware of risk of reheating the food to cause food contamination (58.3%) as well as eating and drinking while handling food (48.3%).

Moreover, majority of the respondents were aware that there are microorganisms that can cause foodborne illnesses and also may lead to death (95%) but most of them are not aware of the actual organisms responsible for foodborne illnesses. Those who were not aware of *Salmonella* (50%), *Staphylococcus* (73.3%), *Listeria* (70%), *Clostridium* (75%).

Although knowledge scores are satisfactory, certain positive microbiological tests reveal a gap between the knowledge and practices of food service workers. The lack of well-defined food safety systems and standards, such as HACCP, in most sampled schools, along with the insufficient use of essential resources like gloves and sanitizers in daily operations, may account for this situation (Illés et al., 2018).

Table 5: Food safety knowledge of food service workers

| Parameters | Choice | Percentage % |
|---|--------|--------------|
| Wearing gloves, masks and hairnets is one part of personal hygiene | Yes | 95 |
| | No | 5 |
| Wearing mask is important during food preparation | Yes | 86.7 |
| | No | 13.3 |
| Wearing gloves is important during food preparation | Yes | 83.3 |
| | No | 16.7 |
| Wearing hairnets is a part of personal hygiene during food preparation | Yes | 88.3 |
| | No | 11.7 |
| Workers should avoid touching their hairs after washing hands | Yes | 96.7 |
| | No | 3.3 |
| Eating and drinking while working increase the risk of food contamination | Yes | 51.7 |
| | No | 48.3 |
| Proper cleaning and handling of instruments reduce the risk of food contamination | Yes | 96.7 |
| | No | 3.3 |
| Food service workers cannot have long nails or coloring it | Yes | 98.3 |
| | No | 1.7 |
| Use of gloves reduce the risk of transmitting infections to consumers | Yes | 95 |
| | No | 5 |
| Broken gloves have to be changed with the new one | Yes | 100 |

| Parameters | Choice | Percentage % |
|--|--------|--------------|
| Cleaning equipment after work can reduce the risk of cross contamination | No | 0 |
| | Yes | 98.3 |
| Separating dirty zone from clean zone can reduce cross contamination | No | 1.7 |
| | Yes | 100 |
| Contaminated food always has some changes in colors, odor and taste | No | 0 |
| | Yes | 99 |
| Reuse of cooking oil is dangerous for health | No | 1 |
| | Yes | 83.3 |
| Reheating cooked food can contribute to food contamination | No | 16.7 |
| | Yes | 41.7 |
| Are you aware that some microorganisms can cause foodborne diseases to you may lead to death | No | 58.3 |
| | Yes | 26.7 |
| Have you ever heard of Staphylococcus? | No | 73.3 |
| | Yes | 95 |
| Have you ever heard of Salmonella? | No | 5 |
| | Yes | 50 |
| Have you ever heard of Listeria? | No | 50 |
| | Yes | 30 |
| Have you ever heard of Clostridium? | No | 70 |
| | Yes | 25 |
| | No | 75 |

Observation of food and hygiene practices

Table 5 presents the results of observations made regarding food hygiene and practices in schools. Of the eight schools that took part in the study, observations made around the kitchen area reveal that 77.8% of the foodservice workers wears protective gear, such as hairnets and closed shoes. Additionally, the majority of dustbins used in these kitchens are covered (55.5%)

Table 6: Observation of Food Hygiene and Practices in School Kitchens

| Parameter | Choice | Percentage% |
|---|--------|-------------|
| Does food service workers wear all protective gears like closed shoes and hairnets | Yes | 77.8 |
| | No | 22.2 |
| Does the food service workers practice proper hand hygiene such as washing hand with soap and water before handling food and while preparing food | Yes | 77.8 |
| | No | 22.2 |
| Does food service workers have short nails and clean hands | Yes | 88.9 |
| | No | 11.1 |
| Handwashing before or after food preparation | Yes | 77.8 |
| | No | 22.2 |
| Utensils are in good conditions | Yes | 88.9 |
| | No | 11.1 |

| | | |
|---|---------------------|------|
| Mode of cleaning utensils | Cold water and soap | 88.9 |
| | Cold water | 11.1 |
| Are dustbin covered | Yes | 55.5 |
| | No | 44.5 |
| Status of kitchen area | Good | 33.3 |
| | Average | 55.6 |
| | Bad | 11.1 |
| Does workers exhibit knowledge of basic food safety principles during food handling | Yes | 88.9 |
| | No | 11.1 |
| Does the workers use separate cutting board and knives for raw and cooked food | Yes | 33.3 |
| | No | 66.7 |

Microbial status

The results of microbial tests conducted on food contact surfaces (cups, spoons, and plates) in five different schools using 75 collected swabs show that total viable counts (TVC) and total coliform counts (TCC) vary (Table 7). The TVC for cups ranged from 2.19 to 2.67 Log₁₀ CFU/ml across the five schools, with no significant differences (p=0.71). The TCC was generally low with most schools showing no coliform counts except for school A (1.13 Log₁₀ CFU/ml) and school E (0.7 Log₁₀ CFU/ml). The plates were also assessed for TVC and results ranged from 2.29 to 3.12 CFU/ml with no statistical difference between schools (p=0.49). The TCC in most schools was below or close 1.0 Log₁₀ CFU/ml indicating minimal presence of coliforms. Different from other surfaces spoon varied significantly in TVC values (p=0.001), the TCC was not detected in the spoon by the method used.

Table 7: Microbial status (TVC and TCC) of the food contact surfaces

| Food contact surface | School | N | TVC (Log ₁₀ CFU/ml) | | TCC (Log ₁₀ CFU/ml) | |
|----------------------|--------|---|--------------------------------|---------|--------------------------------|---------|
| | | | Mean ± SD | P-value | Mean ± SD | P-value |
| Cup | A | 5 | 2.57 ^a ± 0.5 | 0.71 | 1.13 ^a ± 1.56 | 0.27 |
| | B | 5 | 2.58 ^a ± 0.73 | | 0 ^a ± 0 | |
| | C | 5 | 2.67 ^a ± 0.55 | | 0 ^a ± 0 | |
| | D | 5 | 2.19 ^a ± 0.21 | | 0 ^a ± 0 | |
| | E | 5 | 2.39 ^a ± 0.73 | | 0.7 ^a ± 1.57 | |
| Spoon | A | 5 | 1.77 ^a ± 0.12 | 0.001 | 0 ± 0 | NA |
| | B | 5 | 1.8 ^a ± 0.15 | | 0 ± 0 | |
| | C | 5 | 2.13 ^b ± 0.25 | | 0 ± 0 | |
| | D | 5 | 2.05 ^{ab} ± 0.08 | | 0 ± 0 | |
| | E | 5 | 2.23 ^b ± 0.17 | | 0 ± 0 | |
| Plate | A | 5 | 3.12 ^a ± 1.45 | 0.49 | 1.22 ^a ± 1.72 | 0.99 |
| | B | 5 | 2.37 ^a ± 0.19 | | 0.96 ^a ± 2.15 | |

| | | | |
|---|---|--------------------------|--------------------------|
| C | 5 | 2.49 ^a ± 0.66 | 1.23 ^a ± 1.71 |
| D | 5 | 2.79 ^a ± 0.79 | 0.99 ^a ± 1.36 |
| E | 5 | 2.29 ^a ± 0.21 | 0.70 ^a ± 1.56 |

Mean values with different superscript letters are significant different ($p < 0.05$).

The results for *E. coli* isolated from food contact surfaces are presented in Table 8. All food contact surfaces that were tested coliform positive, further test was carried out for identifying the presence of *E. coli* as the results shown in the table 8. The cups in school A and E were found to have *E. coli* 40% and 20%, respectively. The plates in all schools exhibited *E. coli* contamination, as indicated in Table 8, suggesting potential fecal contamination in school kitchens. However, according to international microbiological guidelines for food contact surfaces, the observed level (< 20 CFU/mL) is insufficient to cause foodborne illness (Hasell & Salter, 2003). The unsatisfactory results linked to cups and plates can be attributed to food service workers not adequately drying these utensils. The piled rims inhibit adequate drying, thereby facilitating the potential persistence of residual microbes. Furthermore, the use of inadequate cleaning tools, including textile cloths and non-antibacterial sponges, exacerbates this issue.

Table 8: *E. coli* isolation from food contact surfaces

| School | Cup | | Plate | |
|--------|---------|----|---------|----|
| | Present | | Present | |
| | N | % | N | % |
| A | 2 | 40 | 2 | 40 |
| B | NT | - | 1 | 20 |
| C | NT | - | 2 | 40 |
| D | NT | - | 2 | 40 |
| E | 1 | 20 | 1 | 20 |

NT = Not Tested

Discussion

The present study aimed to evaluate the level of food safety knowledge among foodservice workers in private primary schools in Morogoro Municipal. The results indicate generally a high level of food safety knowledge, with an average knowledge score of 81%. More than half of the respondents scored above this average, reflecting a satisfactory level of awareness regarding food safety practices among the participants.

Demographic Information and Food Safety Knowledge of Respondents

The demographic analysis showed that majority of food 2223 workers were female (73.3%) related to results from other studies conducted in Africa by Ackah *et al.* (2011) in Ghana and Sibanyoni *et al.* (2017) in South Africa with higher number of female food service workers where these studies revealed that,

most females are employed in this area because they have acquired enough experience from cooking at home. Though there was no significant difference in food safety knowledge score between males and females, with male knowledge score of 80.92% and that of females was 80.77%, as any gender is free to acquire and apply any knowledge potentials.

Most respondents were predominantly within the age group of 21 to 40 years (66.7%) regarded as younger adult group which is a good work force in school kitchens. However, regardless of different age groups as shown in Table 1, there was no significant outcome of age on food safety knowledge statistically, possibly because knowledge can be acquired and retained at any age. In contrary to the results founded by Illés *et al.* (2018) where the knowledge level of adult workers more than 40 years was higher than that of younger adult group. Moreover, there is an increasing trend of knowledge with working experience where those with more than 10 years of experience has high mean knowledge (86.72%) than others, this might be due exposure to potential practical skills which highlights the importance of formal education and trainings.

Most of respondents have education background of primary (41.7%), secondary (40.0%) and above secondary (15.0%) and only a small proportion were illiterate (3.3%), implying that this literate group can handle the food safely, since they could read and write and might also easily remember whatever trainings or instructions given. The analysis showed that education level significantly influenced food safety knowledge, with those possessing education above secondary school exhibiting significantly higher knowledge scores compared to those with lower educational levels ($p=0.034$). A study by Schlegelová *et al.* (2010), found that demographic factors such as age, education, and income level were associated with differences in food safety knowledge, it revealed that individuals with higher education levels were more likely to have better food safety knowledge compared to those with lower education and income levels.

Food Hygiene Knowledge among Food service workers

The study discloses that most food service workers have generally high understanding of essential hand washing and hand hygiene practices, where most of respondents (96.6%) know their role to wash their hands both before and after the food preparation work. Moreover, similar percentage accept that washing the hands properly can reduce the risk of food contamination. Furthermore, 93.2% of them know that cleaning hands with only water is not enough. In addition, 94.6% were aware of the correct way to handle an injured hand during food handling, by covering the wound with water proof bandage. This demonstrates that the basic hygiene principles are well-set among food service workers, the same as demonstrated by Tan *et al.* (2013) where high percentage of respondents 90% had good hand hygiene knowledge.

Nevertheless, there are notable gaps observed in handwashing knowledge, while 57.6% of respondents correctly know that it's necessary to wash their hands both after visiting the toilets and after picking the nose. Only 28.8% of them thinks that it's necessary to wash hands only after visiting the toilet signifying lack of knowledge. Additionally, there was other contamination sources such as coliform bacteria from the nose, where school A had low performance in this question giving high number of coliforms observed in microbial test. A significant portion of 2224 workers (61%) wrongly believe that it is acceptable to handle food and money or when sick with Flu, colds, cough that underscores a highly need for comprehensive education on potential risks of food illness transmission. These negative results on hand hygiene knowledge of food service workers has also shown by Baş *et al.* (2006) where food service workers had lack basic hygiene knowledge such as on cross contamination.

On food hygiene knowledge, the study shows that food service workers generally possess a strong understanding of potential food hygiene practices with high level of awareness on key areas, cleaning and sanitation protocols are well understood as evidenced by 86.7% of respondents who agreed that the surfaces should be cleaned with water and soap before use and 96.7% recognize the importance of washing knives used by wet foods with water and soap. Also, the same percentage acknowledged the necessity of covering the mouth when coughing or sneezing implying a solid commitment of maintaining proper hygienic and sanitation practices. Similarly, several studies have also found out that most of food service workers has good hygiene knowledge (Al-Shabib *et al.*, 2017; Darko *et al.*, 2015; Karikari *et al.*, 2021). However, there are areas where improvement is needed as 48.3% agreed that the wet foods can come to contact with dry food and an equal percent disagree with such contact highlighting the need for clear guidelines and more targeted education on cross contamination risk so that to remove that confusion.

Food safety knowledge of food service workers

Table 4 presents the food safety knowledge of foodservice workers, covering various aspects of personal hygiene and food handling practices. From the result it was found that people were aware of the importance of wearing gloves, masks, and hairnets (95%), also most of the food service workers seem to know that avoid touching hair while working (96.7%). The average score was displayed (51.7%) as a lot of food service workers did not recognize as eating and drinking while cooking is not safe as it can be the cause of cross contamination. Most of respondents recognized the risk of foodborne illnesses but were not aware of specific microorganisms responsible for such illnesses including *Salmonella* (50%) had heard of it, *Listeria* (30%) had and *Clostridium* (25%).

These results indicate that food service workers have a good understanding of general hygiene practices and the importance of using personal protective equipment. The high percentages agreeing on most statements suggest strong awareness of food safety principles, such as proper cleaning and personal hygiene, which are very important for preventing foodborne illnesses. However, food service workers still lack awareness about the risks of reheating food and the dangers of eating and drinking while handling food, and this tell that further training is needed in this area. Additionally, the low recognition of specific foodborne pathogens like *Salmonella*, *Listeria*, and *Clostridium* suggests a need for more detailed education on microbiological hazards in food safety.

Similar to other studies, this research shows that food service workers generally understand the importance of personal hygiene and proper food handling practices. Including the research done by Seaman & Eves (2006) also found high levels of compliance with handwashing and use of protective clothing among food handlers. Consistent with findings from Clayton (2004), this study indicates high compliance with the use of gloves, masks, and hairnets. Unlike previous studies where knowledge of specific pathogens was relatively higher (Putri & Susanna, 2021), While the majority of respondents were aware that microorganisms can cause foodborne illnesses (95%), there was a lack of specific knowledge about the food pathogens responsible which is the same scenario reported by Sani & Siow (2014) where majority of food service workers (73.2%) had poor knowledge of foodborne pathogens. Most of respondents were not aware of microorganisms like *Salmonella* (50%), *Listeria* (70%), and *Clostridium* (75%), indicating an area where further education is necessary. The relatively low awareness of the risks associated with reheating food contrasts with findings from studies by Ko (2013), which reported higher awareness levels among foodservice workers. This difference could be due to variations in training programs or regional differences in food safety education.

Observation of food and hygiene practices

Only few schools used separate cutting boards (33.3%) which is similar to two schools which were observed to be using separate cutting boards for raw and cooked food, whereas (66.7%) did not use separate cutting boards which is similar to six schools. Other scores were above the average and this means that they put into practices what they know, very few schools were observed to be going against the knowledge they have including covering of dustbins as only (55.5%) of schools were covering their dustbins while the rest leave them open as the result allowing cross contamination to food. The findings from Table 6 indicate generally a moderate to high level of compliance with food hygiene and safety practices among the foodservice staff in the observed schools. However, this percentage is not enough to conclude if there is completely hygiene and safety practices.

The previous findings by Abd Lataf Dora-Liyana *et al.* (2018), the study shows a generally high level of food safety knowledge and compliance among food handlers in schools. The importance of proper hand hygiene is consistently emphasized across various studies, including this one and studies by Abdul-Mutalib *et al.* (2012) and Akabanda *et al.* (2017), which report similar findings regarding the critical nature of handwashing practices among food handlers. While this study reports 77.8% compliance, other studies, such as those by Aluh *et al.* (2021), report higher compliance rates, indicating better adherence in other regions or settings. The percentage of covered dustbins is lower in this study compared to the findings by Ameme *et al.* (2016), who reported higher compliance with this practice in their study of schools in Ghana. Also, compared to findings by Ali *et al.* (2022), the practice of using separate cutting boards for raw and cooked food is significantly lower in this study (33.3%).

Microbial status results

The microbial test results for food contact surfaces across different schools reveals varying levels of total viable counts (TVC) and total coliform counts (TCC). Total Viable Count (TVC) results show moderate contamination levels on cups and plates, with mean TVC values ranging from 2.19 to 2.67 log CFU/ml for cups and 2.29 to 3.12 log CFU/ml for plates. Tamburini *et al.* (2015) said that the curved surfaces can affect contamination levels since microorganisms can quickly deposit on non-flat and rough surfaces with many gaps like in cups and plates even if these surfaces are cleaned cannot reach every corner that may lead to biofilm formation. The contamination level on these surfaces is consistent with findings from other studies, suggesting that improper washing techniques and inadequate drying may contribute to the persistence of bacteria (da Silva *et al.*, 2014). Spoons showed lower TVC values (1.77 to 2.23 log CFU/ml) but significant differences between schools, signifying inconsistent cleaning practices. These findings suggest that while basic cleaning is performed, the effectiveness and consistency vary across different items and schools (Talon *et al.*, 2007), this elaborated that different cleaning and disinfecting procedures could be responsible for variation in microbial contamination in different surfaces.

Total Coliform Count (TCC) results highlight potential fecal contamination, particularly on cups and plates. According to TBS code of hygiene TZS.118: 2007, there is a zero-tolerance policy for *E. coli* on food and on-food-contact surfaces, Coliform bacteria may pose a serious health risk to the children when contaminate their food. Coliform bacteria were detected in cups from Schools A and E also in plates from various other schools, with TCC values ranging from 0 to 1.23 log CFU/ml. The absence of coliforms on spoons suggests better hygiene practices for these utensils also due to smooth stainless-steel surface which easiest cleaning, this shown also by Nam *et al.* (2023). However, study by WM (2014) found coliform on spoon. The isolation of *E. coli* in both cups and plates, particularly in School A, further underscores serious gaps in hygiene knowledge of food service workers indicating potential risks of

foodborne illnesses due to inadequate hand hygiene and sanitation practices in these schools. The presence of *E. coli* may consequently result in the presence of other indicator coliforms such as *Salmonella* and *Staphylococcus* (Naili Nahar & Nor Ainy Mahyudin, 2018).

Linking these microbial findings to the overall assessed food safety knowledge shows a clear gap between theoretical understanding and practical implementation among food service workers. While a high percentage of workers recognized the importance of cleaning and personal hygiene for instance 98.3% agree that work areas should be clean, 90% agree that personal hygiene prevents contamination, the inconsistent application of these practices is evident in the microbial contamination observed. For instance, despite strong agreement on the necessity of proper handwashing (93.3%), the presence of *E. coli* indicates gaps in hand hygiene. This discrepancy highlights the need for enhanced training and stricter enforcement of food safety and hygiene standards to ensure that theoretical knowledge is effectively translated into practice. Similarly, different studies revealed this gap between knowledge of food service workers and microbial contamination in their working places (Illés *et al.*, 2018; Nhlapo *et al.*, 2014; Popović *et al.*, 2022; Sibanyoni & Tabit, 2019).

Conclusion

The survey demonstrated a significant level of food safety knowledge among food service workers in schools. The analysis of microbial contamination on food contact surfaces in five schools reveals significant insights into the state of hygiene practices. The findings indicate moderate to high levels of microbial contamination on cups, spoons, and plates, with notable differences in Total Viable Count (TVC) and Total Coliform Count (TCC) across schools. The presence of *E. coli* on some surfaces highlights serious gaps in hygiene practices, particularly in handwashing and sanitization. These microbial results, when compared with the previously assessed food hygiene knowledge, highlight a gap between theoretical understanding and practical application among food service workers. Regardless of high levels of theoretical knowledge regarding hygiene practices, as indicated by survey responses. The lack of mandatory food safety regulations and accountability structure in schools for school management and food service workers makes it clear that hygiene may not be a priority and that food service workers may not receive frequent training on proper sanitation practices. General training is insufficient to address this challenge, resources, or motivation to implement them. To protect the health of these young people, school management and policymakers should invest in detailed, timely food service worker trainings that cover both theoretical and practical food safety issues, as well as sanitizers, aprons, and hand washing stations.

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Declaration of competing interest

The authors declare no competing conflict of interest

Data availability

The data generated and analyzed in this study are available from the corresponding author upon reasonable request.

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Author Contributions



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