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Research Article

Knowledge, attitude, practice, and microbiological hand hygiene assessment of food handlers in food and drink establishments in Aba'ala district, Afar region, Ethiopia

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Abstract

Foodborne diseases remain a major public health concern, especially in low-resource settings where poor food handling practices facilitate transmission. This cross-sectional study assessed food safety knowledge, attitudes, and practices (KAP), along with hand hygiene status using microbiological analysis, among food handlers in Aba'ala town, Ethiopia. A total of 151 food handlers from 120 establishments were selected using simple random sampling. Data were collected via questionnaires, observational checklists, and hand swab analysis, with 45 samples tested for aerobic bacterial counts. SPSS v23 was used for descriptive and Chi-square analyses. Mean knowledge, attitude, and practice scores were 73.3%, 89.6%, and 66.6%, respectively. Despite relatively good knowledge and attitudes, only 2% correctly identified safe food temperature ranges. Observations showed poor hygiene conditions, including limited handwashing facilities (87%) and low use of protective items such as aprons (89%) and hair coverings (80%). Most food handlers (88.9%) had bacterial counts above acceptable limits (≥ 20 CFU/cm²). Knowledge was associated with socio-demographic factors ($p < 0.05$), while practice was linked to education level ($p < 0.001$). Overall, inadequate food safety practices persisted despite adequate knowledge, highlighting the need for training, improved infrastructure, and stronger regulatory enforcement.

Keywords: *Aba'ala, Attitude, Knowledge, Practice, Food handlers, Food safety, Ethiopia*

1 INTRODUCTION

Foodborne diseases are among the leading causes morbidity and mortality worldwide and continue to represent major public health concern. According to the World Health Organization, an estimated 600 million people suffer from foodborne diseases annually, resulting in approximately 420,000 deaths worldwide (Havelaar et al. 2013; WHO, 2015).

Food contamination can occur at any stage of the food production, processing, transportation, storage, preparation, and serving. Among these stages, food handlers play a pivotal role in ensuring food safety. Inadequate personal hygiene, improper food handling practices (Ehiri and Morris 1996; Patil *et al*., 2005), poor sanitation, and insufficient knowledge of food safety principles have been identified as major contributors to foodborne diseases outbreaks worldwide (Clayton et al., 2002; Green et al., 2005; Sharif et al., 2013). Consequently, assessing the food safety knowledge, attitudes, and practices of food handlers is essential for identifying potential risks and designing effective intervention strategies.

Several studies have demonstrated that although food handlers may possess adequate theoretical knowledge regarding food safety, this knowledge is often not translated into appropriate food handling behaviors. Such discrepancies between knowledge and practice increase the risk of food contamination and subsequent disease outbreaks. Furthermore, self-reported food handling practices may not accurately reflect actual behavior, making direct observational assessments and microbiological evaluations important complementary approaches for assessing food safety compliance (Clayton and Griffith, 2004; Zanin et al., 2017).

In Ethiopia, foodborne and waterborne diseases remain major public health concerns. The problem is particularly pronounced in regions characterized by limited access to safe water, inadequate sanitation infrastructure, and weak food safety regulatory systems. The Afar Region faces significant environmental and public health challenges due to its arid climate, water scarcity, and limited sanitation facilities. Previous studies have identified watery diarrhea and other food- and waterborne illnesses as common health problems in the region (Assefa et al., 2010; FMOH, 2021).

Aba’ala town serves as a commercial center connecting trade routes between Djibouti, Tigray, and neighboring districts. Rapid urbanization, population growth, and increasing demand for prepared foods have contributed to a growing number of food and drink establishments. Consequently, a larger proportion of the population depends on foods prepared outside the household, potentially increasing exposure to foodborne pathogens if food safety standards are not adequately maintained (WHO, 2022).

Despite the growing importance of food establishments in Aba'ala town, evidence regarding food handlers' knowledge, attitudes, practices, and actual hygiene status remains scarce. In particular, there is limited information linking self-reported food safety behaviors with objective microbiological indicators of hand hygiene. Such information is crucial for

understanding existing gaps and developing targeted interventions aimed at improving food safety and protecting public health (Zanin et al., 2017). Therefore, this study aimed to assess the food safety knowledge, attitudes, and practices of food handlers working in food and drink establishments in Aba'ala town and to evaluate their hand hygiene status through microbiological assessment of hand swab samples. The findings are expected to provide evidence for policymakers, public health authorities, and food safety regulators to develop effective interventions that enhance food safety standards and reduce the burden of foodborne diseases.

2 MATERIALS AND METHODS

2.1 Description of the study area

The study was conducted in Aba'ala town, located in Administrative Zone Two of the Afar Regional State, northeastern Ethiopia. Aba'ala is situated approximately between 13°15′–13°30′ N latitude and 39°39′–39°55′ E longitude and an area of 1,188.72 km^2. It is about 50 km east of Mekelle city, Tigray region. The district is bordered by Megale district to the south, the Tigray Region to the west, Berhale district to the north, Afdera district to the northeast, and Erebti district to the east (Figure 1). Abaala has a total population of 37,963, of whom 20,486 are men and 17,477 women (CSA 2007).

The woreda is characterized by a semi-arid climate with bimodal rainfall averaging about 422 mm annually (Yirgalem 1999). Due to recurrent water scarcity, many households rely on alternative water sources, including rivers, springs, and hand-dug wells. Consequently, waterborne and foodborne diseases remain major public health concerns in the district.

2.2 Source population

The source population consisted of all food handlers employed in food and drink establishments operating within Aba'ala town.

2.3 Study population

The study population included food handlers working in hotels, restaurants, cafeterias, snack houses, juice houses, and other food service establishments who were present during the study period and consented to participate.

2.4 Study design and Period

A community-based cross-sectional study was conducted among food handlers working in registered food and drink establishments in Aba'ala town from November 2018 to June 2019. The study employed a mixed-methods approach involving: (i) A structured questionnaire survey to assess food safety knowledge, attitudes, and practices (KAP);(ii) Direct

observational assessment of personal and environmental hygiene conditions; and (iii) Microbiological examination of food handlers' hands to objectively evaluate hand hygiene status.

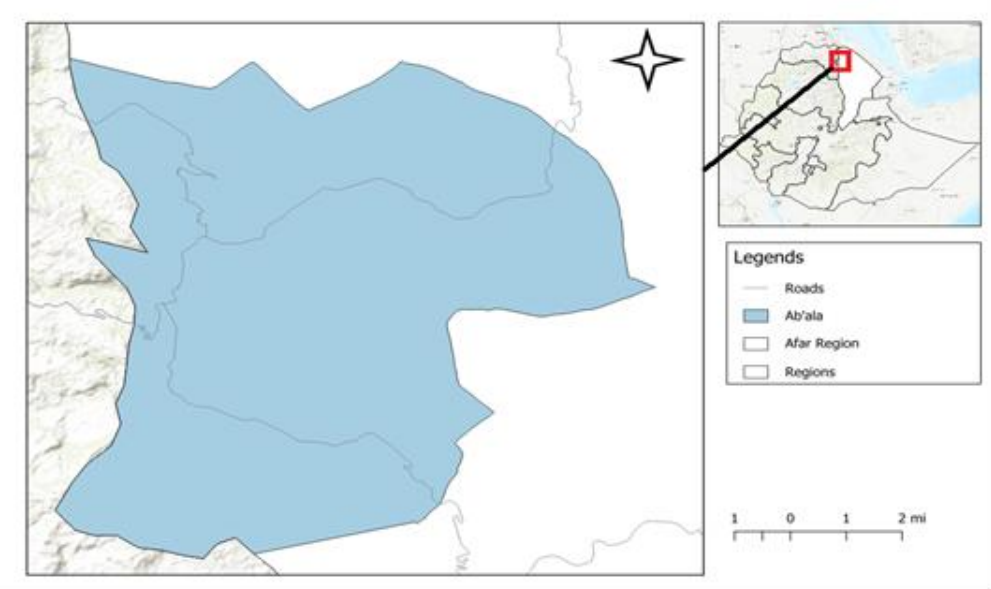


Figure 1. Map of the study area (Ab'ala district).

2.5 Sample size determination and sampling technique

The sample size for the questionnaire survey was calculated using a single population proportion formula by Thrusfield (2005):

$$n = \frac{z^2 p(1-p)}{d^2}$$

Where

- "n" represents the required total sample size,
- "*z*" *is* the standard normal value at a given confidence level,
- "p" is the estimated prevalence of *S. mansoni* infection, and
- "d" is the margin of error.

Substituting the values:Z = 1.96, P = 0.50, and d = 0.05, yielded an initial sample size of 384 participants.

Since the total number of food handlers in Aba'ala town was fewer than 10,000 (N = 250 [as per the data obtained from the district health office]), finite population correction was applied using the following formula:

$$n_f = \frac{n}{1+\frac{n}{N}}$$

Where

- nf = corrected sample size,
- n = initial sample size,
- *N* = total population size. The corrected sample size was 151 food handlers.

For sampling, a list of all registered food and drink establishments was obtained from the Aba'ala Town Administration Office. The total number of food handlers employed in these establishments was obtained from establishment records and municipal registration data. A sampling frame containing all eligible food handlers was prepared. Participants were selected using simple random sampling techniques. Each eligible food handler was assigned a unique identification number, and random numbers were generated using a lottery method to select study participants.

For microbiological assessment, 30% of the survey participants (n = 45) were randomly selected for hand-swab sampling. This sample size was decided based on the available resources for laboratory analysis.

2.6 Data collection instruments and procedures

Data were collected using three complementary approaches: (i) Structured questionnaire survey; (ii) Direct observational assessment; and (iii) Microbiological examination of hand swabs.

2.6.1 Questionnaire survey

For the purpose of this study, a structured questionnaire was adopted from previous validated similar studies and it was modified to fit the local context (Mekasha *et al*., 2016; Sharif *et al*.,2013). Data collection was conducted through face-to-face interviews by trained diploma-level health professionals under the supervision of senior investigators. The questionnaire was prepared in English and training was given to data collectors and supervisors for one day on the objective and importance of the study, confidentiality of information, respondents' right, techniques of interview and observation. The questionnaires included four parts. Socio-demographic characteristics, food safety knowledge (14 items), food safety attitudes (12 items), and food safety practices (20 items).). Responses were recorded using dichotomous scales (Yes or No).

2.6.2 **Observational survey**

An observational checklist adapted from previously published studies was used to assess hygiene conditions within food establishments (Iwu *et al,.* 2017). personal and environmental hygiene indicators. The checklist evaluated personal hygiene indicators (cleanliness of clothing, fingernail condition, use of aprons, use of hair coverings, and general personal appearance), and environmental hygiene indicators (availability of handwashing facilities,

availability of soap and towels, cleanliness of service areas, adequacy of water supply, presence of disease vectors, food protection measures, and general sanitation status). Observations were conducted without prior notification to minimize observer bias.

2.6.3 Microbiological assessment

***Sample Collection*:** A second visit to the food and drink establishments was done to collect hand swabs from 45 participants who had been participated in the questionnaire survey. Each sterile swab was dipped into a falcon tube containing 10 ml peptone water to moisten the swab tip and then swabbed over the palm and fingertips of the food handler's hand. The hand swabs were collected from 2.00 pm.to 4.30 pm during which the food handlers had a relaxed time. Each sample was clearly labeled and transported in an insulated ice box to the Microbiology Laboratory of College of Veterinary Medicine, Mekelle University for laboratory analysis.

***Laboratory analysis*:** The hand swab was vortexed for 10 seconds to release bacteria from the cotton swab. Ten-fold dilution was made for further enumeration. Microbial loads of aerobic bacteria were analyzed using Petrifilm™ Aerobic plate count. Petrifilm™ plates were incubated as stated in the manufacturer's instructions. For each type of microbial enumeration, a duplicate test was carried out to validate and ensure reproducibility.

2.7 Data Quality Assurance

Several measures were implemented to ensure data quality as follows:

Questionnaire validation: The questionnaire was developed following an extensive literature review and adaptation of validated instruments used in previous studies. Content validity was reviewed by experts in food safety, public health, and epidemiology.

***Pretesting*:** A pilot study was conducted among 30 food handlers from establishments outside the study area. Findings from the pretest were used to improve clarity, wording, and consistency of questionnaire items.

Training of data collectors: Data collectors received one day of intensive training covering, including study objectives, interview techniques, ethical considerations, observation procedures, sample collection methods, and quality control procedures. Also, questionnaires were checked daily for completeness and consistency by supervisors and principal investigators.

Reliability assessment: Internal consistency was assessed using Cronbach's alpha coefficient. The questionnaire demonstrated excellent reliability with an overall Cronbach's alpha value of 0.88, exceeding the recommended threshold of 0.70 (Reynaldo and Santos 1999).

2.8 Operational definitions

Food Safety Knowledge: Food safety knowledge was assessed using 14 questions. Each correct response received one point, while incorrect responses received zero points.

Food Safety Attitude: Food safety attitude was assessed using 12 statements. Positive responses received one point, while negative responses received zero points.

Food Safety Practice: Food safety practice was assessed using 20 practice-related questions. Desirable practices received one point, while undesirable practices received zero points.

***Categorization of KAP Scores*:** Composite scores of knowledges, attitude, and practice were calculated by summing the scores of individual items for each respondent. The mean score was used as the cut-off point to classify respondents KAP levels. Participants scoring ≥ 73.3%, 89.6%, and 66.6% of the total score were categorized as having good knowledge, positive attitude, and good practice, respectively.

2.9 Data Analysis

After data collection, questionnaires were verified; the rate of return was 100%. Questionnaires were coded randomly. From Descriptive statistics, percentages were determined by using SPSS version 23. Tabular and categorization method was used as a method of data analysis for quantitative information. Depending on the right answers given by the respondents the food safety knowledge, attitude and practice score were determined. Descriptive statics used for microbiological data. Chi-square was used to determine the food safety knowledge, attitude and practice scores percentages in relation to the demographic data. Hand hygiene status was evaluated based on established aerobic bacterial count criteria. Food handlers with aerobic bacterial counts ≥20 CFU/cm² were classified as having unacceptable hand hygiene status, while counts below this threshold were considered acceptable (Sneed *et al.* 2004; Tan *et al*. 2013).

3 RESULTS

3.1 Socio-demographic characteristics of respondents

A total of 151 food handlers participated in the study. Most respondents were females (74.8%, n = 113), and aged 21-25 years (55.0%, n = 83). Regarding educational attainment, secondary school education was the most common level achieved (37.1%, n = 56), followed by primary education (34.4%, n = 52). More than half of the respondents were single (51.7%, n = 78). The majority (88.1%) had less than five years of work experience in food handling.

None of the participants reported receiving formal food safety training. A detail of the socio-demographic information of the respondents is presented in Table 1.

Table 1. Socio demographical data of the respondents in Aba'ala town (N=151)

Variable	Category	Frequency (n)	Percentage (%)
Sex	Male	38	25.2
	Female	113	74.8
Age (years)	<20	15	9.9
	21–25	83	55.0
	26–30	16	10.6
	>30	37	24.5
Educational status	Illiterate	16	10.6
	Read and write	15	9.9
	Primary school	52	34.4
	Secondary school	56	37.1
	Diploma and above	12	7.9
Marital status	Single	78	51.7
	Married	52	34.4
	Widowed	7	4.6
	Divorced	14	9.3
Work experience (years)	<5	133	88.1
	6–10	12	7.9
	11–15	4	2.6
	>15	2	1.3
Food safety training	Yes	0	0.0
	No	151	100.0

3.2 Knowledge of respondents on food safety

The food safety knowledge was determined using 14 items. The overall knowledge of score ranged from 2% to 100%. High proportion of respondents correctly recognized the importance of washing food items before consumption and the role of cross-contamination in food poisoning (100%). Whereas, only 2% correctly identified recommended food temperature ranges for safe food storage and serving (>63^{o}c or -5^{o}c) The mean knowledge score was 73.3 % (Table 2).

3.3 Attitude of respondents on food safety

Food handlers generally demonstrated positive attitudes toward food safety. The overall attitude score ranged from 60.3% to 100%, with a mean score of 89.6%. All respondents agreed that safe food handling is part of their professional responsibility and that handwashing and cleaning of work areas should be performed before commencing work (Table 3).

Table 2. Food safety knowledge score of respondents (N= 151)

Food safety knowledge statement	Correct response n (%)
Use of jewels such as rings, watches, wearing in food handling cause food contamination	90 (59.6)
Food handler with disease such as diarrhea, flu and sore throat poses a risk of food contamination	116 (76.8)
Wearing gloves while preparing food reduces food contamination risks	117 (77.5)
If suffering from infectious disease of the skin it is necessary to take leave from work	121 (80.1)
All bacteria found in food are not harmful	76 (50.3)
Keeping food at refrigerator helps to prevent bacterial contamination	135 (89.4)
Insects such as cockroaches and flies might transmit food borne Pathogens	118 (78.1)
Unwashed/poorly washed foods have many risks of food contamination	151 (100)
Poor individual hygiene of food handlers can cause food borne infection	113 (74.8)
Healthy food handlers might carry food borne pathogens	106 (70.2)
In correct application of cleaning and sanitization procedures for equipment's increase the risk of food born disease	133 (88.1)
Cross contamination is the main factor contributed to food poisoning	151 (100)
The safe temperature of cooked food is >63^{o}c or -5^{o}c	3 (2)
Training on food safety information is useful for your job?	121 (80.1)

Table 3. Food safety attitude score of respondents (N= 151)

Food safety attitude statement	Positive response n (%)
Safe food handling to avoid contamination and disease is my part job responsibility	151 (100)
Food handlers with wounds, bruises or injuries on their hands must not touch or handle food	139 (92.1)
Food handlers should be medically examined every six months	124 (82.1)
Food handlers should not have long nails	140 (92.7)
Wiping vegetables or fruits minimizes risk of food born infection	138 (91.4)
Work area must be cleaned before start working	151 (100)
Hands should be washed before start working	151 (100)
Food handlers must cover their mouth and nose when coughing or sneezing.	130 (86.1)
Food handlers should not smoke while working.	151 (100)
Food handlers should not rub their hands-on face, hair, etc. while working	136 (90.1)
The same towel should not be used to clean many places.	91 (60.3)
Separate kitchen utensils must be used to prepare raw and cooked food	121 (80.1)

3.4 Practices of respondents towards food safety

Food safety practices were evaluated using 20 items. The overall practice score ranged from 0% to 100%, with a mean score of 66.6%. Although all respondents reported washing their hands before starting work and using separate utensils for raw and cooked foods, none reported using gloves or face masks during food preparation and serving (Table 4).

Table 4. Practices of respondents towards food safety

Food safety practice statements	Desirable practice n (%)
Clean the work area before you start work	138 (91.4)
Wash your hands before you start work	151 (100)
Chew gum while working	106 (70.2)
Rub your hands on your face, hair, etc. while working	90 (59.6)
Use jewelry and a watch while working	144 (95.4)
Separate raw food from cooked food	151 (100)
Use separate kitchen utensils for raw and cooked food	151 (100)
Refreeze defrosted foods	125 (82.8)
Touch food with wounded hand that does not wrapped up	51 (33.8)
Wash your hands before and after touching unwrapped raw foods	117 (77.5)
Use gloves when you touch or distribute unwrapped foods	0 (0)
Use protective clothing (apron) when you touch or distribute unwrapped foods	96 (63.6)
Use mask when you touch or distribute unwrapped foods	0 (0)
Use cap when you touch or distribute unwrapped foods	53 (35.1)
Use different chopping board for raw food and fresh produce (vegetables and fruit)	122 (80.8)
Do you wash and sanitize the working clothes	131 (86.8)
Use a different cloth or towel to dry plates	106 (70.2)
Wash and sanitize the knife after chopping raw Food	136 (90.1)
Use clean and washed plate for ready-to-eat foods	129 (85.4)
Work when you are sick (flu, cold, diarrhea, coughing, etc.)	16 (10.6)

3.5 Observational assessment of personal and environmental hygiene

Direct observation revealed deficiencies in both personal hygiene practices and sanitary conditions of food establishments. Most food handlers were not wearing aprons (89.0%) or hair coverings (80.0%). In addition, the majority of establishments lacked adequate water supply (97.0%) and handwashing facilities equipped with soap and towels (87.0%) (Table 5).

Table 5. Observational findings of hygiene conditions in food establishments (N = 151).

Category	Checklist	Observation	
		Yes n (%)	No n (%)
Personal Hygiene	Neatly dressed handlers	36 (24)	115 (76)
	Well-kept finger nails	59 (39)	92 (61)
	Use of hair covering	30 (20)	121 (80)
	Use of apron	16 (11)	135 (89)
Environmental Hygiene	Prepared food protected from flies and rodents	54 (36)	97 (64)
	Presence of clean wash hand basin/soap/towel	20 (13)	131 (87)
	Clean service table and surrounding	22 (15)	129 (85)
	Evidence of disease vectors in premises	119 (79)	32 (21)
	Uncooked food items placed on bare floor	84 (56)	67 (44)
	Adequate supply of water	5 (3)	146 (97)
	Adequate sanitary conditions	25 (16)	126 (84)

3.6 Microbiological assessment of hand hygiene

Hand hygiene assessment of the food handlers revealed that 88.9 % (n = 40) of them had an aerobic bacterial count exceeding the threshold of ≥20 CFU/cm^2, indicating poor personal hygiene. Only five (11.2%) food handlers demonstrated acceptable bacterial counts (Table 6).

Table 6. Aerobic bacterial counts among food handlers (N = 45)

Microbial Indicator	Hygiene Status	Number (n)	Percentage (%)	Minimum Count (CFU/cm²)	Maximum Count (CFU/cm²)
Aerobic bacterial count	Above threshold	40	88.9	24	224
	Below threshold	5	11.1	<1	13

3.7 Association between socio-demographic characteristics and food safety knowledge, practice, and attitude (KAP) Scores

Chi-square analysis demonstrated significant associations between food safety knowledge and age, sex, educational status, and marital status. Educational status was also significantly associated with food safety practices (Table 7).

Table 7. Association between socio-demographic characteristics and food safety knowledge, attitudes, and practices score (KAP)

Demographic Characteristics	Knowledge		Attitude		Practice	
	χ^2	P-value	χ^2	P-value	χ^2	P-value
Gender	15.231	<0.001	6.252	0.012	0.789	0.397
Age	12.662	0.005	11.905	0.008	5.718	0.126
Educational Status	151.000	<0.001	10.589	0.014	23.179	<0.001
Marital Status	25.617	<0.001	10.589	0.008	1.517	0.678
Experience	30.899	0.157	18.656	0.770	28.880	0.225

4. DISCUSSION

The present study assessed food safety knowledge, attitudes, practices, and hand hygiene status among food handlers in Aba'ala town and identified substantial gaps between awareness and actual hygienic behavior. The majority of the respondents were female (75%), aged 21 - 25 years, and had attained secondary or tertiary level of education. Similar demographic characteristics have been reported in previous studies, where food vendors were predominantly female (Chukuezi 2010; Okojie and Isah 2014) and had attained secondary or tertiary education (Chukuezi 2010; Monney et al., 2013; Okojie and Isah 2014; Mizanur et al. 2012). On the contrary, studies conducted in other settings reported that food vendors were

predominantly male (Muinde and Kuria 2005; Duse, Da Silva, and Zietsman 2003) and had either no formal education or only primary-level education (Nurudeen, Lawal, and Ajayi, 2014; Musa and Akande 2003).

The findings of the present study indicate that most food handlers possessed a relatively good level of food safety knowledge. This finding is consistent with studies done in Nigeria (Afolaranmi et al. 2015; Bamidele et al. 2015), which reported satisfactory food safety knowledge among food vendors. However, contrary findings have been reported from Ethiopia, Malaysia, Iran, Korea, and Thailand, where food handlers demonstrated inadequate food safety knowledge (Tessema et al., 2014; Mizanur et al. 2012; Zain and Naing, 2002). Such variations may be attributed to dereferences in educational background, access to food safety information, training opportunities, and local safety regulatory frameworks.

Notably, none of the respondents had received formal food safety training. This finding is similar to a study done in Turkey, which revealed that most food handlers lacked prior food safety training and exhibited poor knowledge of hygiene food preparation and distribution practices (Baş et al., 2006). The absence of food safety training may reflect inadequately developed food safety systems, limited training opportunities, and weak implementation of food safety policies. Furthermore, nearly all respondents (98%) failed to correctly identify the recommended safe temperatures for hot and cold ready-to-eat foods, indicating critical knowledge gap regrading temperature control. This finding is supported by Afifi and Abushelaibi (2012), who similarly reported inadequate knowledge of food temprtaure requirments among food handlers. Since temperature control is one of the most important measures for preventing microbial growth and foodborne disease transmission, inadequate knowledge in this area poses a considerable food safety risk.

The chi-square analysis demonstrated significant associations between food safety knowledge and several sociodemographic characteristics. Age ($p = 0.005$), gender ($p < 0.001$), educational status ($p < 0.001$), marital status ($p < 0.001$) was significantly associated with food safety knowledge. These finding are in agreement with those reported by Slow and Norrakiah (2011), who found that sociodemographic characteristics can influence food safety awareness and understanding.

This study also revealed that the majority participants (94.7%) had positive attitudes toward food safety. This finding is consistent with the study conducted by Tokuç et al. (2009), which reported most food handlers demonstrated positive attitudes toward food safety and hygiene. Although respondents generally exhibited favorable attitudes and adequate knowledge

regarding food safety, their food handling practices were comparatively poorer. This discrepancy highlights the well-recognized gap between knowledge and practice in food safety. Possessing knowledge alone does not necessarily lead to behavioral change, and the successful implementation of safe food handling practices depends on multiple factors, including training, workplace conditions, supervision, and resource availability.

One of the fundamental principles of food hygiene is the use of personal protective equipment, including gloves and face masks, during food preparation and distribution to minimize contamination risks. However, all respondents (100%) reported that that they did not use either gloves or face masks while handling food. This finding contrasts with that reported by Çakiroğlu and Uçar (2008), who documented higher compliance with the use of protective equipment among food handlers. The observed difference may be attributable to limited food safety training, inadequate awareness, lack of access to protective equipment, and lower educational attainment among food handlers in the study area.

Food handlers' hands are recognized as one of the vehicles for transmission of foodborne pathogens and cross-contamination. Hedberg et al. (2006) reported that 35% of foodborne disease outbreaks were associated with bare-hand contact with food. In the present study, all respondents reported washing their hands before food preparation, a finding considerably higher than that reported by DeBess et al. (2009), where only about 34.5% of food handlers practiced appropriate handwashing. Although self-reported handwashing compliance was high, the microbiological findings suggest that hand hygiene practices may not have been performed effectively or consistently. This discrepancy highlights the limitations of relying solely on self-reported practices and underscores the importance of objective assessments of hygiene behavior.

Training food handlers on proper hand hygiene practices can have substantial public health benefits by reducing the risk of food contamination and disease transmission. While knowledge is an important prerequisite for safe food handling, translating knowledge into practice is often a complex process influenced by behavioral, environmental, and organizational factors. In the present study, educational status was significantly associated with food safety practices ($p < 0.001$), whereas the remaining socio-demographic characteristics showed no significant association. This finding suggests that education may play an important role in improving compliance with food safety practices.

The microbiological assessment further revealed that 88.9% of food handlers had aerobic bacterial counts exceeding the acceptable threshold of ≥20 CFU/cm2, indicating poor hand hygiene and a potentially increased risk of food contamination. This prevalence was substantially higher than that reported by Lee et al. (2017), who found that 65% of food handlers exceeded the same threshold. The higher prevalence observed in the present study may be attributed to the absence of food safety training, inadequate handwashing facilities, poor sanitation infrastructure, and limited regulatory oversight. Similarly, the observational assessment demonstrated poor levels of both personal and environmental hygiene. Most food handlers were not using aprons or hair coverings, and the majority of establishments lacked adequate water supplies, handwashing facilities, and satisfactory sanitary conditions. These findings contrast with those reported by Martins (2006) and von Holy and Makhoane (2006), who documented relatively better hygiene conditions in food service establishments. The poor hygiene conditions observed in the present study may have contributed to the high levels of bacterial contamination detected among food handlers and underscore the need for comprehensive interventions aimed at improving food safety practices, sanitation infrastructure, and regulatory compliance.

5 CONCLUSION AND RECOMMENDATIONS

Food handlers in Aba'ala town demonstrated relatively good food safety knowledge and positive attitudes toward food safety; however, these were not adequately translated into safe food handling practices. The substantial gap between knowledge and practice was further evidenced by poor personal and environmental hygiene conditions observed in food establishments and the high prevalence of unacceptable aerobic bacterial counts on food handlers' hands. Educational status was significantly associated with food safety practices, highlighting the importance of education in promoting safe food handling behaviors. Therefore, based on the above concluding remarks the following recommendations have been forwarded.

- ☞ Regular food safety training should be implemented for food handlers to enhance their knowledge, attitudes, and practices related to food hygiene and safety.
- ☞ Relevant stakeholders should enforce strict hygienic control measures through continuous monitoring and supervision to ensure compliance with food safety standards.
- ☞ Further study should investigate barriers that limit the implementation of food handlers' knowledge and attitudes into safe food handling practices.

☞ Further microbiological investigation is needed to identify specific foodborne pathogens to better characterize potential public health risks.

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Ethics approval and consent to participate

The study was approved by the Health Research Ethics Review Committee (HRERC) of Mekelle university. Permission was also obtained from the concerned bodies of Aba'ala municipality office and Aba'ala administration health office. Participants were provided with verbal consent to inform them the purpose of the study and assured that the information provided by her/him was kept confidentially and used only for the purpose of this research. The study was conducted in accordance with the ethical standards of the institutional and national research committee.

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Authors' contributions

AYA and MG has conceived of the study, carried out the overall design and execution of the study, performed data collection and statistical analysis. OAE and GG has assist the design, analysis, comment and approve the research project and drafted the manuscript. All authors read and finally approved this manuscript for submission.

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