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Dishwashing practice and its determinants among food handlers in food and drinking service establishments in Dessie City and Kombolcha Town, Northeastern Ethiopia

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Background: Food contamination arising from various sources, including the use of dirty utensils, is a significant global and national public health concern. Proper dishwashing practices are critical in mitigating this issue by ensuring food safety, yet their effectiveness depends on various factors. In settings with high food safety concerns and limited measurement capabilities, addressing these factors is hindered by the paucity of research. To bridge this gap, this study proposes to evaluate the dishwashing practice employed by food handlers in food and drinking establishments and its determinants in Dessie City and Kombolcha Town, Northeastern Ethiopia.

Methods and Materials: An institution-based cross-sectional study was done on 405 food handlers from 405 food and drinking establishments from 25 June 2022 to 25 August 2022 in Dessie City and Kombolcha Town. Data were collected by pre-tested semi-structured questionnaires and observational checklists. Multivariable (adjusted odds ratio) logistic regression analysis with a 95% confidence interval (CI) was used.

Results: More than one-third of food handlers in Dessie City and Kombolcha Town food and drinking establishments lack adequate three-compartment dishwashing practices. Among those demonstrating inadequate practices, only one-third achieved an acceptable level of microbial load, ≤ 1 log CFU/cm². Being widowed (adjusted odds ratio (AOR) = 5.92, 95% CI [1.78–19.68]), taking safety training (AOR: 3.08, 95% CI [1.61–5.64]), and having a favorable attitude (AOR: 4.81, 95% CI: 2.65–8.72) were determinants to having adequate three-compartment dishwashing practices. Furthermore, having detergents (AOR = 3.07, 95% CI [1.67–5.63]) and having a water storage tank (AOR: 5.55, 95% CI [2.73–11.283]) were determinants to having adequate three-compartment dishwashing practice.

Conclusion: Training status, marital status, attitude, availability of detergent and a water storage tank or container, and number of customers visiting the food and drinking service establishments were contributor determinants for practicing three-compartment dishwashing adequately.

KEYWORDS

total viable count, attitude, food safety, knowledge, training

Introduction

Food contamination happens when dangerous bacteria and chemicals are found in a consumable item. Food contamination by pathogens can cause illness, hospitalization, and even death. The World Health Organization estimates that every day, one in 10 people may become ill because of contaminated food. Among those, 40% are children under the age of five, and 200 of them suffer from catastrophic illnesses like cancer or diarrhea (World Health Organization, 2024). Unsafe food causes more than obvious illnesses; it also has psychological effects on consumers and lowers their quality of life (Czuber-Dochan et al., 2020; Zanetta et al., 2022). The affected public group, patrons at hotels and restaurants where most foodborne diseases are reported (Lalit et al., 2015), is negatively impacted by this issue (World Health Organization, 2023). In connection with these issues, communities and individuals who lack knowledge about food safety are more likely to be exposed to foodborne illnesses (Bolek, 2020) that commonly cause diarrheal disease in children under 5 years of age (Rukambile et al., 2020), and practicing inappropriate food handling causes tremendous health effects leading to outbreaks due to food intoxication (Isere et al., 2022; Nazir et al., 2023).

Inadequately cleaned and sanitized utensils contain contaminants that contaminate meals. These contaminants can survive in the meal on which they arrive. Consequently, they bring unfavorable changes beyond the nature of the food. Because of these changes (modifications), the meal can be spoiled, become disgusting and unpleasant to eat, and finally become unsafe for consumption (FDA, 2001; Matthews et al., 2024). To prevent such contamination, washing and/or sanitizing food service utensils with hot water or chemical sanitizer (Shahbaz et al., 2020; Lee et al., 2007) and following appropriate three-compartment dishwashing practices are among the preventive measures (Lee et al., 2007; Food and Administration, 2017), as combined hygienic activities bring better food safety results (Müller-Hauser et al., 2022).

The efficiency of the manual cleaning method used in most food and beverage companies can be impacted by the procedures followed when cleaning utensils (Lee et al., 2007). Therefore, the removal tendency of pathogenic microbes from dishes (food service utensils) depends on the quantity and sizes of the utensils, the time allotted for cleaning them, the initial microbial load, the detergent's quality, the type of organic

matter on the utensils, the washing temperature, the attitude of the worker, and the complexity of the utensils to be cleaned (Mattick et al., 2003). Alleviating these impacts is a key resolution measurement to significantly lessen the foodborne public health burdens, as foodborne-related illnesses are difficult to control (Todd, 2020; Abebe, 2020; Organization, 2020; Abebe et al., 2020). Therefore, one of the primary ways to address this issue is to implement a three-compartment dishwashing system in food and drinking service establishments (FDEs) (Food and Administration, 2017) and increase food handlers' awareness of how to use the system (Lalit et al., 2015; Arduser and Brown, 2005; Ehuwa et al., 2021).

For better cleaning and the intended result of reducing the risk of foodborne illnesses associated with food contact equipment (FCE) it is better to use procedures for washing that are recommended by the FDA than rely on arbitrary methods (Food and Administration, 2017; Bloomfield et al., 2017). Following these steps allows the washing system to remove organic soils needed for microbial growth and to kill microbes. Taking these actions, one can easily eliminate the organic soils that are necessary for microbial growth and eradicate microorganisms. Furthermore, as food handlers who also serve as dishwashers are essential to maintaining effective food safety regulations, these cleaning methods can lessen or prevent cross-contamination that frequently happens when food personnel contact previously contaminated surfaces (Food and Administration, 2017).

According to Australian Standard Guidelines, FDEs with utensils with total viable counts $>1 \log/\text{CFU}/\text{cm}^2$ were not acceptable for delivering services (Food and Administration, 2017). According to the British Columbia Communicable Disease (BCCDC) Classification, utensils used in FDEs can be classified as clean ($<5 \text{ CFU}/\text{cm}^2$ total viable counts), contaminated ($5\text{--}10 \text{ CFU}/\text{cm}^2$ total viable counts), and very contaminated ($>10 \text{ CFU}/\text{cm}^2$ total viable counts) (NSW Food Authority, 2013). Thus, investigating how the dishwashers practice three-compartment dishwashing is crucial to constructing proper measurement plans in FDE.

To the researchers' knowledge, little investigation has been conducted into three-compartment dishwashing practices in FDEs in Dessie City and Kombolcha Town, Ethiopia. As a result, this study was designed to evaluate the three-compartment dishwashing practices followed by food handlers in eating and drinking facilities in Dessie City and Kombolcha Town, Ethiopia. The results of this study may be crucial in assisting health policymakers and project managers in developing practical strategies for preventing food-related illnesses in Dessie City and Kombolcha Town. It might also serve as a model for comparable cities and towns in Africa.

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval; COR, crude odds ratio; ETB, Ethiopian birr; FDA, Food and Drug Authority; FDEs, food and drinking service establishments; VIF, variance inflation factor.

Methods and materials

Study area

The study was conducted in Dessie and Kombolcha. Dessie City, which is the capital of the South Wollo Zone in Amhara Region, Ethiopia, is located approximately 400 km northeast of Ethiopia's capital city, Addis Ababa. Its location is latitude and longitude of 11°8'N, 39°38'E/11.133°N, 39.633°E, with an elevation between 2,470 m and 2,550 m above sea level. Dessie has 26 kebeles, 20 urban, and six peri-urban. According to the Ethiopian Statistics Service report, the population of Dessie City as of July 2021 is 257,122. Among the residents, 127,154 are men (Ethiopian Central Statistical Agency, 2021). According to the Dessie City health office, there are 424 food and drinking establishments with licenses.

Kombolcha Town is located at 11°07' N, 39°43'E, 1,875 m above sea level, and 376 km northeast of Addis Ababa. According to the Ethiopian Statistics Service report of the population, Kombolcha district has a total population of 125,654, of whom 75,297 are men (Ethiopian Central Statistical Agency, 2021). The mean annual rainfall is 841.1 mm, and the maximum and minimum annual mean temperatures of the town are 27.4°C and 12.9°C, respectively. According to the Kombolcha Town health office, there are 245 FDEs. Because many travelers cross Dessie and Kombolcha every day, eating in FDEs is common.

Study design and period

An institution-based cross-sectional study was conducted among 405 food handlers for 2 months, from 25 June 2022 to 25 August 2022, in Dessie City and Kombolcha Town, Northeast Ethiopia. Data collection by interview and observation was carried out simultaneously. Swab samples were also collected during observations.

Population

The source populations of the study were all licensed FDEs found in Dessie City and Kombolcha Town, Northeast Ethiopia. Preliminary data were obtained by doing assessments of the availability of a three-compartment dishwashing system.

Study population and study unit

The study populations of this study were randomly selected from licensed food and drinking establishments from preliminary assessed FDEs found in Dessie City and Kombolcha Town. The study units were dishwashers working in the selected FDEs.

Sample size determination and sampling procedure

The sample size (n) was determined by using a single population proportion formula based on assumptions of the proportion of good

food hygiene practice (p) = 46.47% from a study conducted in Asella Town, Ethiopia, among FDEs (Haileselassie et al., 2012), with a standard normal distribution confidence interval ($z_{\alpha/2} = 1.96$), margin of error (d) = 0.05, and standard normal distribution confidence interval ($z_{\alpha/2=1.96}$) (Kelsey, 1996). Then, a 10% non-response rate was added. Finally, 420 food handlers working in the dishwashing unit were taken, where n = the total sample size estimated from both Dessie and Kombolcha. Because the numbers of FDE in Dessie City and Kombolcha Town were not equal, sample distribution was done proportionally for each area.

$$n = \left(\frac{Z_{\alpha}}{2} \right)^2 \times P (1 - P) \div d,$$

where n represents sample size; $Z_{\alpha/2}$ represents critical value of the normal distribution at $\alpha/2$ (95% confidence level); $\alpha = 0.05$, and the critical(Z) value is 1.96; p is the sample proportion, which is 0.4647 (46.47%); and d represents margin of error, which was taken as 0.05 (5%) (Daniel and Cross, 2018). Furthermore, $n = \frac{(1.96)^2 \times 0.4647(1-0.4647)}{(0.05)^2} = 382$, with 10% (38) non-response rate n = 420.

To determine the number of FDEs with a three-compartment dishwashing system, pre-surveys were conducted in the urban kebeles of Dessie City and Kombolcha Town. Of the total 669 FDEs (hotels, cafés and restaurants, cafeterias, butcher houses, and juice houses), 462 (291 in Dessie and 171 in Kombolcha) had a three-compartment dishwashing system. A proportional allocation was used to examine the study subjects (FDEs). As a result, 261 food handlers from 265 FDEs ($291 \times 420 / 462$) in Dessie City and 155 food handlers from 155 food and drink service establishments ($171 \times 420 / 462$) in Kombolcha Town were taken.

Then, from each chosen establishment, one food handler was selected. If an establishment had more than one food handler, one was chosen at random. We returned once the same day or the next day when food handlers from the chosen establishment were not accessible during the survey. Non-respondents were defined as those who were not available for the revisits. Finally, 420 food handlers were taken as a sample for this study (Figures 1, 2). A total of 405 people participated in the study (Table 2).

Laboratory procedures for microbial analysis

Sample collection: Microbiologists collected swab samples from plates in all study FDEs. We selected plates for the swab test because they are used frequently for food service and are a major source of contamination. Due to resource limitations, we used only one randomly selected plate for swab testing from each FDE. Because the dishwashers washed food utensils at peak times (breakfast, lunch, and dinnertime), the samples were collected during these periods (morning: 8:00 a.m.–9:30 a.m.; at midday: 12:00 p.m.–2:00 p.m.; afternoon: 5:00 p.m.–6:00 p.m.). For each plate, one sterilized cotton swab with a wooden applicator stick was used. 10 ml of peptone water served as an immersion for the sterilized cotton stick before swabbing. By taking equivalent dimensions, a 25 cm² area of plates (approximately) was rubbed three times slowly. After the swabbing, the swab cotton sticks were returned to universal bottles containing peptone water.

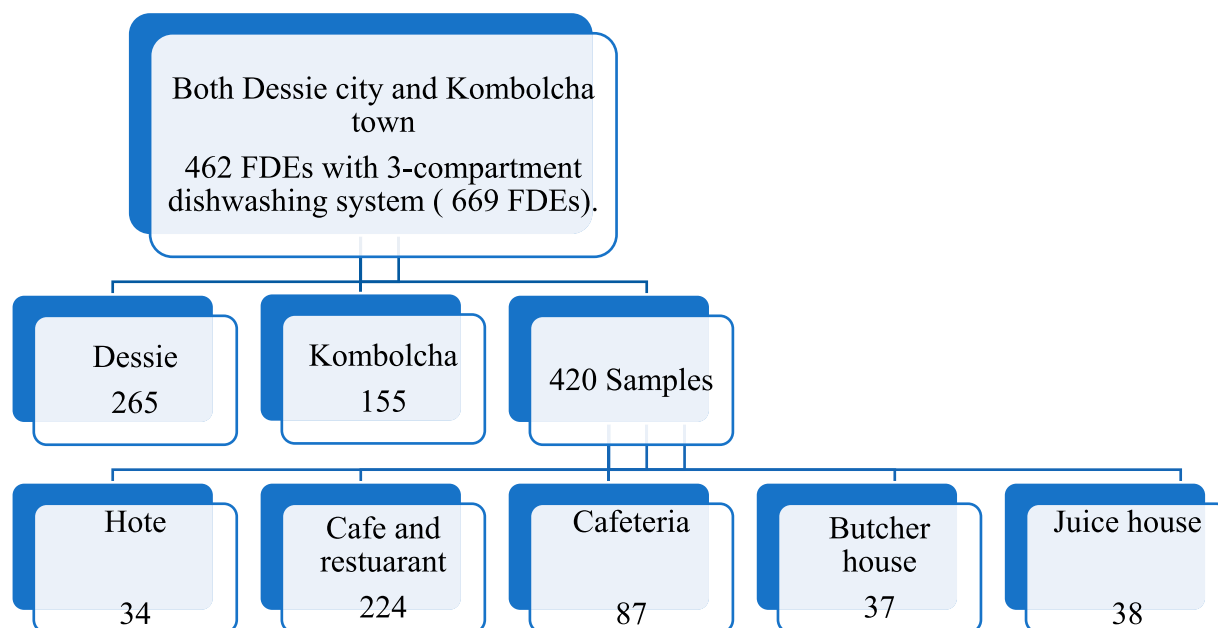


FIGURE 1

Proportional selection of types of FDEs from which food handlers were selected in Dessie City and Kombolcha Town, Northeastern Ethiopia, from 25 June 2022 to 25 August 2022 (n = 420).

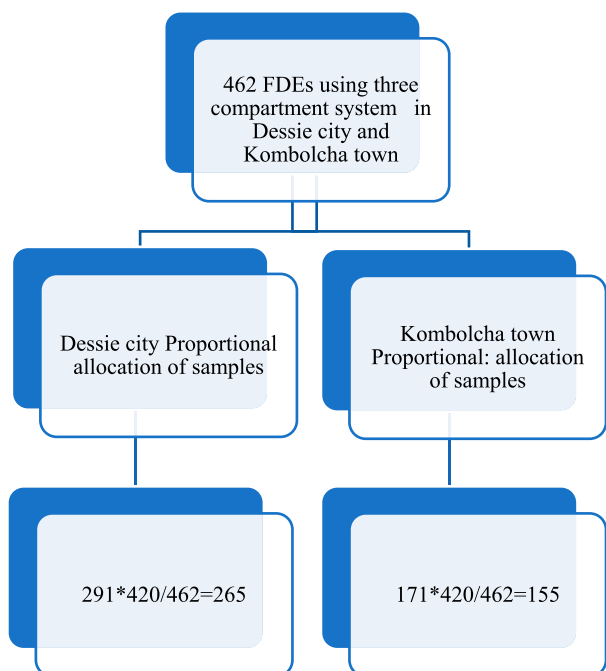


FIGURE 2

The thematic diagram of sampling procedures in selecting food and drinking establishments from which the food handlers were selected in FDEs in Dessie City and Kombolcha Town, Northeastern Ethiopia, from 25 June to 25 August 2022 (n = 420).

Sample transportation: The samples were identified and shipped with an icebox at 4°C to Wollo University Applied Microbiology Laboratory.

Media and sample preparation: Plate count agar was used to count the total viable bacteria on plates. Ten-fold serial dilution was prepared to a dilution factor of 10^3 , and 1 ml of each dilution was pour-plated against the 20 ml of the plate count in labeled Petri dishes in duplicate.

Sample culturing: The labeled Petri dishes were incubated at 35°C for 24–48 h. After the incubation, plates with 30–300 colonies were counted with the help of a digital counter. Calculations were done for each incubated sample, and the average values were taken. Calculations of total viable counts as CFU/ml and CFU/cm² were done as follows (Food and Administration, 1995):

$$\text{CFU/ml of sample} = \frac{\text{Number of colonies} \times \text{total dilution}}{\text{volume plated per culture}},$$

where total dilution is a factor of 10^3 and the volume plated culture is 1 mL.

$$\text{CFU/cm}^2 = \frac{\text{Average count per plate} \times \text{volume}}{(\text{Total surface area} \times \text{No of swabs}) \times \text{Dilution factor}},$$

where total surface area = 25 cm² and number of swabs = 1.

Interpretation of results was made based on information in Table 1 adapted from the British Columbia Centre for Disease Control (BCCDC) Guide for Environmental Health Officers (BCCDC, 2010).

After laboratory investigation, we classified plates with acceptable total viable counts (≤ 10 CFU/cm²) and plates with unacceptable total viable counts (> 10 CFU/cm²). Because there are no national standards in Africa, we used Australian Food Standards for this classification (NSW Food Authority, 2013).

TABLE 1 Interpretation guidance for laboratory results for total viable counts on plates in FDEs in Dessie City and Kombolcha Town, Northeastern Ethiopia, from 25 June 2022 to 25 August 2022 (N = 405).

Interpretation	Counts on plate surfaces per 25 cm ²	Log conversion
Clean (satisfactory and acceptable)	Less than 5 CFU per cm ²	<0.69
Contaminated but acceptable	~5–10 CFU per cm ²	~0.69–1.00
Very contaminated (unacceptable)	More than 10 CFU per cm ²	>1.00

Quality control in the laboratory

Each of the methods, including disinfection, test assortment, transportation, and hatching, was performed with mindfulness to maintain aseptic procedure (Lews, 2003). All the equipment, including Petri dishes, chambers, test cylinders, containers, and medium, were disinfected appropriately in an autoclave at 121°C for 15 min to prevent cross-contamination. To guarantee the legitimate sanitization of equipment and medium, some Petri dishes containing only the medium were incubated and utilized as controls. The procedures to culture the sample were based on the manufacturer's guidelines.

Data collection and data quality assurance

An in-person interview was conducted to gather information about the socio-demographics of the food handlers working in the dishwashing unit. Pre-tested structured questionnaires and observational checklists used in prior studies were modified (Adane et al., 2018; Alemayehu et al., 2021; Azanaw et al., 2019; Chekol et al., 2019; Reta et al., 2021) and FDA food code 2017 (Food and Administration, 2017). A checklist for observation was used to evaluate the characteristics of the establishments (the type of establishment, the source of water, water interruptions, the type of service the establishment gives, the presence of food safety posters, and the availability of separate handwashing stations), as well as the procedures that the dishwashing crew adheres to. The temperature of the water was measured by thermometer as recommended by the FDA Food Code 2017. Washers were interviewed regarding their demographics. The dishwasher was asked 10 attitude questions and 12 knowledge questions to gauge attitude compliance and knowledge of food hygiene.

Four environmental health professionals administered the pre-tested questionnaire, spoke with the food handler, and witnessed their cleaning techniques. For 2 days, the primary investigator trained the data collectors on how to administer questionnaires ethically. To ensure the accuracy and dependability of the data, the primary investigator and the co-investigators conducted daily reviews. Prior to analysis, the obtained data were entered into the Statistical Package for the Social Sciences (SPSS) version 25.0 and cleaned.

Operational definitions

Adequate knowledge: Represents the knowledge of food handlers who score greater than or equal to the mean score on 12 knowledge questions (6 of 12 questions) (Alemayehu et al., 2021).

Handlers who scored below the mean score were considered to have inadequate knowledge.

Favorable attitude: Represents the attitude of food handlers who score greater than or equal to the mean score of 10 attitude questions (6 of 10 questions). Handlers who scored less than the mean score were considered to have an unfavorable attitude (Alemayehu et al., 2021).

Food and drinking establishment: An institution that provides food and drink services to a relatively large number of users in the form of breakfast, lunch, dinner, or beverages. In this study, it includes hotels, cafés and restaurants, cafeterias, butcher houses, and juice houses.

Adequate three-compartment dishwashing practice: Refers to any washing practices with three-compartment dishwashing fulfilling six or more of ten recommendations adapted from FDA food code 2017 (Food and Administration, 2017).

Data analysis

The study used EpiData version 4.6 for data entry and cleaning and IBM SPSS Statistics Version 25.0 for data analysis. Before proceeding to any analysis, the data were cleared and managed. To check the variables' effect on each other, a multicollinearity test was used. Multicollinearity tests served to control confounds by omission of variables with a variance inflation factor (VIF) > 10, preventing redundancy. A bi-variable analysis identified potential predictors ($p < 0.05$), preventing confounds for reliable results. Binary logistic regression was applied to show a statistical association between dependent and independent variables. Bi-variable (crude odds ratio) and multivariable (adjusted odds ratio) logistic regression analyses with a 95% confidence interval (CI) were used. From the bi-variable analysis, variables with p -value < 0.25 were considered for multivariable analysis and variables with P -value ≥ 0.25 were excluded from multivariable analysis to reduce multicollinearity issues and due to little statical consideration.

Ethical considerations

This study requested ethical clearance and an approval letter from Wollo University, College of Medicine Health Sciences Research Ethics Committee (Ref. No. CMHS/1524/2014). After gaining clearance from the committee, the principal investigator obtained a formal letter from the ethics committee. Then, the investigator sent the letters to the Dessie and Kombolcha Health Offices. Verbal and written consent was conducted between the data collectors and Health Department Office head/delegated person and managers and washing staff working in the establishments. The data collectors were assured of the confidentiality of the manager, the

washing staff, and the establishment profile, and they were assured that this study was not for the purpose of any punishment or for any legal procedures.

Results

Socio-demographic and behavioral determinants

In total, 420 food handlers who worked in 405 FDEs cleaning dishes were enrolled in the study. However, fifteen (15) food handlers declined to take part in the study because they were unwilling to participate. Therefore, 405 (a response rate of 96.42% of food handlers) participated in the actual study. Among all study participants, 56.5% of the participants were Christians, while 43.5% were Muslims. The participants' average age was 24.70 (± 4.61). In terms of marital status, the largest group of participants (45.2%) was married, 40% were single, and the remaining groups were divorced (9.1%) and widowed (5.2%) (Table 2). Among the participants, 51.36% (208) had a favorable attitude, and 60.74% (246) of food handlers had adequate knowledge of food hygiene and safety. Most study participants (60.5%) had received training about food hygiene and safety in the past 1 year.

Characteristics of food and drinking establishments

Cafés and restaurants made up slightly more than half (54.1%) of the FDEs. The average number of years the FDEs served was 6.94 (± 4.03). Tap water was available in 338 (83.5%) of the FDEs. Among the 405 FDEs, 52.1% (211) had separate handwashing facilities for food handlers. The mean number of food handlers in the FDEs was 5.09 (± 3.07). Only 60% (243) of FDEs had detergents for washing dishes (Table 3). A water storage tank or containers were present in slightly more than half (54.3%) of FDEs. The regulatory body had inspected only 6.9% (28) of FDEs at least once in the past year. Of the total FDEs, 61.00% (247) served fewer than 50 customers per day.

Three-compartment dishwashing practice score

The mean score of the criteria of practice fulfilled by the washer was found to be 5.5 (± 1.17). However, based on the cutoff point, only 29.63% (95% CI, [25.20–34.30]) of food handlers follow adequate three-compartment dishwashing practices. Most (79.3% (321)) scraped leftover food from dishes prior to washing. More than 75% of the washers used the first sink for scrubbing dishes. However, only about 56% of them used detergents for washing purposes. Almost none (1%) of the washers used warm water to wash dishes. Surprisingly, only 45.2% of the washers used potable water for washing dishes. Approximately half (4.9%) of the washers rinsed the dish they washed in the second sink (Table 4). However, only 14.8% of them used warm water to rinse the dishes in the second sink.

Approximately 39.3% of the washers used chemical sanitizers to soak dishes in the third sink. Only 2.2% of the washers used hot water to sanitize dishes. Most (76.3%) of the washers exposed the dishes they washed to air to dry.

Bi-variable logistic analysis of determinants related to three-compartment dishwashing practice

Twenty-nine study variables were subjected to a bivariate logistic regression model. In binary logistic regression analysis, 18 variables were found to have a p-value of less than 0.25. Among socio-demographic variables, the religion of the washer, age group, marital status, training attendance in the last year, monthly income in ETB, and medical checkup in the last year were all found to have a p-value of less than 0.25. Moreover, the washer's knowledge and attitude had p-values < 0.25 (Table 5). Establishment-related factors that were of concern were the classification of establishment, type of ownership, duration in service, number of food handlers, monthly income, presence of cleaning chemicals, presence of a drainage system, inspection of food contact surfaces within the past year, and number of customers served. These items were discovered to have p-values of less than 0.25.

To control for confounders, all 18 determinant variables with a p-value < 0.25 were entered into the pared-down multivariable analysis model. Among the variables that were entered, six variables with a p-value of < 0.05 were strongly associated with three-compartment dishwashing practices. These included the washer's marital status, training status, attitude, detergent availability, water storage tank or container presence, and the number of customers to the establishments. The final condensed multivariable logistic regression analysis revealed the principal factors influencing three-compartment dishwashing procedures within food and beverage establishments in Dessie City and Kombolcha Town.

Widowed washers had a 5.92 times higher likelihood of adopting three-compartment dishwashing than washers who had never been married (AOR: 5.92, 95% CI [1.78–19.68]). Washers who had received training at least once in the last year were 3.01 times more likely to adopt proper three-compartment dishwashing than those who had not received any training (AOR: 3.01, 95% CI [1.61–5.64]). The individuals who had a positive attitude toward dishwashing had a 4.81 times greater likelihood of performing the task effectively than those with a negative attitude (AOR: 4.81, 95% CI [2.65–8.72]). Likewise, the individuals who worked in FDEs that supplied detergents had 3.07 times greater odds of having good dishwashing practices than their counterparts who worked in institutions that did not supply such detergents (AOR: 3.07, 95% CI [1.67–5.63]).

Washers in FDEs with a water storage tank or container were 5.55 times more likely to wash dishes properly than washers in FDEs without such a tank or container (AOR: 5.55, 95% CI [2.73–11.28]) (Table 6). Washers in FDEs serving 50 or more customers per day were also 1.89 times more likely to wash dishes properly than washers in FDEs serving fewer customers (AOR: 1.89, 95% CI [1.016–3.518]).

TABLE 2 Socio-demographic and behavioral determinants among food handlers in food and drinking establishments in Dessie City and Kombolcha Town, Northeastern Ethiopia, from 25 June 2022 to 25 August 2022 (n = 405).

S. no.	Determinant	Category	Frequency	%
1	Sex of washers	Male	16	4
		Female	389	96
2	Religion of the washer	Muslim	176	43.5
		Christian	229	56.5
3	Age group of washers	<30	246	60.7
		30–34	73	18
		35–39	52	12.8
		≥40	34	8.4
4	Marital status of the washer	Single	164	40.5
		Married	183	45.2
		Divorced	34	9.1
		Widowed	21	5.2
5	Educational level completed by the washer	Primary school	146	36.05
		High school	224	55.31
		Diploma	35	8.64
6	Licensure status of washers to work in food and drinking establishments	Yes	0	0
		No	405	100
7	Worker's work experience in food and drinking establishments	<2 years	160	39.5
		≥2 years	245	60.5
8	Training status of the washer in the past 1 year	Yes	251	62.0
		No	154	38.0
9	Medical checkup of the washer in the past 1 year	Yes	19	4.7
		No	386	95.3
10	Other responsibilities of the washer other than washing dishes	Waiter	167	41.2
		Cook	228	58.8
11	Monthly income of the washer	1,100–1,700	131	32.3
		1,701–2,000	83	20.5
		2,001–2,500	140	34.6
		2,501–3,500	51	12.6
12	Working hours per day	≤8 h	285	70.37
		>8 h	120	29.63
13	Knowledge of washers	Inadequate	159	39.26
		Adequate	246	60.74
14	Attitude of washers	Unfavorable	197	48.64
		Favorable	208	51.36

TABLE 3 Characteristics of food and drinking establishments in Dessie City and Kombolcha Town, Northeastern Ethiopia, from 25 June 2022 to 25 August 2022 (n = 405).

S. no.	Study variable	Category	Frequency	%
1	Type of establishment	Cafeteria	80	19.8
		Café and restaurant	219	54.1
		Hotel	34	8.4
		Butcher house	37	9.1
		Juice house	35	8.6
2	Ownership status of the food and drinking establishment	Rented	225	55.6
		Privately owned	180	44.4
3	Service years of the food and drinking establishment	<5 years	86	21.2
		5–9 years	274	67.7
		10–14 years	29	7.2
		15–19 years	14	3.5
		>19 years	2	0.5
4	Availability of posters containing food hygiene messages	Yes	18	4.4
		No	18	95.6
5	Frequency of work shifts in hours in the food and drinking establishment	Every 8 h	368	90.9
		Every 12 h	37	9.1
6	Type of source water	Tap water in the compound	338	83.5
		From other sources outside of the compound	67	16.5
7	Availability of handwashing facilities for food handlers	Yes	211	52.1
		No	194	47.9
8	Number of workers working	<5 workers	169	41.7
		5–10 workers	211	52.1
		11–15 workers	17	4.2
		>15 workers	8	2
9	Monthly income of the establishments	<25,000 ETB	218	53.8
		≥25,000 ETB	187	46.2
10	Availability of detergents	Yes	243	60
		No	162	40
11	Availability of drainage system for dishwashing facilities	Yes	205	50.6
		No	200	49.4
12	Availability of water storage tank or container	Yes	185	54.3
		No	220	45.7
13	Inspection status of the food and drinking establishment in the past 1 year	Yes	28	6.9
		No	377	93.1
14	Number of customers who visited the establishment	<50	247	61.0
		≥50	168	39.0

(Continued on following page)

TABLE 3 (Continued) Characteristics of food and drinking establishments in Dessie City and Kombolcha Town, Northeastern Ethiopia, from 25 June 2022 to 25 August 2022 (n = 405).

S. no.	Study variable	Category	Frequency	%
15	Time of washing session	Morning	127	31.37
		Midday	236	58.27
		Late afternoon	42	10.37

Morning = 8:00 a.m.–9:30 a.m.; midday = 12:00 p.m.–2:00 p.m.; late afternoon = 5:00 p.m.–6:00 p.m.

TABLE 4 Three-compartment dishwashing practice score among food handlers in food and drinking establishments in Dessie City and Kombolcha Town, Northeastern Ethiopia, from 25 June 2022 to 25 August 2022 (n = 405).

S. no.	Activity	Observations/answers, % (N)	
		Yes	No
1	The washer scrapes leftover food from the dishes prior to washing	20.70 (84)	79.30 (321)
2	The washer uses the first sink/bowl to scrub the dishes	22.50 (91)	77.50 (314)
3	The washer uses detergents	43.70 (177)	56.30 (228)
4	The washer uses warm water for washing (minimum temperature of 43°C)	99.00 (401)	1 (4)
5	The washer uses potable water for washing	45.20 (183)	54.80 (222)
6	The washer uses the second sink to rinse the dishes in clean water	51.10 (207)	48.90 (198)
7	The washer uses warm water in the second sink (minimum temperature of 43°C required)	85.20 (345)	14.80 (60)
8	The washer uses the third sink to soak the dishes in a chemical sanitizing solution	60.70 (246)	39.30 (159)
9	The washer uses hot water (minimum temperature is 77°C)	97.80 (396)	2.20 (9)
10	The washer exposed the washed utensils for air-drying	23.70 (96)	76.3 (309)
	Total	55.00 (2,226)	45.00 (1,824)

Microbiological analysis

According to BCCDC, 61.48% (249) of the FDEs were found to have very contaminated plates (>10 CFU/cm²). The remaining 37% (150) were found to have contaminated plates (5–10 CFU/cm²) and clean plates (<5 CFU/cm²). The current study depicted that 61.5% of FDEs under study were found with a total viable count that exceeded the Australia Standard Guidelines (1 log CFU/cm²) (Table 7). However, 56.66% (68) of plates washed by dishwashers who followed adequate three-compartment dishwashing practices were found with an acceptable level of total viable count (≤ 1 log CFU/cm²). While in FDEs in which dishwashers followed inadequate three-compartment dishwashing practices, 30.88% (88) Figure 3 of plates were found with an acceptable level of total viable count (< 1 Log CFU/cm²). Among all FDEs, only 38.50% (95% CI [33.80%–43.50%]) were found to have plates with an acceptable total viable count as per the Australian standard guideline (<1 CFU/cm²) (Table 3).

Using the one-sample t-test analysis, the study showed that the mean log CFU/cm² (1.05 ± 0.007) of total viable counts exceeded the Australia Standard Guidelines. There was a significant difference in mean log CFU/cm² among the plates in FDEs ($p < 0.001$). When compared with the Australian Standard Guidelines (1.00 log CFU/cm²), the average total viable count in log CFU/cm² was 0.05 (t 95%

CI [0.038–0.067]). However, the mean log CFU/cm² among FDEs that practiced adequate three-compartment dishwashing was 1.014 ± 0.014 log CFU/cm². According to a one-sample t-test analysis, there was no significant mean log CFU/cm² difference among FDEs ($p = 0.134$). The mean log CFU/cm² of bacterial count among FDEs in which plates were washed by an inadequate three-compartment dishwashing practice was found to be $\log 1.069 \pm 0.009$ CFU/cm².

Compared to the Australian Standard Guidelines, there was a significant difference in the mean log CFU/cm² of total viable counts among FDEs whose plates were washed by an inadequate three-compartment dishwashing system ($p < 0.001$). Based on the t-test analysis, there was $\log 0.069$ (95% CI: 0.052–0.086) CFU/cm² higher total viable count on plates when compared with the Australian standard guideline (1 log CFU/cm²).

According to a one-sample t-test, there was a significant mean log CFU/cm² difference in total viable count on plates washed by an inadequate three-compartment dishwashing system when compared with the mean log CFU/cm² (1.014 log CFU/cm²) of viable counts on plates washed by an adequate three-compartment. This study found that plates washed using an inadequate three-compartment dishwashing method had, on average, 0.055 log CFU/cm² more total viable counts compared to those washed using an adequate method (95% CI: 0.038–0.072; $p < 0.001$).

TABLE 5 Bi-variable logistic regression analysis of determinants related to three-compartment dishwashing practice among food handlers in food and drinking establishments in Dessie City and Kombolcha Town, Northeastern Ethiopia, from 25 June 2022 to 25 August 2022 (n = 405).

Study variable	Inadequate practice, 70.37% (285)	Adequate practice, 29.63% (120)	Crude odds ratio at 95% CI	p-value
Sex of washers				
Male	3.51 (10)	5 (6)	1.15 (0.15–4.08)	0.49
Female	96.49 (275)	95 (114)	1	1.00
Religion of the washer				
Muslim	53.68 (153)	63.33 (76)	1	1.00
Christian	46.32 (132)	36.67 (44)	1.49 (0.96–2.31)	0.07
Age group of washers				
<30	66.32 (189)	47.50 (57)	1	1.00
30–34	16.14 (46)	22.50 (27)	1.496 (1.11–3.41)	0.020
35–39	9.47 (27)	20.83 (25)	3.07 (1.65–5.70)	<0.001
>=40	8.07(23)	9.17(11)	1.59(0.73–3.46)	0.245
Marital status				
Single	36.14 (103)	38.33 (46)	1	1.00
Married	49.12 (140)	39.17 (47)	0.75 (0.47–1.21)	0.24
Divorced	10.88 (31)	13.33 (16)	1.16 (0.58–2.32)	0.68
Widowed	3.86(11)	9.17 (11)	2.24 (0.91–5.54)	0.005
Educational status				
Primary school	38.60 (110)	30.00 (36)	1	1.00
High school	52.63 (150)	61.67 (74)	1.51 (0.94–2.41)	0.86
Diploma	8.77 (25)	8.33(10)	1.22 (0.54–2.79)	0.63
Worker work experience in FDEs				
<2 years	39.30 (112)	40.00 (48)	1	1.00
>=2 years	60.7 (173)	60.00 (72)	0.97 (0.63–1.50)	0.89
Training status				
Yes	57.89 (165)	71.67 (86)	1.84 (1.16–2.92)	0.01
No	42.11 (120)	28.33 (34)	1	
Medical checkup of the washer in the past 1 year				
Yes	95.09 (271)	90.00 (108)	2.15 (0.96–4.79)	0.06
No	4.91 (14)	10.00 (12)	1	1.00
Other responsibilities of the washer				
Waiter	42.46 (121)	38.33 (46)	1	1.00
Cook	57.54 (164)	61.67 (74)	1.19 (0.77–1.84)	0.44
Monthly income of the washer (ETB)				
1100–1700	35.79 (102)	24.17 (29)	1	1.00
1701–2000	21.05 (60)	19.17 (23)	1.35(0.72–2.54)	0.56
2001–2500	33.33 (95)	37.50 (45)	1.67(0.97–2.87)	0.07
2501–3500	9.83 (28)	19.16 (23)	2.89(1.45–5.75)	0.003

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TABLE 5 (Continued) Bi-variable logistic regression analysis of determinants related to three-compartment dishwashing practice among food handlers in food and drinking establishments in Dessie City and Kombolcha Town, Northeastern Ethiopia, from 25 June 2022 to 25 August 2022 (n = 405).

Study variable	Inadequate practice, 70.37% (285)	Adequate practice, 29.63% (120)	Crude odds ratio at 95% CI	p-value
Working hours per day by the washer				
≤8 h per day	69.82 (199)	70.83 (85)	1.05 (0.66–1.68)	0.84
>8 h per day	30.18 (86)	29.17 (35)	1	1.00
Knowledge of the washer working in FDEs				
Inadequate knowledge	42.11 (120)	13.68 (39)	1	
Adequate knowledge	57.89 (165)	86.32 (81)	1.15 (0.97–2.37)	0.07
Attitude				
Unfavorable attitude	58.25 (166)	25.83 (31)	1	1.00
Favorable attitude	41.75 (119)	74.17 (89)	4.01 (2.50–6.42)	<0.001
Type of establishment				
Cafeteria	20.00 (57)	19.17 (23)	2.76 (1.03–7.39)	0.43
Café and restaurant	58.95 (168)	42.50 (51)	0.66 (0.30–1.44)	0.30
Hotel	5.26 (15)	15.83 (19)	0.88 (0.37–2.09)	0.77
Butcher house	7.37 (21)	13.33 (16)	1.66 (0.33–4.37)	0.30
Juice house	8.42 (24)	9.17 (11)	1	1.00
Ownership status of the FDE				
Rented	48.07 (137)	35.83 (43)	1	1.00
Privately owned	51.93 (148)	64.17 (77)	1.66 (1.07–2.57)	0.02
Service years of the FDE				
<5 years	25.96 (74)	10.00 (12)	1	1.00
5–9 years	64.91 (186)	73.33 (88)	2.92 (1.52–5.65)	0.001
10–14 years	6.67 (19)	8.33 (10)	3.25 (1.22–8.64)	0.018
15–19 years	1.57 (5)	7.50 (9)	11.10 (3.18–38.82)	<0.001
>19 years	0.89 (1)	0.84 (1)	6.17 (0.36–105.35)	0.21
Availability of posters containing food hygiene messages				
Yes	4.21 (12)	5.00 (6)	1	1.00
No	95.79 (273)	95 (114)	1.19 (0.44–3.27)	0.76
Frequency of work shift				
Every 12 h	9.47 (27)	8.33 (10)	1	1.00
Every 8 h	90.53 (258)	91.67 (110)	1.15 (0.54–2.46)	0.72
Type of source water				
Tap water in the compound	80.70 (230)	90.00 (108)	2.15 (1.11–4.19)	0.02
From other sources	19.30 (55)	10.00 (12)	1	1.00
Availability of separate handwashing facilities for food handlers				
Yes	49.12 (140)	45.00 (54)	1.18 (0.77–1.81)	0.45
No	50.88 (145)	55.00 (66)	1	1.00

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TABLE 5 (Continued) Bi-variable logistic regression analysis of determinants related to three-compartment dishwashing practice among food handlers in food and drinking establishments in Dessie City and Kombolcha Town, Northeastern Ethiopia, from 25 June 2022 to 25 August 2022 (n = 405).

Study variable	Inadequate practice, 70.37% (285)	Adequate practice, 29.63% (120)	Crude odds ratio at 95% CI	p-value
Number of workers working in food and drinking establishments				
<5 workers	46.67 (133)	30.00 (36)	1	1.00
5–10 workers	50.52 (144)	55.83 (67)	1.72 (1.08–2.75)	0.02
11–15 workers	1.75 (5)	10.00 (12)	8.87 (2.93–26.81)	<0.001
>15 workers	1.06 (3)	4.17 (5)	6.16 (1.41–26.99)	0.02
Monthly income of the FDE				
<25,000 ETB	58.95 (168)	41.67 (50)	1	1.00
≥ 25,000 ETB	41.05 (117)	58.33 (70)	2.01 (1.30–3.09)	0.002
Availability of detergents				
Yes	52.98 (151)	76.67 (92)	2.92 (1.79–4.73)	<0.001
No	47.02 (134)	23.33 (28)	1	1.00
Availability of drainage system for dishwashing facilities				
Yes	45.96 (131)	61.67 (74)	1.89 (1.22–2.92)	0.004
No	54.04 (154)	38.33 (46)	1	1.00
Availability of water storage tank or container				
Yes	37.54 (107)	65.00 (78)	4.08 (2.39–6.95)	<0.0001
No	62.46 (178)	35.00 (42)	1	1.00
Inspection status of the food and drinking establishment in the past 1 year				
Yes	4.21 (12)	13.33 (16)	3.5 (1.60–7.65)	0.002
No	95.79 (173)	86.67 (104)	1	1.00
Number of customers who visited the establishment				
<50	67.37 (192)	45.83 (55)	1	1.00
≥50	33.63(93)	54.17(65)	2.44 (1.58–3.77)	<0.0001
Time of washing session				
Morning (8:00 a.m.–9:30 a.m.)	31.93 (91)	30.00 (36)	1.155 (.719–1.855)	0.55
Midday (12:00 p.m.–2:00 p.m.)	56.84 (162)	61.67 (74)	0.790 (0.352–1.772)	0.56
Late afternoon (5:00 p.m.–6:00 p.m.)	11.23 (32)	8.33 (10)	1	1.00

Bi-variable logistic analysis of determinants related to total viable counts

From binary analysis, we identified seven variables with $p < 0.25$ and considered them for multivariable analysis (Table 8). These variables were the work experience of dishwashers, medical checkup status of dishwashers, working hours the dishwasher spent per day, attitude of the dishwasher toward food safety and hygiene, ownership status of the establishment, availability of detergents in the FDEs, and three-compartment dishwashing practice (Table 6).

Multivariable logistic analysis of determinants related to total viable counts

From multivariable analysis, three (3) variables (having a favorable attitude toward food hygiene and safety, spending ≤ 8 h per day on working, and practicing adequate three-compartment dishwashing practice) were statistically significant ($p < 0.05$) determinants for FDEs for having plates with acceptable total viable counts. The odds of an acceptable level of total viable counts on plates in FDEs in which dishwashers worked ≤ 8 h was

TABLE 6 Multivariable logistic regression analysis of determinants related to three-compartment dishwashing practice among food handlers in FDEs in Dessie City and Kombolcha Town, Northeastern Ethiopia, from 25 June 2022 to 25 August 2022 (n = 405).

Study variable	Inadequate practice, 70.37% (285)	Adequate practice, 29.63% (120)	Crude odds ratio at 95% CI	AOR at 95% CI	p-value
Marital status of the washer					
Single	36.14 (103)	38.33 (46)	1	1	1.00
Married	49.12 (140)	39.17 (47)	0.75 (0.47–1.21)	1.031 (.559–1.901)	0.923
Divorced	10.88 (31)	13.33 (16)	1.16 (0.58–2.32)	2.354 (0.859–6.447)	0.096
Widowed	3.86 (11)	9.17 (11)	2.24(0.91–5.54)	5.916 (1.779–19.679)	0.004*
Training status in the past 1 year					
Yes	57.89 (165)	71.67 (86)	1.84 (1.16–2.92)	3.011 (1.608–5.638)	0.001*
No	42.11 (120)	28.33 (34)	1	1	1.00
Attitude toward food hygiene and safety					
Unfavorable attitude	58.25 (166)	25.83 (31)	1	1	1.00
Favorable attitude	41.75 (119)	74.17 (89)	4.01 (2.50–6.42)	4.811 (2.654–8.723)	<0.001*
Availability of detergents					
Yes	52.98 (151)	76.67 (92)	2.92 (1.79–4.73)	3.067 (1.671–5.631)	<0.001*
No	47.02 (134)	23.33 (28)	1	1	1.00
Availability of water storage tank or container					
Yes	37.54 (107)	65.00 (78)	4.08 (2.39–6.95)	5.550 (2.730–11.283)	<0.001*
No	62.46 (178)	35.00 (42)	1	1	1.00
Number of customers					
<50	67.37 (192)	45.83 (55)	1	1	1.00
≥50	33.63 (93)	54.17 (65)	2.44 (1.58–3.77)	1.891 (1.016–3.518)	0.044*

The bold values in the table are statistically significant values.

TABLE 7 Total viable counts among washed plates in FDEs in Dessie City and Kombolcha Town, Northeastern Ethiopia, from 25 June 2022 to 25 August 2022 (n = 405).

Surface contamination	Frequency	Percent	Valid percent	Cumulative percent
>10 CFU/cm ²	249	61.5	61.5	61.5
5–10 CFU/cm ²	150	37.0	37.0	98.5
<5 CFU/cm ²	6	1.5	1.5	100.0
Total	405	100.0	100.0	–

1.90 times higher than those who worked >8 h per day (AOR: 1.90, 95% CI [1.17–3.09]).

The odds of an acceptable level of total viable counts on plates in FDEs having dishwashers with a favorable attitude toward food hygiene and safety were 2.28 times higher than in FDEs whose dishwashers had an unfavorable attitude toward food hygiene and safety (AOR: 2.28, 95% CI [1.45–3.58]) (Table 9). The odds of acceptable levels of total viable counts on plates washed by an adequate three-compartment dishwashing system were 2.24 times higher than those washed by an inadequate (AOR: 2.24, 95% CI: [1.38–3.63]).

Discussion

Nearly one-third of food handlers (29.63%) practiced an adequate three-compartment system. This result was greater than that of a study carried out in Asmara, Eritrea (20.9%) (Idris et al., 2020) and in Fiche Town, Ethiopia (11.90%) (Teferi et al., 2021). The results, however, show are lower than those of a study carried out in Debark Town (73.7935) and Asella Town (46.47%) (Bekera et al., 2021). The potential discrepancy may be due to differences in the socio-demographic traits of food handlers and the method and the

Total viable counts on adequately washed dishes vs Inadequately washed plates

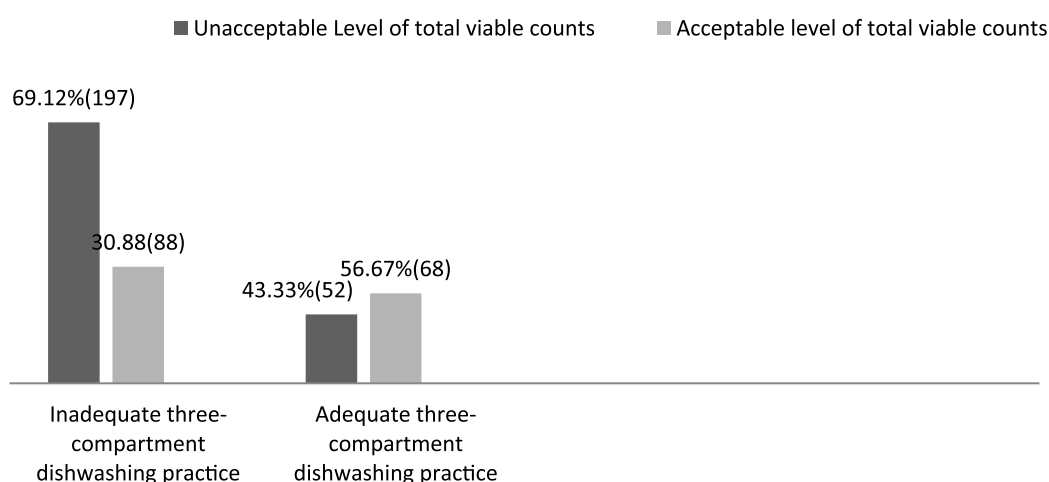


FIGURE 3

Total viable counts among adequately washed plates vs. inadequately washed plates by the three-compartment dishwashing system in Dessie City and Kombolcha Town, Northeastern Ethiopia, from 25 June 2022 to 25 August 2022 (n = 405).

tool of the assessment. The other reason might be due to the time variations when the research is done.

It is crucial to wash food utensils using the proper three-compartment dishwashing technique to ensure the provision of cleaned utensils (Lee et al., 2007). According to the study's findings, 29.63% of food handlers who worked in the dishwashing unit cleaned food utensils properly using a three-compartment dishwashing system. Our finding was comparable with studies in Arba Minch Town (32.6%) (Legesse et al., 2017), Dire Dawa City (29.9%), and Addis Ababa (34.40%) (Oumer, 2019; Girmay et al., 2020). Meanwhile, our findings were lower than those in Debarq (40.1%) (Chekol et al., 2019), the University of Gondar (46.7%) (Lema et al., 2020), and Fiche Town (50.5%) (Teferi et al., 2021).

According to the study's findings, nearly half of the food handlers employed by the dishwashing unit were married (45.2%), followed by single, divorced, and widowed people. According to our findings, only 38% of the food-handling employees in the dishwashing unit received food safety training in the past year. Even while having educated food workers helps prevent the spread of foodborne illnesses (Boro et al., 2015), there were a sizable number of food handlers employed in the dishwashing unit who had not received training in the research areas. The inability of health regulatory organizations to monitor whether food handlers had received training or to provide training could be the probable reason for this lower achievement. According to the study's findings, approximately half of the food handlers working in the dishwashing unit (48.65%) had an unfavorable attitude regarding concerns related to food safety and cleanliness. This might be the result of responsible bodies not raising enough awareness to improve food handlers' working attitudes.

Additionally, fewer than half of FDEs (40%) offered detergents in the dishwashing area, while a little more than half (54.32%) provided water storage tanks or container servings as a backup. This can result from the owner or managers being unwilling to purchase a detergent and water storage tank. According to the current study, 61% of all

FDEs were FDEs that served fewer than 50 consumers per day. The explanation may be related to the poor quality of the services provided. One of the most effective ways to attract customers is to provide meals in an attractive, high-quality, and hygienic manner.

In contrast to single food handlers, our analysis found that being a widowed food handler was a key factor in an adequate three-compartment dishwashing technique. Research from Gondar City, Ethiopia, found that single food handlers were less likely to have superior food-handling practices, which supports this (Azanaw et al., 2019). The widowed washer's lifetime of experience, socioeconomic background, and acquired talents could all play a role in the discrepancies between widowed and single food handlers. However, the study done in Dessie City (Adane et al., 2018) found that the marital status of the food handler had no significant association with acceptable food safety measures.

Food handlers with food safety training had a higher likelihood of performing adequate three-compartment dishwashing techniques than those without the training. Studies carried out in Ethiopia's Arba Minch Town (Legesse et al., 2017), Dire Dawa City (Oumer, 2019), Gondar City (Azanaw et al., 2019), Debre Markos Town (Alemayehu et al., 2021), and Hargeisa, Somaliland (Abdilahi et al., 2025) provided evidence in favor of this conclusion. This suggested that developing expertise through training would improve the effectiveness of dishwashers, as training can change the dishwasher behavior (Sobhan et al., 2024). Furthermore, food handlers with a favorable attitude were more likely to have an adequate three-compartment dishwashing practice than those with an unfavorable attitude toward food hygiene and safety.

Studies conducted in Brazil (da Vitória et al., 2021), Malaysia (Moy FoongMing et al., 2018), and Nigeria (Madaki and Miroslava, 2021) provide support for this study. Additionally, it is backed up by research done in Ethiopia, namely in the cities of Dire Dawa (Oumer, 2019), Gondar City (Azanaw et al., 2019), Addis Ababa

TABLE 8 Bi-variable logistic regression analysis of determinants related to total viable counts in FDEs in Dessie City and Kombolcha Town, Northeastern Ethiopia, from 25 June 2022 to 25 August 2022(n = 405).

Study variable	Unacceptable level, 61.48% (249)	Acceptable level, 38.52% (156)	Crude odds ratio at 95% CI	p-value
Sex of dishwashers				
Male	6.04 (9)	4.48 (7)	1	
Female	93.96 (240)	95.52 (149)	0.79 (0.29–2.19)	0.66
Religion of the dishwasher				
Muslim	42.17 (105)	45.51 (71)	1	
Christian	57.83 (144)	54.49 (85)	0.87 (0.58–1.31)	0.51
Age group of dishwashers				
<30	60.24 (150)	61.53 (96)	1	0.281
30–34	18.47 (46)	17.31 (27)	1.54 (0.70–3.35)	0.444
35–39	11.65 (29)	14.74 (23)	1.41 (0.59–3.39)	0.170
>=40	9.64 (24)	6.42 (10)	1.90 (0.76–4.77)	
Marital status of the dishwasher				
Single	32.93 (82)	42.95 (67)	1	0.250
Married	49.39 (123)	41.03 (64)	1.75 (0.66–4.54)	0.822
Divorced	11.64 (29)	11.54 (18)	1.12 (0.43–2.87)	0.602
Widowed	6.04 (15)	4.48 (7)	1.33 (0.46–3.89)	
Educational level completed by the dishwasher				
Primary school	37.75 (94)	33.33 (52)	1.21 (0.55–2.66)	0.641
High school	52.61 (131)	59.61 (93)	1.55 (0.72–3.32)	0.260
Diploma	9.64 (24)	7.06 (11)		
Worker's work experience in food and drinking establishments				
<2 years	42.57 (10)6	34.61 (54)	1	
>=2 years	57.43 (143)	65.39 (102)	1.40 (0.93–2.12)	0.11
Training status of the dishwasher in the past 1 year				
Yes	61.45 (153)	62.82 (98)	1.06 (0.70–1.60)	0.78
No	39.55 (96)	37.18 (58)	1	
Medical checkup of the dishwasher in the past 1 year				
Yes	5.23 (13)	8.34 (13)	1.65 (0.74–3.66)	0.22
No	94.77 (236)	91.66 (14)3	1	
Other responsibilities of the dishwasher other than washing dishes				
Waiter	39.36 (98)	44.23 (69)	1	0.33
Cook	60.64 (151)	55.77 (87)	0.82 (0.55–1.23)	
Monthly income of the dishwasher (ETB)				
<=2219	131	59	1	
>2219	118	97	1.83 (0.94–2.12)	0.97

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TABLE 8 (Continued) Bi-variable logistic regression analysis of determinants related to total viable counts in FDEs in Dessie City and Kombolcha Town, Northeastern Ethiopia, from 25 June 2022 to 25 August 2022(n = 405).

Study variable	Unacceptable level, 61.48% (249)	Acceptable level, 38.52% (156)	Crude odds ratio at 95% CI	p-value
Working hours per day by the dishwasher				
>8 h per day	34.54 (86)	14.06 (35)	1	
≤8 h per day	65.46 (163)	85.94 (121)	1.82 (1.15–2.88)	0.01
Knowledge of the dishwasher working in the food and drinking establishment				
Inadequate knowledge	37.75 (94)	41.66 (65)	1	
Adequate knowledge	62.25 (155)	58.34 (91)	0.85 (0.56–1.28)	0.43
Attitude toward food hygiene and safety				
Unfavorable attitude	58.63 (146)	32.69 (51)	1	
Favorable attitude	41.37 (103)	67.31 (105)	2.92 (1.92–4.44)	<0.001
Type of establishment				
Cafeteria	20.48 (51)	25.64 (40)	1	0.42
Café and restaurant	60.64 (151)	57.69 (90)	0.76 (0.39–1.48)	0.82
Hotel	9.64 (24)	8.97 (14)	1.09 (0.51–2.32)	0.44
Juice house	9.24 (23)	7.70 (12)	0.69 (0.28–1.76)	
Ownership status of the food and drinking establishment				
Rented	48.59 (121)	37.82 (59)	1	
Privately owned	51.41 (128)	62.18 (97)	1.55 (1.03–2.34)	0.03
Service years of the food and drinking establishment				
<5 years	22.89 (57)	18.59 (29)	1	0.44
5–9 years	67.87 (169)	67.31 (105)	1.22 (.734–2.03)	0.46
10–14 years	6.83 (17)	7.69 (12)	1.39(.585–3.29)	0.01
15–19 years	1.61 (4)	6.41 (10)	4.91 (1.42–17.00)	0.99
>19 years	0.80 (2)	0.00 (0)	0.00 (0.00)	
Availability of posters containing food hygiene messages				
Yes	3.61 (9)	5.77 (9)	1.63 (0.63–4.21)	0.31
No	96.39 (240)	94.23 (147)	1	
Type of source water				
Tap water in the compound	82.33 (205)	85.26 (133)	1.24 (0.72–2.15)	0.44
From other sources outside of the compound	17.67 (44)	14.74 (23)	1	
Availability of a separate sink for handwashing				
Yes	51.81 (129)	52.56 (82)	0.97 (0.65–1.45)	
No	48.19 (120)	47.44 (74)	1	0.88
Number of workers working in the food and drinking establishment				
<5 workers	45.78 (114)	35.26 (55)	1	0.068
5–10 workers	49.39(123)	56.41(88)	1.48 (0.97–2.26)	0.233
11–15 workers	3.61 (9)	5.13 (8)	1.84 (0.67–5.04)	0.098

(Continued on following page)

TABLE 8 (Continued) Bi-variable logistic regression analysis of determinants related to total viable counts in FDEs in Dessie City and Kombolcha Town, Northeastern Ethiopia, from 25 June 2022 to 25 August 2022(n = 405).

Study variable	Unacceptable level, 61.48% (249)	Acceptable level, 38.52% (156)	Crude odds ratio at 95% CI	p-value
>15 workers	1.22 (3)	3.20 (5)	3.46 (0.79–14.98)	
Monthly income of the establishment				
<25,000 ETB	55.42 (138)	51.28 (80)	1	
>=25,000 ETB	44.58 (111)	48.72 (76)	1.18 (0.71–1.76)	0.46
Availability of detergents				
Yes	57.03 (142)	64.74 (101)	1.38 (0.92–2.09)	0.12
No	42.97 (107)	35.26 (55)	1	
Availability of drainage system for dishwashing facilities				
Yes	52.21 (130)	48.08 (75)	0.85 (0.57–1.27)	0.42
No	47.79 (119)	51.92 (81)	1	
Availability of water storage tank or container			1.09 (0.72–1.66)	
Yes	62.65 (156)	64.74 (101)	1	0.67
No	37.35 (93)	35.26 (55)		
Inspection status of the food and drinking establishment in the past 1 year				
Yes	6.83 (17)	7.05 (11)	1.04 (0.47–2.27)	
No	93.17 (232)	92.95 (145)	1	0.93
Number of customers who visited the establishment				
<50	61.85 (154)	59.62 (93)	0.91 (0.61–1.37)	0.65
>=50	38.15 (95)	40.38 (63)	1	
Three-compartment dishwashing practice				
Inadequate practice	79.1 (79.10)	56.41 (88)	1	
Adequate practice	20.9 (52)	43.59	2.93 (1.89–4.55)	<0.001*
Time of washing session				
Morning (8:00 a.m.–9:30 a.m.)	31.79 (79)	30.77 (48)	1.129 (0.725–1.757)	
Midday (12:00 4 p.m.–2:00 p.m.)	56.22 (140)	61.54 (96)	0.658 (0.308–1.407)	0.59
Late afternoon 5:00 p.m.–6:00 p.m.	11.90 (30)	7.69 (12)	1	0.28

(Abdi et al., 2020), Debre Markos Town (Alemayehu et al., 2021), and Debark Town (Chekol et al., 2019). Improving the dishwasher's mindset is a key option to have better food-handling procedures in FDEs. Having an adequate attitude enables dishwashers to follow appropriate washing procedures, such as using an appropriate amount of detergent and rinsing utensils properly.

Food handlers working in establishments that had a water storage tank or container had better three-compartment dishwashing practices than those working in establishments that did not. The results of studies conducted in Addis Ababa, Ethiopia (Abdi et al., 2020) and Somaliland (Abdilahi et al., 2025) are consistent with this conclusion. This indicated

that the availability of a water storage tank or container can solve the interruption in FDEs. The study also indicated that the availability of detergents was a determinant for washing dishes adequately. This finding is in line with a study in Kenya (Ogutu et al., 2022). The current study also revealed food handlers who were working in establishments that served more than 50 customers per day had better three-compartment dishwashing practices than their counterparts. This may be the result of owners or managers consistently focusing on hygienic problems to attract clients. The other reason might be that the establishment is able to comply with cleanliness regulations thanks to the cash it receives from its large customer base.

TABLE 9 Multivariable logistic regression of determinants related to total viable counts among washed plates in FDEs in Dessie City and Kombolcha Town, Northeastern Ethiopia, from 25 June 2022 to 25 August 2022 (n = 405).

Study variable	Unacceptable level, 61.50% (249)	Acceptable level, 38.5% (156)	Crude odds ratio at 95% CI	AOR at 95% CI	p-value
Medical checkup in the past 1 year					
Yes	5.23 (13)	8.34 (13)	1.65 (0.74–3.66)	1.02 (.42–2.49)	0.963
No	94.77 (236)	91.66 (14)3	1	1	
Ownership status of the food and drinking establishment					
Rented	48.59 (121)	37.82 (59)	1	1	
Privately owned	51.41 (128)	62.18 (97)	1.55 (1.03–2.34)	1.38 (0.89–2.13)	0.149
Availability of detergents					
Yes	57.03 (142)	64.74 (101)	1.38 (0.92–2.09)	1.11 (0.71–1.75)	0.638
No	42.97 (107)	35.26 (55)	1	1	
Working hours per day by the dishwasher 1					
>8 h per day	34.54 (86)	14.06 (35)	1	1.90 (1.17–3.09)	
≤8 h per day	65.46 (163)	85.94 (121)	1.82 (1.15–2.88)		0.009*
Attitude toward food hygiene and safety					
Unfavorable attitude	8.63 (146)	2.69 (51)	1	1	
Favorable attitude	41.37 (103)	67.31 (105)	2.92 (1.92–4.44)	2.28 (1.45–3.58)	<0.001*
Worker's work experience in food and drinking establishments					
<2 years	42.57 (10) 6	34.61 (54)	1	1	
≥2 years	57.43 (143)	65.39 (102)	1.40 (0.93–2.12)	1.30 (.83–2.03)	0.249
Three-compartment dishwashing practice					
Inadequate practice	79.1 (79.10)	56.41 (88)	1	1	
Adequate practice	20.9 (52)	43.59	2.93 (1.89–4.55)	2.24 (1.38–3.63)	<0.001*

The bold values in the table are statistically significant values

The study found that only 1.5% (6) of FDEs were found with clean plates (plates with <5 CFU/cm²), and 37% were found with contaminated plates (plates with 5 CFU/cm²–10 CFU/cm²). These values are much different than those found in Shashamane Town, Ethiopia (94% and 6%, respectively) (Yemane and Tamene, 2022) and a study done in South Africa (20% and 60% respectively (Nhlapo et al., 2014). Most FDEs used plates with a total viable that count exceeded the Australian Standard Guidelines (≤ 10 CFU/cm²). The study also revealed that 61.5% of the plates were very contaminated even after washing, which is much higher than a study done in Saudi Arabia (Bukhari et al., 2021). The difference might be the difference in study settings and food handler socio-demographic variations. However, this finding was supported by a study done in Malaysia in which all cafeterias under study were found to have bacterial counts that exceeded Australian Standard Guidelines. However, there is a small difference, which might be due to the difference in study area and washing procedures that took place or that plate washing might not be performed (Zulfakar et al., 2018).

One-sample t-test analysis revealed that the total FDEs were found to have a significant mean log CFU/cm² difference when compared with the Australian Standard Guidelines when the one-sample t-test was performed for all FDEs (both practicing adequately and inadequately dishwashing practice together). However, the separate one-sample t-test analysis depicted that those plates washed by an inadequate three-compartment dishwashing system had a higher mean value than the standard and the mean value of the total viable count of plates washed by an adequate three-compartment dishwashing system ($p < 0.001$). This finding is supported by Lee et al. (2007). These higher mean values might be due to the effectiveness of adequate three-compartment dishwashing practices in removing or decontaminating microbes from plates.

The odds of plates washed by dishwashers working ≤ 8 h per day were 1.90 times more likely to have acceptable total viable counts than their counterparts. These might be due to long work hours related to expanded weakness, unfortunate mindset, unfortunate recuperation from work, and decreased apparent well-being (Caruso, 2014). Consequently, the odds of plates

washed by dishwashers having a favorable attitude were 2.28 times more likely to have an acceptable level of total viable counts than their counterparts. These findings align with studies done in Shashamane Town (Tesfaye and Tegene, 2020) and Addis Ababa (Abdi et al., 2020) in Ethiopia. The odds of plates washed with an adequate three-compartment dishwashing system were 2.24 times higher than their counterparts. These are in line with the FDA's Food Code 2017, which states that the procedure it recommends can remove microbial loads from plates (Food and Administration, 2017).

Strengths of the study

The study made an effort to address the three-compartment dishwashing techniques that were not covered by earlier studies.

Limitations of the study

In this investigation, we used cross-sectional data at a single instant. We suggest that subsequent researchers do a case-control study about our concern. The researchers might draw incorrect conclusions based on the snapshot data. Our results were quantitative in nature, and we might have lost important participant information. Therefore, we urge future researchers to include qualitative investigations in addition to quantitative ones. Additionally, we did not investigate the effectiveness of three-compartment dishwashing techniques in our study, either. We, therefore, encourage future researchers to conduct laboratory analyses to assess the effectiveness of the three-compartment dishwashing procedure in FDEs.

Conclusions and recommendations

Only 29.63% of the food handlers employed by the dishwashing unit washed the food utensils properly. Three-compartment dishwashing practices in FDEs were influenced by the level of training, marital status, and attitude of food handlers working in the dishwashing unit, as well as the availability of detergent, the presence of a water storage tank or container, and the number of customers who visited the FDEs. Our finding also elucidated that washing plates with a three-compartment dishwashing system can significantly reduce total viable counts.

The study adds to public health by demonstrating the part of correct three-compartment dishwashing procedures in reducing microbial contamination on food utensils. It outlines the major factors that impact the effectiveness of dishwashing, such as food handlers' training, attitudes, and the availability of essential resources like detergents. The research proves that poor dishwashing leads to increased bacterial counts, which supports the need for greater regulation, additional training programs, and resource provision to enhance food safety and prevent foodborne illnesses in FDE.

Considering our findings, encouraging food handlers to increase their awareness of food safety through ongoing training and broadening their attitudes through health education and

promotion is a crucial strategy for raising adequate three-compartment dishwashing techniques in Dessie City and Kombolcha Town. We recommend that the Ethiopian Ministry of Health adopt policies that include dishwashing standards, food handler employment criteria such as training certifications, and awareness creation campaign frequencies.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the Wollo University College of Medicine and Health Sciences Research Ethics Committee. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

MM: conceptualization, data curation, formal analysis, investigation, methodology, project administration, resources, software, validation, visualization, writing – original draft, and writing – review and editing. MA: conceptualization, formal analysis, investigation, methodology, project administration, validation, writing – original draft, and writing – review and editing. BA: data curation, formal analysis, resources, software, supervision, validation, writing – original draft, and writing – review and editing. GK: data curation, formal analysis, methodology, resources, software, supervision, validation, writing – original draft, and writing – review and editing. AT: data curation, formal analysis, resources, software, supervision, validation, writing – original draft, and writing – review and editing. GY: data curation, formal analysis, resources, software, supervision, validation, writing – original draft, and writing – review and editing. LK: data curation, formal analysis, resources, software, supervision, validation, writing – original draft, and writing – review and editing. AA: data curation, formal analysis, resources, software, supervision, validation, writing – original draft, and writing – review and editing. YB: data curation, formal analysis, resources, software, supervision, validation, writing – original draft, and writing – review and editing. MG: conceptualization, investigation, methodology, project administration, validation, visualization, writing – original draft, and writing – review and editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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