



Microbiological Contamination in Restaurants and Food Hygiene Practices among Migrant Food Handlers in Samut Sakhon Province, Thailand

ABSTRACT

Food hygiene and sanitary conditions are important public health concerns, especially in countries such as Thailand, where food businesses have been growing rapidly. The growth of the restaurant industry has led to increased hiring of migrant food handlers. Microbiological contamination of ice and non-food items, along with inappropriate food hygiene practices, are among the main factors leading to foodborne illnesses and outbreaks. The objectives of this study were to screen qualitatively for coliform bacterial contamination and determine food hygiene practices among migrant food handlers in restaurants. A cross-sectional study was conducted in the Samut Sakhon province, Thailand, which is one of the provinces with the highest number of migrants. A random walk sampling was used to select restaurants. Of 256 ice and tableware samples from 32 restaurants, tabletops (69%) and ice (58%) had the highest percentages of positive coliform contamination. Most migrant food handlers had fair levels of food hygiene practices.

Increasing age, less work experience and never having received food safety training were related to greater coliform contamination of tabletops and ice samples, although no statistically significant differences were found. Further studies should be conducted with larger samples, including samples drawn from populations of non-migrant food handlers.

INTRODUCTION

The spread of foodborne illnesses is a growing and serious public health worldwide, especially in low- and middle-income countries (46). Such diseases can be caused by the consumption of food and beverages that are contaminated with pathogens (9, 35). Thailand is a tropical country within the World Health Organization's Southeast Asia Region, which has high rates of morbidity and mortality from foodborne illnesses (21). In 2015, Thailand had more than one million reported cases of acute diarrhea (7). A campaign called "Clean Food Good Taste" was established in 1989 in a collaborative effort that included the Ministry of Public Health, the Tourism

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Authority of Thailand, and the Ministry of Interior of Thailand (47). The purpose was to improve food safety and sanitary conditions associated with restaurants and street vendors. This initiative involves inspection of food establishments to screen for coliform contamination by use of an SI-2 test kit, which was developed by the Ministry of Public Health, Thailand. The campaign was said to be helpful in promoting business of restaurants and food vendors by reassuring tourists and local consumers (23).

Food handlers play a significant role in either spreading or preventing foodborne illnesses. Studies and reports indicate that poor hygienic practices of food handlers are among the risk factors that contribute to both sporadic cases and outbreaks of foodborne illnesses around the world (2, 3, 13, 45). Today, ready-to-eat food, convenience stores and restaurants are important to the Thai culinary culture (20). Moreover, Thailand is famous for food tourism, with many of its restaurants located in the area around the Bangkok Metropolitan Region (9, 42). Hiring migrant workers in food services and establishments is preferred because of the lower wages they accept, as compared to those of Thai workers (14). The Samut Sakhon province, a famous tourism destination in Thailand, has a high number of migrant workers (10). With the increasing numbers of migrant food handlers, it has become a challenge to promote positive food handling behaviors and practices (31, 45). In addition, concerns regarding pathogenic contamination should not focus solely on food. Previous studies have revealed high pathogen contamination of non-food items, such as tables, chairs and floors, in restaurants, and good sanitation practices and effective cleaning processes are required to eliminate such pathogens (8, 28).

Therefore, it appears to be important to study coliform contamination in restaurants as well as the hygienic practices of food handlers. Few such studies have been conducted in Thailand (19). The purpose of this study was to screen for coliform contamination in ice and non-food items such as tabletops and tableware and to determine the quality of food hygiene practices among migrant food handlers in the Samut Sakhon province, Thailand.

MATERIALS AND METHODS

Study design, participants and data collection

A cross-sectional study was conducted in the Samut Sakhon province, which is located in the central part of Thailand, adjacent to Bangkok province. It is one of the most widely recognized coastal provinces in Thailand, and its fame as a tourist destination is due partly to its relatively inexpensive seafood sold in many well-known restaurants (27, 41). The sample size (number of restaurants to be included in the study) was obtained by the formula $[n = \log_{10}(1-P) / \log_{10}(1-d)]$, with $P = 95\%$ confidence level and $d =$ the maximum tolerable fraction of food that is contaminated. The formula, which is used to detect the fraction of contam-

inated food and evaluate restaurant sanitary conditions, is used for calculation of the sample size needed for a certain implementation in terms of legal frameworks and a monitoring program in food safety and management systems (44). A 10% non-response rate was added. Therefore, a total sample size of 32 restaurants was determined to be necessary.

Study participants were selected in a two-step process. First, restaurants were randomly chosen by using a random-walk method (43). The inclusion criteria for restaurants were that they had been operating for at least one year and that they hired migrants as food handlers. One migrant food handler was recruited from each selected restaurant. The inclusion criteria for migrant food handlers were that they were able to understand and communicate in Thai or Burmese, had worked as a food handler in the restaurant for a minimum of one year prior to data collection, and agreed to participate in the study. When more than one food handler was willing to participate, one was randomly selected for a structured face-to-face interview. Eight items were randomly chosen to be screened for the presence of coliform contamination. These consisted of two ice samples, a spoon, a fork, a plate, a bowl, a glass, and a tabletop, all of which were located in the work station of the selected migrant food handler.

SI-2 test kit

Screening for coliform contamination was performed using an SI-2 test kit, which contains a culture broth that supports the growth of coliform bacteria, with bromocresol purple as a pH indicator, and which was developed by the Ministry of Public Health, Thailand. Because this test kit was routinely used in government sectors, especially among provincial public health officers under the Ministry of Public Health and as part of the "Clean food good taste project" campaign (39), it was selected for use in this study so as to further support and more easily communicate the study's results with the Ministry of Public Health. The test kit gives a qualitative result, as positive or negative for contamination with coliform bacteria. A sterile swab (RLDC, MOPH, Nonthaburi, TH) wet with an SI-2 medium (RLDC, MOPH, Nonthaburi, TH) was swabbed onto approximately four square inches of each tableware surface; each swab was slowly rotated three times and then left in the bottle of SI-2 medium. For each ice sample, one milliliter of melted ice was pipetted into the SI-2 medium. All samples were left at room temperature (approximately 32°C–35°C) for 24 hours. At the end of 24 hours, if the color of the medium had changed from purple to yellow, this indicated the presence of coliform bacteria and was interpreted as positive for contamination (32).

Questionnaire

A face-to-face interview was conducted, using a structured questionnaire to collect information on food hygiene practices among migrant food handlers. All interviews were performed by the researchers and a trained Burmese research

assistant. The questionnaire on food hygiene practices was developed in English, following a literature review of related studies conducted in Malaysia and Ghana (1, 45); it was revised for this study's purposes. Translators were hired to translate the questionnaire from English to Thai and from English to Burmese, using the method of forward and backward translation (48). Then the accuracy and meaning of the translated versions, both forward and backward, were assessed and revised as needed before the questionnaire was finalized. The questionnaire was divided into two sections, containing seven questions in section I on general demographic characteristics of the study participants and 13 questions in section II on food hygiene practices. Food hygiene practices were measured on a 5-point Likert scale ranging from "Never" to "Always," with a total possible score from a minimum of 13 to a maximum of 65 points. The mean and standard deviation of the score was used to categorize the level of practice as either "Poor practice," "Fair practice" or "Good practice." Reliability of the questionnaire was evaluated using Cronbach's alpha (alpha value = 0.928).

Data analysis

Data analysis was performed using the Statistical Package for Social Sciences version 22 (SPSS, Inc. Chicago, IL, USA). Descriptive statistics were calculated and reported as frequencies, percentages, means \pm standard deviations (SD) and medians and interquartile ranks (IQR). Spearman's

Rank-Order correlation and a Mann Whitney U test were used to determine associations between independent variables and the coliform contamination score. A one-way analysis of variance (ANOVA) was performed for normally distributed data with more than three groups within the independent variables. A Kruskal-Wallis test was performed for non-normal data. The variables with *P*-value < 0.20 were selected and binary logistic regression analyses were performed. Differences were considered statistically significant if the *P*-value was < 0.05; these are reported along with the odds ratio (OR) and 95% confidence intervals (CI).

Ethical considerations

This research was approved by the Ethics Review Committee for Research Involving Human Research Subjects, Health Science Group, Chulalongkorn University, which reviewed the protocol, information sheet, and consent forms (Approval #COA No.181/2019). Permission was obtained from owners of the restaurants, and written informed consent was obtained from the migrant food handlers before data collection. All data were collected anonymously, and coding to ensure anonymity was employed.

RESULTS AND DISCUSSION

Microbiological contaminations

The prevalence of coliform contamination from the 32 restaurants in the Samut Sakhon province are shown in [Table 1](#).

TABLE 1. Coliform contamination of restaurant samples in the Samut Sakhon province (n = 256)

Type of sample	Sample	Total	
		Contamination	
		(n)	(%)
Ice ^a	64	37	57.813
Tableware ^b	160	64	40.000
▶ Utensils	64	26	40.625
- Spoons	32	13	40.625
- Forks	32	13	40.625
▶ Dishes	64	30	46.875
- Plates	32	14	43.750
- Bowls	32	16	50.000
▶ Glasses	32	8	25.000
Tabletops	32	22	68.750
Total	256	123	48.047

^aTwo ice samples per restaurant; ^btableware samples included utensils (spoons and forks), dishes (plates and bowls), and glasses.

TABLE 2. General demographic characteristics of migrant food handlers in the Samut Sakhon province, Thailand (n = 32)

General Characteristics	Number (n)	Percentage (%)
Gender		
Male	23	71.9
Female	9	28.1
Age (in years)		
Median	25	
Interquartile Range	9	
Minimum–Maximum	18–48	
Nationality		
Laotian	14	43.8
Burmese	18	56.3
Level of education		
Primary school or lower	13	40.6
Secondary school	17	53.1
High school and Vocational school	2	6.3
Work experience (in years)		
Median	3.5 years	
Interquartile Range	3 years	
Minimum–Maximum	1–28 years	
Work position		
Waiter/Waitress	21	65.6
Server	11	34.4
Had ever received food safety training		
Yes	8	25.0
No	24	75.0

TABLE 3. Level of food hygiene practices among study migrant food handlers in the Samut Sakhon province, Thailand (n = 32)

Level of practice	Number (n)	Percentage (%)
Poor (Score ≤ 53.6)	6	18.8
Fair (53.6 < Score < 63.2)	22	68.8
Good (Score ≥ 63.2)	4	12.5
Mean ± SD = 58.4 ± 4.8		
Minimum – Maximum = 45–65		

It is well known that bacteria possess an affinity for surfaces and are capable of forming biofilm layers if the surfaces are left uncleaned (12). Bacterial biofilms can be difficult to remove and may be pathogenic in nature (18, 37). Therefore, non-food contact surfaces such as tabletops and chairs that exist in close proximity to food can be important vehicles for both direct and indirect bacterial contamination, which may lead to foodborne illnesses and outbreaks (38).

In our study, tabletops were most frequently found to have coliform contamination. This finding concurs with results of a previous study among non-food items in American restaurants, which highlighted the high rates of bacterial contamination on non-food contact surfaces and the importance of cleaning procedures (28). Food contact surfaces such as utensils and dishes are another important source of contamination through direct contact with food items and consumers (6, 11). Previous studies have demonstrated high rates of contamination with microorganisms on tableware (38, 49). Our findings are in accordance with the results of those studies. More than one-third of the samples from tableware were contaminated with coliform bacteria.

Ice, which is very popular in Thailand and is always in drinks, as well as in many kinds of desserts, has been linked to foodborne and waterborne disease outbreaks in Thailand (22, 29, 34, 40). In our study, more than half of the ice samples were contaminated with coliform bacteria (Table 1). Many factors can contribute to this finding, such as the source of the water, the processing practices used in ice production, problems with packaging and mishandling during transportation, the practice of keeping ice for human consumption in the same tank as ice used to hold cooking ingredients and drinks, and cross-contamination from food handlers (15, 25, 34, 36).

However, contaminated water used for cleaning tableware could be a direct source of coliform bacterial contamination. This study presumed that tap water was used for washing tableware and other cleaning purposes, including cleaning with detergents along with running tap water, which follows the guidelines of the “Clean Food Good taste” campaign, since a majority of the restaurants, are under the auspices of this campaign.

Demographic characteristics of migrant food handlers

General demographic characteristics (gender, age, nationality, level of education, restaurant work experience, work position and whether food safety training had ever been received) are presented in Table 2. As shown in Table 2, most of the 32 workers interviewed were male (71.9%), which differs from the findings of previous studies in Malaysia and Europe, in which more of the food handlers were female (5, 36). This finding could be from the self-selection sampling method whereby food handlers volunteered to participate, whereas in previous studies, food handlers were randomly chosen for interviews. Male food handlers were more

outgoing and willing to cooperate than females. Participants ranged in age from 18 to 48 years old, with a median age of 25 and an interquartile rank of 9 years across the group. More migrant food handlers were from Myanmar than Laos (56.3% and 43.8%, respectively). Slightly over half (53.1%) had completed secondary school education. However, almost 40% had completed only primary school or had lower levels of education. The amount of restaurant work experience varied from one year to as long as 28 years, with a median of 3.5 years and an IQR of 3 years. Almost two-thirds (65.6%) of the food handlers worked as waiters or waitresses. Lastly, most (75%) had never received food safety training.

Food hygiene practices of migrant food handlers

More than two-thirds (68.8%) of the food handlers were found to have a fair level of food hygiene practices, whereas 18.8% had poor practices (Table 3). Only about 13% of the participants were categorized as having a good level of food hygiene practices, in contrast to findings of a previous study in Malaysia, where 50% of the food handlers had good practices (4). The main differences noted in this study are that the majority of the food handlers always worked while ill and wore jewelry; food handlers in the previous study did not (Table 4). Of additional concern is the observation that workers reported always using the same dishcloth for drying dishes and cleaning tables. Since dishcloths used for cleaning were found to contain high levels of enteric bacteria, this practice might contribute to the high percentage of coliform bacterial contamination from the tabletop samples in this study (28).

Associations among general characteristics, levels of food hygiene practices and coliform bacterial contamination

Results of this study show that age, work experience, gender, food safety training, work position, level of education and food hygiene practices have different degrees of impact on coliform bacterial contamination of non-food items in restaurants. Table 5 shows that both age and work experience were positively correlated with total coliform contamination and contamination in ice, specifically (P -value < 0.2). However, age was the only variable to be positively correlated with coliform contamination on utensils (P -value < 0.2). Table 6 shows a significant association between workers' gender and whether they had received food safety training to a positive score for coliform contamination of utensils and tabletops (P -value < 0.2). Males were more likely to be associated with contamination of tabletops than females (mean ranks of 18.02 and 12.61, respectively), while workers who had never received food safety training were associated with contamination more than those who had (mean ranks of 17.50 and 13.50, respectively).

Interestingly, contamination of utensils was more often associated with those who had received food safety training than with those who had not (Table 6). Results also indi-

TABLE 4. Migrant food handlers' responses to questions about food hygiene practices (n = 32)

Statement	Frequency (%)				
	Never	Rarely	Sometimes	Often	Always
1. Wash your hands after using toilet	0 (0)	0 (0)	1 (3.1)	3 (9.4)	28 (87.5)
2. Wash your hands after touching body parts (such as nose picking or picking your nails, etc.)	2 (6.3)	1 (3.1)	8 (25.0)	4 (12.5)	17 (53.1)
3. Wash your hands after cleaning table	1 (3.1)	1 (3.1)	5 (15.6)	1 (3.1)	24 (75.0)
4. Take a bath/shower 1–2 times a day	0 (0)	0 (0)	2 (6.3)	3 (9.4)	27 (84.4)
5. Keep fingernails long	1 (3.1)	1 (3.1)	8 (25.0)	4 (12.5)	18 (56.3)
6. Wear jewelry such as ring when serving or handling food	1 (3.1)	2 (6.3)	5 (15.6)	3 (9.4)	21 (65.6)
7. Work when you are sick (such as having a flu or diarrhea)	4 (12.5)	1 (3.1)	4 (12.5)	1 (3.1)	22 (68.8)
8. Overlap food dishes while serving food	3 (9.4)	0 (0)	2 (6.3)	2 (6.3)	25 (78.1)
9. Wash and sanitize work clothes	2 (6.3)	0 (0)	1 (3.1)	2 (6.3)	27 (84.4)
10. Use the same cloth or towel to dry plates and to clean tables	2 (6.3)	0 (0)	1 (3.1)	1 (3.1)	28 (87.5)
11. How often do you wash the cleaning cloth or towels?	0 (0)	0 (0)	0 (0)	4 (12.5)	28 (87.5)
12. Do you serve or handle food when you have cuts on your hands/fingers?	1 (3.1)	1 (3.1)	1 (3.1)	4 (12.5)	25 (78.1)
13. Your hands/finger touch the food while you are serving	2 (6.3)	0 (0)	4 (12.5)	1 (3.1)	25 (78.1)

TABLE 5. Correlations of age and work experience of migrant food handlers to coliform contamination in restaurants in the Samut Sakhon province

	Age		Work experience	
	<i>r</i>	<i>P</i> -value	<i>r</i>	<i>P</i> -value
Total coliform contamination	0.29	0.107*	0.346	0.052*
Ice	0.328	0.067*	0.31	0.084*
Tableware	0.139	0.448	0.215	0.238
1) Utensils	0.235	0.195*	0.193	0.291
2) Dishes	0.022	0.906	0.142	0.438
3) Glasses	0.082	0.654	0.167	0.362
Tabletops	0.081	0.661	0.2	0.272

*Significance at *P*-value < 0.20.

cate that a worker's level of education has various degrees of impact on coliform contamination (*Table 7*); the significant effect of educational level and coliform contamination was observed only for utensil samples ($P < 0.2$). As seen in *Table 7*, those with a high school education had the least association with the contamination of utensils. It is interesting that migrant food handlers with primary and lower educational

levels were less associated with contamination of utensils than those with a secondary education. However, no statistically significant difference was found between work position and the level of food hygiene practices regarding coliform bacterial contaminations (data not shown).

Table 8 shows the results of a binary logistic regression analysis. Although no statistically significant differences were

TABLE 6. Mann Whitney U test comparing gender and food safety training of migrant food handlers with coliform contamination in restaurants in the Samut Sakhon province

Coliform contamination score	Gender		Received food safety training			
	Mean Rank		P-value	Mean Rank		P-value
	Male (n = 23)	Female (n = 9)		Yes (n = 8)	No (n = 24)	
Total coliform contamination	16.00	17.78	0.625	19.13	15.63	0.354
Ice	16.63	16.17	0.893	17.63	16.13	0.676
Tableware	15.22	19.78	0.208	19.88	15.38	0.232
1) Utensils	15.72	18.50	0.419	21.00	15.00	0.093*
2) Dishes	15.28	19.61	0.212	17.25	16.25	0.781
3) Glasses	15.98	17.83	0.503	16.50	16.50	1.000
Tabletops	18.02	12.61	0.068*	13.50	17.50	0.193*

*Significance at P -value < 0.20.

TABLE 7. Association of level of education of migrant food handlers to coliform contamination in restaurants in the Samut Sakhon province

Factors	Levels of Education						F-value	P-value
	Primary school and Lower education (n = 13)		High school and Vocational school (n = 2)		High school and Vocational school (n = 2)			
	Mean (SD)	95% CI	Mean (SD)	95% CI	Mean (SD)	95% CI		
Total coliform contamination	3.31 (1.377)	2.48–4.14	4.29 (2.285)	3.12–5.47	3.50 (3.536)	-28.27–35.27	0.906	0.415
Ice	1.15 (0.801)	0.67–1.64	1.18 (0.809)	0.76–1.59	1.00 (1.4140)	-11.71–13.71	0.04	0.961
Tableware	1.46 (1.266)	0.70–2.23	2.47 (1.736)	1.58–3.36	1.50 (2.121)	-17.56–20.56	1.619	0.216
1) Utensils	0.54 (0.776)	0.07–1.01	1.06 (0.827)	0.63–1.48	0.50 (0.707)	-5.85–6.85	1.711	0.198*
2) Dishes	0.69 (0.751)	0.24–1.15	1.12 (0.781)	0.72–1.53	1.00 (1.414)	-11.71–13.71	1.049	0.363
3) Glasses	16.19 ^c		17.21 ^c		12.5 ^c		0.842 ^b	0.657 ^a
Tabletops	16.58 ^c		15.58 ^c		21.5 ^c		1.007 ^b	0.604 ^a

*Significance at P -value < 0.20; ^aanalyzed by Kruskal-Wallis H test; ^bChi-square value; ^cMean rank.

seen with each additional year in the age of food handlers, the odds of having a high total coliform contamination score were increased by 1.139. On the other hand, with every year of increase in the work experience of food handlers, the odds of having no coliform contamination in the ice samples were multiplied by 1.102.

Overall, age had a significant effect on food safety among workers, especially for those who are older and have less food safety knowledge (26, 33). In line with previous studies, results from this study indicate that the older the migrant food handlers, the higher the odds of having a high level of

total coliform contamination. This finding might be because they were less knowledgeable than younger food handlers, as mentioned in previous studies (16, 30). Work experience and educational level are normally perceived as factors contributing to good food hygiene and sanitation practices; it has been found that more experience translates to better food hygiene and safety practices (24).

As expected, the migrant food handlers who had received food safety training had a 1.732-fold increased odds of having no association with contamination of tabletop samples (95% CI 0.262 – 11.467), compared with those who had never

TABLE 8. Factors associated with absence of coliform contamination in restaurants in the Samut Sakhon province

Factor	OR	95% CI	P-value
High level of total coliform contamination			
Age (in years)	1.139	0.985 – 1.318	0.079
Coliform contamination in ice samples^a			
Age (in years)	0.850	0.663 – 1.091	0.202
Work experience (in years)	1.012	0.729 – 1.406	0.942
Coliform contamination in utensil samples^a			
Age (in years)	0.926	0.790 – 1.087	0.347
Ever received food safety training ^b	0.553	0.055 – 5.592	0.616
Level of education ^b			
Primary school or lower	2.069	0.071 – 60.065	0.672
Secondary school	0.474	0.017 – 12.881	0.657
Coliform contamination in tabletop samples^a			
Gender ^b	0.277	0.046 – 1.685	0.163
Ever received food safety training ^b	1.732	0.262 – 11.467	0.569

*Significance at P -value < 0.05; ^aNo contamination; ^bReference groups: Never received food safety training, High school/Vocational school, Female.

received the training (*Table 8*). Previous studies have shown that training usually increases appropriate practices among food handlers, although the effect typically lasts for only three months (*16, 17, 30*).

CONCLUSIONS

Results of this study emphasize the high prevalence of coliform contamination, especially in the case of tabletops and ice samples. Increasing age, less work experience and never having received food safety training were three factors shown to be linked to high levels of total coliform contamination of tabletops and ice. This finding demonstrates that food safety training prior to employment in restaurants, as well as re-training of long-term employees, is important. Several topics may need to be emphasized, such as the importance of not working while ill and separating dishcloths used for drying dishes from those used to clean tables. Restaurant owners and public health officers may want to pay extra attention to the practices of food handlers, since these practices might contribute to coliform contamination of non-food samples in restaurants.

Several limitations affect interpretation of these results. First, because this is a cross-sectional study, it was not possible to determine causal relationships. Second, the study population was only a fraction of the entire community of the Samut Sakhon province, which limits generalizability of the results. Furthermore, lack of accuracy of the results of tests for coliform contamination could be associated with the water source and with the cleaning methods. It is recommended that future studies should have a larger sample size and include non-migrant food handlers. In addition, observation of food hygiene practices, consideration of the water source and scrutiny of cleaning methods are recommended.

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