

Food handlers' compliance with personal hygiene standards and microbiological quality of food-contact surfaces in selected food outlets in Kuching and Kota Samarahan, Sarawak

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Abstract

Unhygienic personal practices among food handlers contribute to foodborne diseases, and the risk increases due to microbial contamination on food contact surfaces, including utensils, mainly through cross-contamination. The present work assessed the compliance of 1,600 food handlers ($n = 1,600$) with personal hygiene standards as outlined in the Food Hygiene Regulations 2009. A cross-sectional descriptive study was conducted using a modified questionnaire and observation checklist. Additionally, the present work evaluated the microbiological quality of food-contact surfaces in the food establishments located in Northern Kuching, Southern Kuching, Samarahan 1, and Samarahan 2. The microbial assessment revealed that between 70 and 96.97% of utensils and serving tables sampled from each of the four study areas exhibited satisfactory hygiene levels ($\text{CFU}/\text{cm}^2 < 80$), indicating good sanitation practices. No statistically significant differences were found, indicating comparable proportions of satisfactorily hygienic utensils ($p = 0.161$, $\text{SD} = 7.06$) and serving tables ($p = 0.941$, $\text{SD} = 5.0$) across the study areas. Demographic analysis showed that most respondents from the four areas were female, predominantly aged between 19 and 25, and had educational qualifications ranging from secondary school to college or university level. The percentage of food handlers who had attended food handling courses and received typhoid vaccinations varied from 25.5 to 85.5%. In terms of compliance with personal hygiene standards, which encompassed attire as well as hygienic and unhygienic personal practices, Northern Kuching recorded the highest conformity at 90.60%, followed by Southern Kuching at 88.65%, Samarahan 2 at 84.48%, and Samarahan 1 at 62.83%. Despite these differences, no statistically significant difference was observed ($p = 0.135$; $\text{SD} = 12.80$), indicating overall comparable levels of adherence to personal hygiene standards among the four areas. The present work noted that participation in a food handling course was more closely associated with personal hygiene compliance than with demographic characteristics, such as gender or formal education level. Therefore, the present work highlighted the importance of providing food safety training to all food handlers in Sarawak as a strategy to reduce the risk of foodborne disease outbreaks in food establishments.

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Introduction

Foodborne diseases present a serious threat to public health and safety. They are described as an infection or intoxication caused by ingesting food contaminated with viable foodborne pathogens or

toxins (USDA, 2024). A foodborne disease outbreak occurs when two or more individuals experience similar illnesses after consuming a typical food (CDC, 2024b). Symptoms of foodborne disease include diarrhoea, stomach pain or cramps, nausea, vomiting, and fever (CDC, 2024a). A 2019 World

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Bank report estimated the economic burden of foodborne diseases at US\$95.2 billion per year for total productivity lost and approximately US\$15 billion per year for treating foodborne diseases (WHO, 2024).

Lifestyle trends such as dining out, takeaway, and online food delivery have become increasingly common due to growing urbanisation that allows little time for home meal preparation (Gazi *et al.*, 2010; Lau and Ng, 2019; Gargiulo *et al.*, 2022). However, it is challenging to know whether food handlers at food establishments maintain good personal hygiene and apply proper food handling practices during food preparation. In the United States, restaurants are the primary source of foodborne disease outbreaks (CDC, 2019). The National Environmental Assessment Reporting Systems (NEARS) documented 800 foodborne disease outbreaks associated with 875 retail food establishments between 2017 and 2019 (Moritz *et al.*, 2023). In Saudi Arabia, restaurants and food-serving establishments were linked to 51% of foodborne cases in 2018 (MOH, 2018). In Malaysia, the incidence rate of food poisoning increased from 43.77 to 53.67 per 100,000 people from 2022 to 2023 (MOH, 2023; 2024), more than double the rate of 18.4 incidents in 2021 (MOH, 2022). Many reported foodborne outbreaks in Malaysia involved schools; however, cases linked to food outlets have also been documented. The actual number of food poisoning incidents in Malaysia is probably higher as most cases go unreported due to mild symptoms and a complicated chain of monitoring systems (Soon *et al.*, 2011; Abdul-Mutalib *et al.*, 2015). Furthermore, Malaysia's hot climate, high humidity, and the nature of its food create optimal conditions for the growth of foodborne bacteria (Chen *et al.*, 2022; Zakaria *et al.*, 2022).

Food handlers are those employed in a food establishment who have direct or indirect contact with food. Therefore, health surveillance organisations must pay attention to this population (Tappes *et al.*, 2020). Factors contributing to improper food handling by food handlers include gender, age, education, income, and occupation (Chen *et al.*, 2022). In addition, knowledge, attitudes, and practices (KAP) are three key factors linked to food handlers' contributions to food poisoning outbreaks (Sharif and Al-Malki, 2010). Approximately, 40% of foodborne outbreaks reported in NEARS were associated with food contamination caused by ill or infectious food workers (Moritz *et al.*, 2023).

To prevent foodborne illness caused by food handlers, the Food Hygiene Regulations 2009, part IV in Regulations 30 - 31, requires that all food handlers attend training and undergo a compulsory medical examination and health conditions. Additionally, all the food handlers must obtain an anti-typhoid vaccination against typhoid fever. Meanwhile, Regulations 32 - 33 stated that food handlers must wear a clean, suitable, light-coloured outer overall or a light-coloured apron, head cover, and footwear. Food handlers shall maintain a high degree of personal cleanliness, for example, by keeping short and clean fingernails, removing their overall or head cover or apron before visiting the toilet, washing their hands before commencing work after using the toilet, and after handling raw food or any contaminated materials. Food handlers also must refrain from any behaviours or actions resulting in contamination. Wearing of any jewellery, watches, or pins is also prohibited. These regulations are imposed as a preventive measure to reduce the potential for a foodborne outbreak (Law of Malaysia, 2023).

However, the ongoing occurrence of foodborne cases highlights compliance gaps, making it a persistent public health concern in Malaysia, including Sarawak. In this context, Kuching, the capital of Sarawak, and Samarahan, recognised as an education hub with rapid growth in residential, commercial, and administrative sectors (Sarawak Tourism Board, 2024), are important areas of focus. As these regions become increasingly known for tourism, education, and urban development, maintaining food safety has become a concern due to the rising number of food establishments and handlers. The Borneo Post (2014) reported approximately 1,017 cases of food poisoning in Sarawak, Malaysia, involving both food outlets and homes. In 2016, 35 wedding guests showed signs of food poisoning after consuming Western cuisine at local eateries in Kuching, Sarawak (The Borneo Post, 2016).

Several studies have investigated food handlers' compliance with personal hygiene standards in food establishments across different areas in Malaysia (Saad *et al.*, 2013; Siau *et al.*, 2015; Elexson *et al.*, 2023). Elexson *et al.* (2023) provided observations regarding the personal hygiene practices of food handlers in Kuching and Lawas, Sarawak. However, further investigation with a larger sample size is necessary to determine the compliance levels of food handlers with personal hygiene in Kuching.

No assessment of food handlers' personal hygiene has been conducted in Samarahan.

Microbial contamination on food processing surfaces and utensils presents another significant factor contributing to foodborne diseases, primarily through cross-contamination. The hygiene of these surfaces in food establishments reflects the safety of meals and beverages served (Bukhari *et al.*, 2021). Hence, the present work aimed to determine the compliance of food handlers in Sarawak, specifically in Northern Kuching, Southern Kuching, Samarahan 1, and Samarahan 2, with the personal hygiene standards outlined in the Food Hygiene Regulations 2009. Additionally, the microbiological quality of food-contact surfaces, including tables and utensils such as plates, forks, and spoons, was evaluated using a swab sampling technique. To the best of our knowledge, this is the first study to assess the hygiene status of utensils on Sarawak food premises. Assessing the personal hygiene of food handlers and the microbiological quality of the food-contact surfaces is crucial to reduce the risk of foodborne disease outbreaks and consequently improve the health status of the individuals and population (Saad *et al.*, 2013).

Materials and methods

Study area and ethical consideration

The present work involved 1,600 food handlers from food premises located in Northern Kuching, Southern Kuching, Samarahan 1, and Samarahan 2, with each area contributing 400 food handlers. The researchers conducted a quantitative cross-sectional descriptive study using a modified questionnaire and observation checklist to assess food handlers' compliance with the Malaysia Food Hygiene Regulations 2009. The present work applied the probability sampling technique (Murwira *et al.*, 2015; Elexson *et al.*, 2023). The Faculty of Resource Science and Technology (FRST), University of Malaysia Sarawak (UNIMAS), provided ethical approval for the present work [approval no.: UNIMAS/NC-15.04/09-01 (33)]. The researchers ensured the respondents' confidentiality and anonymity throughout the research.

Microbiological assessment

Ten locations from each area were selected for microbiological assessment. The microbial

assessment targeted the food-contact surfaces such as spoons, forks, plates, and tables. Sterile swabs pre-moistened with 0.1% buffered peptone water (BPW) were used to swab tables and the whole surface of small utensils, including spoons, forks, and plates. Subsequently, the swabs were soaked in the tube containing 10 mL 0.1% BPW and immediately transported to the Microbiology Laboratory at UNIMAS on the same day. The swab samples in the tubes were then thoroughly vortexed for 30 sec. Approximately, 30 μ L of each sample was spread on Nutrient Agar (NA) (Hi-Media, India) and incubated overnight at 37°C. The following day, plates with colony counts between 30 and 300 were selected to determine the colony-forming units per millilitres (CFU/mL) and colony-forming units per square centimetres (CFU/cm²). All samples were subjected to Gram-staining.

Data analysis

The present work used descriptive statistics for data analysis. The frequencies, percentages, and means were calculated for demographic variables using Microsoft Excel. Additionally, a One-way ANOVA was conducted using IBM SPSS Statistics version 30 to analyse significant differences in the proportion of food handlers who comply with personal hygiene standards and the proportion of utensils and serving tables that meet satisfactory hygiene levels across the four study areas.

Results

Microbiological assessment

Table 1 shows the CFU/mL of samples collected from ten food premises in Northern Kuching, Southern Kuching, Samarahan 1, and Samarahan 2.

In Northern Kuching, nine samples had significant CFU/mL from locations 1 to 4. The samples had CFU/mL values ranging from 1.07×10^8 to 8.10×10^7 . The samples had Gram-negative and Gram-positive bacteria, comprising cocci and bacilli.

In Southern Kuching, five samples had significant CFU/mL from locations 1, 4, 7, and 8. The samples had CFU/mL values ranging from 3.3×10^7 to 6.9×10^8 . The samples had Gram-positive cocci and Gram-negative bacilli.

Samarahan 1 had seven samples with significant CFU/mL from locations 3, 5, and 8. The

Table 1. Microbiological assessment of spoons, forks, plates and table in CFU/mL.

Location	Northern Kuching	Southern Kuching	Samarahan 1	Samarahan 2	Gram-staining result
1	S: TF ₁ TC F: 1.32×10^8 P: 2.29×10^8 T: 1.12×10^8	S: TF ₁ TC F: 6.9×10^8 P: TF ₁ TC T: TF ₁ TC	S: TF ₁ TC F: TF ₁ TC P: TF ₁ TC T: TF ₁ TC	S: TF ₁ TC F: TF ₁ TC P: TF ₁ TC T: TF ₁ TC	F: Gram-negative bacilli (NK), Gram positive cocci (SK) P: Gram-positive bacilli (NK) T: Gram-positive and Gram-negative cocci (NK)
2	S: 1.97×10^8 F: TF ₁ TC P: 8.10×10^7 T: TF ₁ TC	S: TF ₁ TC F: TF ₁ TC P: TF ₁ TC T: TF ₁ TC	S: TF ₁ TC F: TF ₁ TC P: TF ₁ TC T: TF ₁ TC	S: TF ₁ TC F: TF ₁ TC P: TF ₁ TC T: TF ₁ TC	S: Gram-negative bacilli (NK) P: Gram-negative cocci (NK)
3	S: TF ₁ TC F: 6.8×10^8 P: 6.4×10^8 T: 1.07×10^8	S: TF ₁ TC F: TF ₁ TC P: TF ₁ TC T: TF ₁ TC	S: TF ₁ TC F: TF ₁ TC P: TF ₁ TC T: 2.12×10^4	S: TF ₁ TC F: TF ₁ TC P: TF ₁ TC T: TF ₁ TC	F: Gram-negative cocci (NK) P: Gram-positive bacilli (NK), Gram positive cocci (NK) T: Gram-negative cocci (NK), Gram positive cocci in clusters (S1)
4	S: TF ₁ TC F: TF ₁ TC P: TF ₁ TC T: 6.5×10^7	S: 2.18×10^8 F: 2.44×10^8 P: TF ₁ TC T: TF ₁ TC	S: TF ₁ TC F: TF ₁ TC P: TF ₁ TC T: TF ₁ TC	S: TF ₁ TC F: TF ₁ TC P: TF ₁ TC T: TF ₁ TC	T: Gram-positive cocci (NK) S: Gram-negative bacilli (SK) F: Gram-negative bacilli (SK)
5	S: TF ₁ TC F: TF ₁ TC P: TF ₁ TC T: TF ₁ TC	S: TF ₁ TC F: TF ₁ TC P: TF ₁ TC T: TF ₁ TC	S: 1.4×10^4 F: 9.52×10^4 P: 1.8×10^4 T: 7.2×10^4	S: TF ₁ TC F: TF ₁ TC P: 2.5×10^4 T: TF ₁ TC	S: Gram-negative cocci in clusters (S1) F: Gram-negative cocci in clusters (S2) P: Gram-negative bacilli (S1), Gram positive bacilli (S2) T: Gram-positive bacilli in chains (S1)

Location	Northern Kuching	Southern Kuching	Samarahan 1	Samarahan 2	Gram-staining result
6	S: TFTC F: TFTC P: TFTC T: TFTC	S: TFTC F: TFTC P: TFTC T: TFTC	S: TFTC F: TFTC P: TFTC T: TFTC	S: TFTC F: TFTC P: TFTC T: TFTC	None
7	S: TFTC F: TFTC P: TFTC T: TFTC	S: TFTC F: TFTC P: TFTC T: 3.3×10^7	S: TFTC F: TFTC P: TFTC T: TFTC	S: TFTC F: TFTC P: TFTC T: 6.4×10^4	T: Gram-negative bacilli (SK), Gram-positive cocci in clusters (S2)
8	S: TFTC F: TFTC P: TFTC T: TFTC	S: TFTC F: TFTC P: TFTC T: 6.3×10^7	S: 3.88×10^4 F: 1.24×10^4 P: TFTC T: TFTC	S: TFTC F: TFTC P: 4.3×10^4 T: TFTC	T: Gram-negative bacilli (SK) S: Gram-negative cocci in clusters (S1) F: Gram-negative bacilli (S1) P: Gram-positive cocci in clusters (S2)
9	S: TFTC F: TFTC P: TFTC T: TFTC	S: TFTC F: TFTC P: TFTC T: TFTC	S: TFTC F: TFTC P: TFTC T: TFTC	S: TFTC F: TFTC P: TFTC T: 1.2×10^4	T: Gram-positive cocci in clusters (S2)
10	S: TFTC F: TFTC P: TFTC T: TFTC	S: TFTC F: TFTC P: TFTC T: TFTC	S: TFTC F: TFTC P: TFTC T: TFTC	S: 2.9×10^4 F: TFTC P: TFTC T: TFTC	S: Gram-positive cocci in clusters (S2)

S: spoon; F: fork; P: plate; T: table; and TFTC: Too Few To Count.

samples had CFU/mL values ranging from 1.4×10^4 to 9.52×10^4 . The samples had Gram-positive cocci, Gram-negative cocci, Gram-positive bacilli, and Gram-negative bacilli.

Samarahan 2 had five samples with a significant CFU/mL from locations 5, 7, 8, 9, and 10. The samples had CFU/mL values ranging from 1.2×10^4 to 6.4×10^4 . The samples had Gram-positive bacilli and cocci, and Gram-negative cocci.

Since the standards classify sanitation level based on CFU/cm², all initial data recorded in CFU/mL for utensils (spoon, fork, and knife) were converted to CFU/cm². The data in CFU/cm² is presented in Table 2.

Socio-demographic characteristics of food handlers

A total of 1,600 food handlers were recruited, with 400 selected from each study area to participate in the face-to-face interview and observation. The results, shown in Table 3, revealed that the majority of respondents across the four study areas were aged between 19 and 25. The highest proportion of respondents in this age group was found in Southern Kuching (68%) and Samarahan 1 (66.5%).

Samarahan 2 showed a notable percentage (17%) of respondents aged 18 or younger. In contrast, Northern Kuching had a significant proportion (38.75%) in the 26 - 35 age group. The percentage of respondents aged 36 and older was relatively low, with the highest percentage in Northern Kuching (12.25%) and the lowest in Southern Kuching (1.8%).

In Northern Kuching, 53.5% of respondents

Table 2. Microbiological assessment of spoons, forks and plates in CFU/cm².

Location	Northern Kuching	Southern Kuching	Samarahan 1	Samarahan 2
1	S: TFTC	S: TFTC	S: TFTC	S: TFTC
	F: 2.44×10^7	F: 1.278×10^8	F: TFTC	F: TFTC
	P: 2.54×10^6	P: TFTC	P: TFTC	P: TFTC
2	S: 2.736×10^7	S: TFTC	S: TFTC	S: TFTC
	F: TFTC	F: TFTC	F: TFTC	F: TFTC
	P: 9.000×10^5	P: TFTC	P: TFTC	P: TFTC
3	S: TFTC	S: TFTC	S: TFTC	S: TFTC
	F: 1.259×10^8	F: TFTC	F: TFTC	F: TFTC
	P: 7.111×10^6	P: TFTC	P: TFTC	P: TFTC
4	S: TFTC	S: 3.028×10^7	S: TFTC	S: TFTC
	F: TFTC	F: 4.519×10^7	F: TFTC	F: TFTC
	P: TFTC	P: TFTC	P: TFTC	P: TFTC
5	S: TFTC	S: TFTC	S: 1.944×10^3	S: TFTC
	F: TFTC	F: TFTC	F: 1.763×10^4	F: TFTC
	P: TFTC	P: TFTC	P: 2.000×10^2	P: 2.778×10^2
6	S: TFTC	S: TFTC	S: TFTC	S: TFTC
	F: TFTC	F: TFTC	F: TFTC	F: TFTC
	P: TFTC	P: TFTC	P: TFTC	P: TFTC
7	S: TFTC	S: TFTC	S: TFTC	S: TFTC
	F: TFTC	F: TFTC	F: TFTC	F: TFTC
	P: TFTC	P: TFTC	P: TFTC	P: TFTC
8	S: TFTC	S: TFTC	S: 5.389×10^3	S: TFTC
	F: TFTC	F: TFTC	F: 2.296×10^3	F: TFTC
	P: TFTC	P: TFTC	P: TFTC	P: 4.778×10^2
9	S: TFTC	S: TFTC	S: TFTC	S: TFTC
	F: TFTC	F: TFTC	F: TFTC	F: TFTC
	P: TFTC	P: TFTC	P: TFTC	P: TFTC
10	S: TFTC	S: TFTC	S: TFTC	S: 4.028×10^3
	F: TFTC	F: TFTC	F: TFTC	F: TFTC
	P: TFTC	P: TFTC	P: TFTC	P: TFTC

S: spoon; F: fork; P: plate; and TFTC: Too Few To Count.

Table 3. Socio-demographic characteristics of food handlers.

Demographic variable	Category	Northern Kuching		Southern Kuching		Samarahan 1		Samarahan 2	
		n	%	n	%	n	%	n	%
Age	≤ 18	23	5.75	8	2	18	4.5	68	17
	19 - 25	173	43.25	272	68	266	66.5	171	42.8
	26 - 35	155	38.75	113	28.2	79	19.75	115	28.7
	≥ 36	49	12.25	7	1.8	37	9.25	46	11.5
Gender	Male	186	46.5	174	43.5	102	25.5	197	49.3
	Female	214	53.5	226	56.5	298	74.5	203	50.7
Level of education	Primary	9	2.25	2	0.5	11	2.75	3	0.75
	Secondary	179	44.75	206	51.5	59	14.25	270	67.5
	College or university	212	53	192	48	330	82.5	127	31.75
Food handler training course	Yes	325	81.25	342	85.5	122	30.5	272	68
	No	75	18.75	58	14.5	278	69.5	128	32
Typhoid vaccination	Yes	291	72.75	320	80	102	25.5	268	67
	No	109	27.25	80	20	298	74.5	132	33

n: frequencies; and %: percentage.

were females, while 46.5% were males. A comparable pattern was noted in Southern Kuching and Samarahan 2, with 56.5 and 50.7% of respondents being females and 43.5 and 49.3% males, respectively. In contrast, Samarahan 1 had a significantly higher proportion of female respondents (74.5%) than males (25.5%).

The data on education levels revealed that Samarahan 1 had the highest percentage of respondents with college or university qualifications (82.5%), while Samarahan 2 had the lowest (31.75%). In contrast, secondary education was the most common in Southern Kuching (51.5%) and Samarahan 2 (67.5%), while Samarahan 1 had the lowest (14.25%). Primary education was the least common across all locations, with the highest proportion in Samarahan 1 (2.75%) and the lowest in Southern Kuching (0.5%).

The majority of respondents in Northern Kuching (81.25%), Southern Kuching (85.5%), and Samarahan 2 (68%) participated in the Food Handler Training Course. Samarahan 1 had the lowest participation, with only 30.5% attending the training. The remaining 69.5% chose not to participate.

Regarding the typhoid vaccination, 72.75, 80, and 67% of Northern Kuching, Southern Kuching, and Samarahan 2 respondents indicated that they had received the vaccination. In Samarahan 1, only 25.5% of respondents had received the typhoid vaccination. The majority, 74.5%, did not received typhoid vaccination.

Assessment of food handlers' attire

The food handler's attire was assessed following Part IV, Regulation 32 of the Food Hygiene Regulations 2009. The results presented in Table 4 show that nearly all food handlers in Northern Kuching (100%) and Southern Kuching (99%) wore clean attire. Samarahan 2 had the lowest percentage at 67.5%. Similarly, a higher percentage of food handlers in Northern Kuching (79.75%) and Southern Kuching (88.25%) were observed wearing clean aprons compared to other areas, while Samarahan 2 again showed the lowest percentage of clean apron usage (67.5%). Southern Kuching recorded the highest percentages of compliance for proper apron storage at 88.25%, while Samarahan 1 recorded the lowest at 25.75%.

Southern Kuching had the highest compliance with wearing hats or head covers (97.25%), while Samarahan 1 had the lowest (48.8%).

Facemask usage varied significantly, with Samarahan 2 (80.75%) having the highest compliance and Northern Kuching (30.5%) with the lowest. Similarly, Samarahan 2 (85%) had the highest glove usage, and Southern Kuching had the lowest (18.75%).

The highest compliance with avoiding accessories/jewellery was in Southern Kuching (95.25%) and Samarahan 1 (85.8%), while Samarahan 2 had the lowest compliance (26.25%). Meanwhile, Southern Kuching (93.5%) and Samarahan 2 (99%) had the highest compliance with covered shoes, while Samarahan 1 had the lowest (48.5%).

Personal hygiene practices of food handlers

Table 5 summarises the mean percentage of conformity in adhering to personal hygiene practices. Northern Kuching, Southern Kuching, and Samarahan 2 demonstrated high personal hygiene compliance, with more than 92.75 - 100% food handlers maintaining clean and short fingernails, avoiding nail polish, and having no wounds or skin disease. In contrast, Samarahan 1 had significantly lower compliance in nail hygiene (84.5%), nail polish avoidance (66.5%), and absence of wounds/skin infections (80 - 82.75%).

In term of handwashing behaviour, Samarahan 2 had the highest compliance (99.75%), indicating excellent hygiene practices. Meanwhile, Northern Kuching, Southern Kuching, and Samarahan 1 had almost similar handwashing percentages (91 - 95.25%).

Unhygienic personal practices of food handlers

The unhygienic personal behaviour of food handlers was also assessed to evaluate compliance with personal hygiene standards. Table 6 presents the mean percentage of conformity. Northern and Southern Kuching showed consistently high compliance percentages (90.75 - 98.25%) in avoiding all unhygienic behaviours in the observation checklist, such as handshakes, money exchange, coughing, chewing, scratching, and touching food with bare hands. Samarahan 1, however, exhibited the lowest compliance, with percentages ranging from 38.75 to 61.5% for all different unhygienic practices assessed. Samarahan 2 had a slightly higher compliance percentage than Samarahan 1 regarding unhygienic behaviour, but lower than Northern and Southern Kuching.

Table 4. Assessment of food handlers' attire in accordance with Food Hygiene Regulations 2009.

Food handler attire	Northern Kuching				Southern Kuching				Samarahan 1				Samarahan 2			
	Conformity		Non-conformity		Conformity		Non-conformity		Conformity		Non-conformity		Conformity		Non-conformity	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Wear clean apron	319	79.75	81	20.25	353	88.25	47	11.75	314	78.5	86	21.5	288	67.5	112	28
Keep apron in cupboard	293	73.25	107	26.75	353	88.25	47	11.75	103	25.75	297	74.25	270	67.5	130	32.5
Wear hat/head cover	363	90.75	37	9.25	389	97.25	11	2.75	195	48.8	205	54.25	284	71	116	29
Wear face mask	122	30.5	278	69.5	129	32.25	271	67.75	183	45.75	217	54.25	323	80.75	77	19.25
Wear clean clothes	400	100	0	0	396	99	4	1	311	77.25	89	22.25	270	67.5	130	32.5
Wear covered shoes	360	90	40	10	374	93.5	26	6.5	194	48.5	206	51.50	396	99	4	1
Using gloves while handling food	169	42.25	231	57.75	75	18.75	325	81.25	237	59.25	163	40.75	340	85	60	15
Accessories or jewellery on hands and wrists	304	76	96	24	355	95.25	19	4.75	343	85.8	57	14.2	105	26.25	295	73.75

n: frequencies; and %: percentages.

Table 5. Personal hygiene practices of food handlers.

Food handler attire	Northern Kuching		Southern Kuching		Samarahan 1		Samarahan 2									
	Conformity	Non-conformity	Conformity	Non-conformity	Conformity	Non-conformity	Conformity	Non-conformity								
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%								
Fingernails trimmed short and clean	392	98	8	2	395	98.75	5	1.25	338	84.5	62	15.5	384	96	16	4
Wash hands with soap	371	92.75	29	7.25	381	95.25	¹ 9	4.75	364	91	36	9	399	99.75	1	0.25
No open wounds or sores	400	100	0	0	399	99.75	1	0.25	331	82.75	61	17.25	392	98	8	2
Not using nail polish	388	97	12	3	393	98.25	7	1.75	266	66.5	134	33.5	387	96.75	13	3.25
No skin disease or infections	400	100	0	0	396	99	4	1	320	80	80	40	379	94.75	21	5.25

n: frequencies; and %: percentage.

Table 6. Personal unhygienic practices of food handlers.

Category	Northern Kuching			Southern Kuching			Samarahan 1			Samarahan 2						
	Conformity		Non-	Conformity		Non-	Conformity		Non-	Conformity		Non-				
	n	%	n	%	n	%	n	%	n	%	n	%				
Shaking hand	386	96.5	14	3.5	393	98.25	7	1.75	182	45.5	218	54.5	387	96.75	13	3.25
Chewing	388	97	12	3	384	96	16	4	219	54.75	181	45.25	352	88	48	12
Exchanging money	363	90.75	37	9.25	386	96.5	14	3.5	246	61.5	154	38.5	258	64.5	142	35.5
Coughing	392	98	8	2	381	95.25	19	4.75	176	44	224	56	365	91.25	35	8.75
Scratching	388	97	12	3	392	98	8	2	194	48.5	206	51.5	372	93	28	7
Touching food with bare hand	377	94.25	23	5.75	393	98.25	7	1.75	155	38.75	245	61.25	313	78.25	87	21.75

n: frequencies; and %: percentage.

Discussion

Microbiological assessment

Food served in restaurants is susceptible to microbial contamination at any stage, either during storage, handling, processing, or even serving. The contamination may originate from raw materials or be introduced through cross-contamination from air, water, dust, animal wastes, infected food handlers, and their unhygienic practices (Bukhari *et al.*, 2021; Tenna *et al.*, 2023). Hence, microbiological assessment should rely not only on food but also on food contact surfaces, including knives, spoons, tables, plates, cutting boards, trays, cups, glasses, and chairs (Bukhari *et al.*, 2021; Tenna *et al.*, 2023). These surfaces play a critical role in the transmission of contaminants, making their microbiological assessment crucial to reduce the risk of food contamination (Bukhari *et al.*, 2021; Tenna *et al.*, 2023).

In Malaysia, there are currently no standards established under the Food Act 1983 or the Food Hygiene Regulations 2009 specifically for assessing the hygiene of utensils and food-contact surfaces. Therefore, the present work used the United Kingdom Public Health Laboratory Service (PHLS) standards as a reference. According to PHLS standards, total viable counts on food-contact surfaces are classified into three categories: satisfactory (< 80 CFU/cm²), borderline (80 - 1,000 CFU/cm²), and unsatisfactory ($> 1,000$ CFU/cm²) (Sagoo *et al.*, 2003; Gaare and Mishra, 2021).

The present work found that the majority of utensils demonstrated satisfactory sanitation levels, with TPC showing less than 80 CFU/cm². Specifically, 24 utensils (80%) from Northern Kuching, 27 (90%) from Southern Kuching, 24 (86.67%) from Samarahan 1, and 29 (96.97%) from Samarahan 2 were classified as satisfactory. A statistical analysis using One-way ANOVA showed no significant differences in the proportion of hygienic utensils across the four areas ($p = 0.161$, $SD = 7.06$).

Although the entire surface of each serving table was swabbed, the absence of recorded table dimensions (cm²) constitutes a limitation of the present work, as it hindered the expression of bacterial counts in CFU/cm². Nevertheless, hygiene status could still be assessed, as only serving tables with results classified as 'Too Few To Count' (TFTC, corresponding to < 80 CFU/cm²) were included in the

analysis. Based on PHLS, this level is considered satisfactory (Gaare and Mishra, 2021). The TFTC count was found in seven out of ten serving tables (70%) in Northern Kuching and eight out of ten serving tables (80%) in each of the other three areas. A One-way ANOVA analysis also indicated no significant differences in the proportion of hygienic serving tables across these areas ($p = 0.941$, $SD = 5.0$).

Swabbing food contact surfaces followed by viable plate count is a widely accepted method for microbiological assessment in food processing, preparation, and serving settings (Bukhari *et al.*, 2021). Total plate count (TPC) provides the total microbial population on a surface or within a sample and serves as an indicator that reflects the general microbiological condition of a food or the environment (3M Food Safety and Cornell University, 2019). While TPC does not identify specific pathogens or directly assess public health risk, this method is particularly valuable in environmental monitoring programs to determine hygienic status and verify sanitation practices. The TPC values exceeding recommended thresholds indicate ineffective or inadequate cleaning (3M Food Safety and Cornell University, 2019; Gaare and Mishra, 2021). In the present work, TPC results were therefore interpreted as a measure of surface hygiene for utensils and serving tables rather than a direct assessment of food safety risk or the presence of pathogens. Nevertheless, Nahar and Mahyudin (2018) found a correlation between high TPC values and the presence of *E. coli* on spoons in selected restaurants in the Klang Valley, Malaysia. Thus, higher bacterial loads may be associated with increased contamination risk.

The Gram-staining performed on the samples revealed various bacterial morphologies, with Gram-negative bacteria primarily colonising both utensils and serving table surfaces. These findings aligned with those of Jain *et al.* (2020) and Shayeghi *et al.* (2020). Foodborne pathogenic Gram-negative bacteria significantly contribute to human disease worldwide, primarily due to their outer membrane, which plays a crucial role in their growth and survival (Zhang *et al.*, 2021).

Additionally, Gholammostafaei *et al.* (2014) discovered that utensils exhibited the highest contamination relative to food handlers and samples. The cleanliness of food utensils is influenced by knowledge (Saipullizan *et al.*, 2018) as well as the

practices of food handlers (Santana *et al.*, 2009). Therefore, food utensils have a different degree of contamination risk (Santana *et al.*, 2009). The practices that contribute to the contamination of utensils are primarily due to cross-contamination (Bukhari *et al.*, 2021), such as sharing utensils between cooked and uncooked materials. The other factors are over-used sponges to wash utensils (Wolde and Bacha, 2016; Bukhari *et al.*, 2021), as well as the unhygienic use or handling of kitchen cloths, especially knitted cotton cloths (Moretro *et al.*, 2022), inefficient cleaning procedure (Birawida *et al.*, 2019), improper storage of utensils such as utilising open rack or storing utensils without rack (Birawida *et al.*, 2019), low quality or unavailability of water (Tenna *et al.*, 2023), and use of lower-cost ineffective detergent (Bukhari *et al.*, 2021). Bacteria present in food utensils are easily transmitted to food during preparation; thus, contaminated food utensils should not be used for food preparation, especially for ready-to-eat food (Saipullizan *et al.*, 2018). According to Food Hygiene Regulations 2009, all appliances and containers used for raw food shall be cleaned and rendered sanitary before being used for cooked food (Law of Malaysia, 2023). Labovic *et al.* (2023) found significant improvements in the microbiological safety of food contact surfaces after hygiene education.

The ability of bacterial pathogens to survive on non-living objects and cause an exogenous source of infection is significantly due to their ability to form biofilm (Jain *et al.*, 2020). Biofilm can form on various artificial substrates commonly found in the food industry, including stainless steel, polyethylene, wood, glass, polypropylene, and rubber seals of dishwashers (Abdallah *et al.*, 2009; Colagiorgi *et al.*, 2017; Raghupathi *et al.*, 2018). Bacteria in the biofilm can tolerate antimicrobial agents and are challenging to eradicate. As 90% of biofilm structure consists of water, the temperature of the water used for washing dishes has a detrimental effect (Tenna *et al.*, 2023). Sahai *et al.* (2015) showed that a hotter rinse temperature (55°C or above) in domestic dishwashers resulted in fewer bacteria remaining on utensils. A comparison of the washing efficiency between plates cleaned using a dishwasher and those washed by hand and dried with a towel revealed that bacteria grew up to seven-fold on the latter, as the dishwasher effectively removed all bacteria from the plates (Blackmore *et al.*, 1987). Rossvoll *et al.* (2015) reported that a cleaning procedure involving

brushing, rinsing, and drying reduced *E. coli* on an artificially contaminated cutting board. In contrast, disinfection with hypochlorite resulted in no detectable *E. coli* and *Staphylococcus aureus*.

The Food Standard Australia New Zealand (FSANZ, 2023) recommends six steps for effectively cleaning and sanitising utensils: pre-clean, wash, rinse, sanitise, final rinse, and dry. Furthermore, Ontario Regulation 493/175: Food Premises in Part IV Cleaning and Sanitizing, sub-regulations (18) stipulate that food establishments that utilise hand dishwashing must have a three-compartment sink or three separate sinks that are large enough to thoroughly clean and sanitise effectively. Alternatively, a two-compartment sink, or two sinks may be utilised, ensuring that effective cleaning and rinsing occur in the first sink. In contrast, the second sink is allocated for sanitisation. Additionally, food establishments must be equipped with drainage racks. Both the sink and drainage racks shall be made from corrosion-resistant materials. Meanwhile, in sub-regulation (19) of Ontario Regulation 493/175: Food Premises, a method such as using clean water at 77°C for at least 45 sec can be applied for the utensils' sanitation. During the visit, it was observed that spoons and forks were soaked in a glass of hot water while serving customers, as noted in several food premises in Northern Kuching, Southern Kuching, and Samarahan 2.

Socio-demographic characteristics

The analysis of the socio-demographic data presented in Table 3 revealed that the predominant age group among respondents from all four areas is 19 to 25 years, with Southern Kuching recorded the highest proportion (68%), followed by Samarahan 1 (66.5%). This finding is similar to Saad *et al.* (2013), which reported that 47.9% of food handlers in government training centres located in Kedah, Penang, and Perak were between 18 and 30 years old. Likewise, Siau *et al.* (2015) found that 75.2% of food handlers in Putrajaya food courts were 28 years old or younger. Chik *et al.* (2023) also found that most of the food handlers in the restaurant of Taman Negara were 18 to 27 years old. All of these findings suggested that most food handlers were under 30. In contrast, Elexson *et al.* (2023) found a high percentage of food handlers between the ages of 26 to 35 years in food outlets located in Kuching and Lawas, Sarawak, Kuala Penyu, Sabah, and Gurun, Kedah.

The gender distribution across four study areas showed a relatively balanced ratio of females to males in Northern Kuching, Southern Kuching, and Samarahan 2. However, Samarahan 1 had a significantly higher proportion of female respondents (74.5%). Akabanda *et al.* (2017) highlighted the predominance of female participation in the food industry, which is consistent with the finding of Chik *et al.* (2023), who reported that 70% of respondents working in restaurants in Taman Negara Kuala Tahan were female. Tan *et al.* (2013) found that female food handlers displayed better handwashing practices than males, suggesting a potential link between gender and compliance level with personal hygiene standards. However, the present work found no consistent association between the gender of food handlers and their compliance level. For instance, while Samarahan 1 had the highest percentage of female food handlers (74.5%), it exhibited the lowest compliance percentage with personal hygiene standards (62.83%). In contrast, Samarahan 2, which had an almost equal gender distribution, demonstrated comparatively higher compliance (84.48%).

Similarly, formal education was not associated with the compliance level of personal hygiene standards. Samarahan 1 had the highest percentage of college or university-educated food handlers (82.5%), but this did not result in a higher compliance percentage. In contrast, Samarahan 2, which had the lowest percentage of college or university graduates (31.75%), achieved higher compliance. This finding aligned with previous research by Webb and Morancie (2015), which reported that high education had a minimal impact on food safety knowledge among food service workers at university campuses.

Previous studies by Ncube *et al.* (2020) and Malavi *et al.* (2021) emphasised the positive impact of food safety training on knowledge and hygiene practices. The present work noted that areas with higher food handling training course participation, such as Southern Kuching (85.5%) and Northern Kuching (81.25%), exhibited the highest compliance percentage. In contrast, Samarahan 1, with the lowest attendance (30.5%), recorded the lowest compliance. This finding suggested that participation in food handling training influenced personal hygiene compliance.

Typhoid fever is endemic in Malaysia (MSIDC, 2025). In 2022, 213,306 Malaysian food handlers and 24,989 non-Malaysian food handlers

were vaccinated against typhoid (MOH, 2023). The findings of the present work showed that Southern Kuching had the most significant proportion of food handlers who received the typhoid vaccine. In contrast, Samarahan 1 had the lowest percentage of food handlers vaccinated against typhoid (25.5%), which is against the food law as stipulated in Regulation 30, sub-Regulation (1), Food Regulations 2009. This implied that there was a higher risk of contamination and infection for consumers in this area.

Food handlers' attire

Personal hygiene covers the aspects of hand hygiene, attire, personal health, and personal habits or behaviours (Tan *et al.*, 2013). During the observational visit in Samarahan 2, it was noted that 28% of respondents wore either unclean aprons or did not wear an apron. Meanwhile, a significant percentage of non-compliance regarding proper apron storage was observed in Samarahan 1. Lues and Tonder (2005) found that coliforms, *Enterobacteriaceae*, and *S. aureus* were found on 16 to 48% of aprons, with 8% of aprons exceeding the acceptable limit for coliforms. Therefore, the importance of raising awareness about wearing a clean apron during food preparation and ensuring proper apron storage should be emphasised.

High compliance with wearing hats or head covers was observed in Southern Kuching, Northern Kuching, and Samarahan 2. In contrast, Samarahan 1 recorded a higher non-compliance percentage (54.25%) than a compliance percentage (48.8%). This disparity indicated the risk of hair contamination, thus highlighting the need for increased efforts to promote proper head covering practices in Samarahan 1. The hair shaft is continuously exposed to the environment, rendering it a potential site for accumulating Gram-positive and Gram-negative bacteria due to its grooved cuticle surface and elongated and thin structure (Skowron *et al.*, 2021). Therefore, proper hair covering while on duty is essential (Elexson *et al.*, 2023), as it prevents loose hairs from falling into food and consequently reducing contamination risks.

Northern Kuching (42.25%) and Southern Kuching (18.75%) exhibited lower glove compliance than Samarahan 1 and Samarahan 2. Conversely, Elexson *et al.* (2023) reported a higher glove compliance in Kuching. The discrepancy could result from differences in specific research locations within Kuching. Wearing gloves while preparing food is

crucial, as the hands of food handlers are known vectors for transmission of foodborne disease (Lambrechts *et al.*, 2014; Murwira *et al.*, 2015). Ncube *et al.* (2020) detected the presence of *Salmonella* and *Staphylococcus* on food handlers' hands, where the skin lesions are contamination sources. Ready-to-eat foods prepared by hand without cooking are particularly more susceptible to contamination by *S. aureus* (Bischoff *et al.*, 2004; Mengual Lombar *et al.*, 2016). Robinson *et al.* (2016) found that glove use alone reduced the risk of bacterial contamination, but when combined with proper handwashing, the risk was significantly lowered. Therefore, both glove use and adequate hand washing are essential to ensure optimum food safety. Additionally, Ray and Bhunia (2013) highlighted that to reduce the risk of staphylococcal food poisoning, food handlers with respiratory diseases, acute facial acne, skin rashes, boils, and cuts on their hands should not handle the food.

Samarahan 2 had the lowest compliance with hygiene practices that prohibit jewellery, with only 26.25% compliance. During the visits, food handlers were observed wearing items such as watches, gold bracelets, rings, and necklaces. Jewellery, such as rings, can serve as reservoirs for germs. Yildirim *et al.* (2008) demonstrated that ring-wearing increased bacterial colonisation despite hand disinfection, regardless of ring type. Similarly, Mengual Lombar *et al.* (2016) found that accessories like piercings, rings, bracelets, earrings, necklaces, and even recent tattoos can harbour significant bacterial loads such as *E. coli*, thus making them potential sources of food contamination in restaurant or catering settings. In contrast, higher compliance percentages (76 - 95.25%) were recorded in Southern Kuching, Northern Kuching, and Samarahan 1, suggesting higher awareness of the importance of avoiding jewellery use during food preparation.

The observational visits showed that almost all food handlers in Northern Kuching, Southern Kuching, and Samarahan 2 wore covered footwear. The compliance was 99%, indicating a good awareness of hygiene and safety standards in these areas. Samarahan 1 had the lowest compliance at 48.5%. Some respondents were observed wearing open sandals or slippers. Wearing covered shoes is important to protect food handlers from contaminants such as dust, bacteria, and parasites, which can cause illness. Covered shoes also protect against spills, hot liquids, and slipping hazards.

Personal hygienic behaviours of food handlers

Based on the findings shown in Table 5, over 96% of respondents in Northern Kuching, Southern Kuching, and Samarahan 2 exhibited positive attitudes toward personal hygiene habits, such as maintaining short and clean fingernails. Meanwhile, Samarahan 1 exhibited a lower percentage of compliance (84.5%) for this hygiene criterion. A study by Mengist *et al.* (2018) on 220 food handlers revealed that 29.5% were tested positive for various bacterial species under their fingernails, including coagulase-negative *Staphylococcus* (12.3%), *S. aureus* (5%), *E. coli* (2.7%), and other species such as *Klebsiella* (2.7%), *Enterococcus* (1.8%), *Pseudomonas aeruginosa* (1.8%), *Proteus* (1.4%), *Citrobacter* (1.4%), and *Serratia* (0.9%). Food contaminated by gastrointestinal pathogens is often spread by faecal-oral transmission through contaminated nails and fingers, thus emphasising the importance of clean, trimmed fingernails for preventing foodborne illnesses (Scoot, 2013; Mengist *et al.*, 2018).

In addition, the present work found that 91 to 99.75% of food handlers in all areas acknowledged the importance of washing hands with soap and water instead of using water alone. However, challenges persist, especially during high-demand periods such as festivals, when poor hygiene practices may occur due to insufficient inspections or limited knowledge among food handlers (Murwira *et al.*, 2015). Zefenkey (2022) found that alcohol-based hand sanitisers are more effective than water and plain soap for reducing bacteria on hands, though both methods showed comparable results. In contrast, alcohol-free hand sanitiser wipes were less effective and only recommended if cleaning without disinfection is required. Labovic *et al.* (2023) found significant improvements in food handlers' hand hygiene after hygiene education, thus showing the significance of food safety training in improving the personal hygiene practice of food handlers.

Additionally, 94 to 100% of respondents in Northern Kuching, Southern Kuching, and Samarahan 2 had no skin diseases, infections, or open wounds. The result agreed with a previous investigation conducted in Lawas and Kuching, Sarawak (Elexson *et al.*, 2023). Conversely, Samarahan 1 exhibited a lower percentage of compliance (80 - 82.75%). According to the United States Public Health Service Food and Drug Administration (FDA, 2022), food handlers with

uncovered infected wounds or pustular boils are restricted from working unless impermeable covers such as a finger cot or stall and a single-use glove over the impermeable cover are used. This preventive measure is crucial as *S. aureus* contamination often originates from food handlers with skin conditions such as impetigo or open wounds (Michael and Brent, 2007). Supporting this, a study by Akabanda *et al.* (2017) reported that over 90% of respondents agreed that food handlers with infectious skin conditions should take leave, and those with open wounds on their hands or fingers should avoid handling unwrapped foods. Similarly, Labovic *et al.* (2023) found that 90.1% of respondents agreed that individuals with hand wounds should not handle food, thus reflecting a high level of awareness among food handlers regarding this issue.

Observational visits further confirmed compliance with the personal hygiene standards, with most respondents in Northern Kuching, Southern Kuching, and Samarahan 2 refraining from wearing nail polish. In contrast, Samarahan 1 exhibited a lower percentage of conformity, thus suggesting a need for hygiene education in this area. According to the United States Public Health Service Food and Drug Administration (FDA, 2022), food handlers are prohibited from wearing nail polish unless they are wearing gloves in good and clean condition. The nail polish increases the risk of chipped polish contaminating food. Hedderwick *et al.* (2000) demonstrated that artificial nails of healthcare workers are more likely to harbour pathogens, particularly Gram-negative bacilli and yeasts, than natural nails.

Unhygienic personal practices of food handlers

According to the Food Hygiene Regulations 2009, Regulation 33(d), food handlers must avoid any actions that may lead to food contamination during the handling, preparation, transportation, storage, display, or serving. However, several poor hygiene practices were observed during the visit, particularly in Samarahan 1, with non-compliance percentages ranging from 38.5 to 61.25%. These practices included handshaking, chewing, exchanging money, coughing, scratching, and touching food with bare hands. While handshaking holds cultural significance as a common form of greeting among colleagues, friends, and strangers, it can contribute to the spread of drug-resistant microorganisms, which may have serious consequences (M'ikanatha and Breedlove,

2022), especially when practiced during food handling. Additionally, poor hygiene practices of infectious food handlers, such as using bare or unwashed hands to prepare food, especially ready-to-eat food, may transmit the pathogen to foods and food-contact surfaces throughout the preparation, cooking, storage, and serving. This presents a risk not only to other food handlers and staff, but also to customers (Shahbaz *et al.*, 2020). A study by Moritz *et al.* (2023) found that food handlers suspected of having an infectious illness were responsible for 14.4% of foodborne outbreaks due to bare-hand contact with ready-to-eat food.

A significant percentage of food handlers in Northern Kuching and Southern Kuching demonstrated a habit of avoiding exchanging money while handling food. This behaviour contrasted with that observed in Samarahan 1 and Samarahan 2. It was observed during the visit that the number of food handlers present in the food premises may have influenced this behaviour. A limited number of food handlers in the food premises may result in the food handlers performing multiple tasks during food handling, thus posing a risk for cross-contamination. A study conducted by Girma *et al.* (2014) identified paper currency can act as a vector for disease transmission. Their study on 100 samples of Ethiopian banknotes revealed contamination from various microorganisms, including pathogenic strains such as *Salmonella* and *Staphylococcus aureus*. Their further analysis indicated these pathogens can reach an infective dose in 12 to 18 h. Furthermore, the research also highlighted that lower-denomination banknotes exhibited greater contamination levels than higher-denomination notes, probably due to frequent transaction distribution.

Other unhygienic habits such as excessive speaking, snacking, or chewing during food preparation must be avoided as these behaviours can lead to food contamination. Saliva serves as a reservoir for microorganisms in the human mouth, with saliva droplets capable of transferring to food, utensils, or cooking surfaces (Shaw *et al.*, 2017).

Statistical analysis on food handlers' compliance with personal hygiene standards

The assessment of personal hygiene among food handlers included their attire, hygiene, and unhygienic personal practices. Therefore, the mean compliance percentages were calculated based on the frequencies presented in Tables 4 to 6, and the results

are summarised in Table 7. As shown in Table 7, Northern Kuching achieved a compliance mean percentage of 88.65%, Southern Kuching at 90.6%, Samarahan 1 at 62.83%, and Samarahan 2 at 84.48%.

A One-way ANOVA was then conducted using IBM SPSS Statistics Version 30 to evaluate the differences in mean compliance among the four

studied areas. The results indicated no statistically significant difference ($p = 0.135$), with a standard deviation (SD) of 12.80. This suggested that the compliance levels with the personal hygiene standard were similar across Northern Kuching, Southern Kuching, Samarahan 1, and Samarahan 2.

Table 7. Mean percentage of conformity of food handlers to personal hygiene standards.

Location	Mean percentage of conformity (%)			Mean
	Food handler' attire	Personal hygiene practices	Personal unhygienic practices	
Northern Kuching	72.81	97.55	95.58	88.65
Southern Kuching	76.56	98.2	97.04	90.60
Samarahan 1	58.70	80.95	48.83	62.83
Samarahan 2	71.13	97.05	85.29	84.48

Conclusion

The present work revealed food handlers' compliance with personal hygiene standards and the hygiene status of utensils and serving tables in food premises across Northern Kuching, Southern Kuching, Samarahan 1, and Samarahan 2. While most food handlers adhered to the personal hygiene requirements outlined in the Food Hygiene Regulations 2009, a minority of food handlers, particularly in Samarahan 1, exhibited unhygienic practices during food handling and preparation. The findings found that neither academic qualification nor gender was associated with better compliance with personal hygiene standards. The highest compliance percentages were recorded in areas where more food handlers had participated in food safety training, namely in Northern Kuching, Southern Kuching, and Samarahan 2. That said, statistical analysis revealed no significant difference in compliance levels among the four areas, indicating generally comparable adherence to personal hygiene standards.

Furthermore, most utensils and serving tables in the four study areas exhibited satisfactory hygiene, with only a small percentage indicating inadequate sanitation. Statistical analysis also showed no significant differences in the proportion of hygienic utensils and serving tables across the four areas.

Sarawak authorities can utilise this data to implement appropriate control measures aimed at reducing the risk of incidence of foodborne outbreaks in the state. These measures include promoting food handling training through various platforms, increasing awareness among food outlet managers

regarding the importance of maintaining high standards of employee personal hygiene, and conducting stringent and regular inspections of food establishments across Sarawak. As part of this initiative, the authorities could consider offering hands-on food handling training for all food handlers to ensure they possess the essential knowledge and skills related to good personal hygiene and effective food handling practices.

Future studies could investigate whether factors such as the length of experience among food handlers and the number of food handlers on food premises affect their personal hygiene and food safety practices. For microbiological analysis, subsequent studies could also incorporate the use of selective and differential agars for the detection of foodborne pathogens and employ 16S Next Generation Sequencing (NGS) to characterise the bacterial genera present on utensils that exhibit unsatisfactory sanitation levels.

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