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Relating Food Handlers' Knowledge, Attitude, and Self-Reported Practices on Food Safety and Hygiene to the Performance of Food Safety Assurance System: A Multiple Case Study in Government Hospital Kitchens

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ABSTRACT

Government hospital kitchens in Malaysia have been certified with Good Manufacturing Practices (GMP) and Hazard Analysis Critical Control Point (HACCP) to ensure that cooked food is clean and safe for consumption. However, the performances of the Food Safety Assurance System (FSAS)-certified government hospital kitchens have not been evaluated. Although researchers in Malaysia have assessed the knowledge, attitude, and self-reported practices (KAP) on food safety (FS) and hygiene among food handlers, they did not relate the influence of food handlers' KAP on the performance of the FSAS. The objective of the study was to relate food handlers' KAP on FS and hygiene to the FSAS performance in government hospital kitchens in Selangor and Kuala Lumpur, Malaysia. Four government hospital kitchens implementing different kinds of FSAS certification were evaluated. Critical sampling locations were identified, and samples were taken and examined for *Escherichia coli*, Total Yeast and Mould Count (TYMC), *Staphylococcus aureus*,

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Total Plate Count (TPC), and *Salmonella*. The average scores of knowledges on FS and hygiene for ≤ 30 years age group, ≤ 5 years in the employment group, and food handlers with tertiary education were the highest and significantly different compared with the other groups. The FS output of government hospital kitchens implementing stringent FSAS was better (score of 2–3) than kitchens implementing less stringent FSAS (score of 2). The multinomial logistic regression analysis showed that the correlations among the overall percentage scores of KAP and the FS output were not significant ($p > 0.05$). Therefore, it appeared that food handlers' KAP on FS and hygiene did not influence *Salmonella*, *E. coli*, and *S. aureus* levels and, therefore, the FSAS' performance.

Keywords: Food handlers, food safety assurance system, food safety output, government hospital kitchens

INTRODUCTION

Hospital food is an essential source of nutrition for inpatients (Yousif et al., 2013). More than 75% of the population depended on the in-house catering menus during hospitalization (Allison, 2003). Therefore, providing safe food for consumption is a significant responsibility, especially for the young, the elderly, and the immune-suppressed patients (Lund & O'Brien, 2011; Valero et al., 2016). Outbreaks of nosocomial foodborne illness can have severe implications, incurring additional medical costs to the healthcare setting and the risk of spreading the infection to other patients (Lund & O'Brien, 2011). Food is generally safe when free from microbial, chemical, and foreign contaminants (Lund & O'Brien, 2011). The Food Safety Assurance System (FSAS) is therefore enforced in food service establishments by the authorities to ensure food safety (FS) and quality and to avoid foodborne outbreaks (Jacxsens et al., 2009).

Furthermore, Food Hygiene Regulations 2009 have made it mandatory for food premises in Malaysia to implement a Food Safety Assurance Program (Laws of Malaysia., 2009). In addition, most safety and quality certification systems, such as Hazard Analysis Critical Control Point (HACCP) and ISO 22000 Food Safety Management System (FSMS), require an organization to establish a measurable FS objective to measure its performance (Standards Malaysia, 2007, 2012). FS objective specifies the maximum permissible level of a microbiological hazard in a food at the moment of consumption, and it provides the industry with quantitative targets to be met (van Schothorst et al., 2009). In addition, different authors used Microbial Assessment Scheme (MAS) to evaluate FSAS' performance in an organization, in which the selected microbiological parameters and conditions were used to establish FS objectives (Jacxsens et al., 2009; Oses et al., 2012).

Foodborne illness in food service has been associated with FS behavior and the practice of food handlers, where poor personal hygiene and improper holding time and temperature are primarily implicated (Abdul-Mutalib et al., 2015). Knowledge

of food hygiene practices is essential for the food handlers to have the right attitude to perform their duties and produce safe foods for consumption (Baluka et al., 2015). Researchers have used surveys to evaluate the knowledge, attitude, and self-reported practices (KAP) among hospital food handlers (Bou-Mitri et al., 2018; Norhaslinda et al., 2016). Food handlers are usually deemed to have good KAP if they score ≥ 80% of the total marks (Nyarugwe et al., 2018; Pacholewicz et al., 2016). Although different researchers in Malaysia have assessed the KAP among food handlers (Norhaslinda et al., 2016; Suhaila et al., 2020; Tan et al., 2013), they did not relate the influence of food handlers' KAP on the performance of the FSAS.

As mentioned earlier, the MAS has been carefully designed so that its microbiological results can serve as a numerical output in assessing the organization's FS objectives and, therefore, the performance of FSAS (Jacxsens et al., 2009). As a rule of thumb, low numbers of microorganisms and minor variations in the microbial counts indicate an effective FSAS. Researchers have effectively used MAS and KAP surveys to assess the influence of food handlers on the performance of FSAS in a variety of settings (Nyarugwe et al., 2018; Pacholewicz et al., 2016). For example, Nyarugwe et al. (2018) used MAS and KAP surveys, in addition to participatory observation, card-aided interviews, storytelling, and documentation analysis, to assess the performance of FSAS in the milk processing industry in Zimbabwe. Pacholewicz et al. (2016) used MAS and KAP surveys, in addition to observational study and documentation analysis, to assess the influence of food handlers' compliance with procedures of chicken abattoirs in the Netherlands. Government hospital kitchens in Malaysia have been certified with GMP and HACCP to ensure that cooked food is clean and safe for consumption (Ministry of Health, 2018). However, the performances of the FSAS-certified government hospital kitchens have not been evaluated. Therefore, the objective of the present work was to assess the influence of food handlers' KAP on FS and hygiene on the performance of the FSAS in selected government hospital kitchens around Selangor and Putrajaya, Malaysia.

MATERIALS AND METHODS

Characteristics of Government Hospital Kitchens

The present study was conducted in the kitchen of four government hospitals in Selangor and Kuala Lumpur, Malaysia, from 1st August until 31st October 2017. The following codes were given to the government hospital kitchens to disguise their identity: HK1, which is in Kuala Lumpur, and HK2, HK3, and HK4, located in Selangor. HK2 is Good Manufacturing Practices (GMP)-certified, whereas HK1, HK3, and HK4 are GMP- and HACCP-certified. Suhaila et al. (2020) reported using a questionnaire to assess the basic food safety and hygiene knowledge, attitude, and practice (KAP) of food handlers in these government hospital kitchens. A total of 140 food handlers participated in the reported work.

Microbial Assessment Scheme (MAS)

The MAS illustrated by Jacxsens et al. (2009) was used. It comprised of the following: (i) critical sampling locations, (ii) sampling frequencies, (iii) microbiological parameters and methods, (iv) sample preparation of final products, (v) air quality sampling, (vi) swab test's personal hygiene, (vii) food contact surfaces sampling, and (viii) tap water sampling.

Critical Sampling Locations (CSLs)

CSLs were chosen to concur with Jacxsens et al. (2009). The CSLs included final food products, cleanliness of preparation utensils (chopping board, working table, and serving trays), tap water, the air quality of serving and processing areas, and personal hygiene (pre-and post- washing hand) of the participating food handlers.

Sampling Frequencies

A visit was organized to each government hospital kitchen to collect samples at the chosen CSLs. Duplicate samples (n = 2) were collected each for the following: (i) final food products (chicken meals), (ii) tap water, (iii) food contact surfaces — chopping board, (iv) food contact surfaces — working table, (v) food contact surfaces — food tray, (vi) air quality, (vii) the hands of food handlers (pre-washing hand), and (viii) the hands of food handlers (post-washing hand). Sixty-four (64) samples (8 CSLs × 4 government hospital kitchens × 2 duplicates) were obtained.

Microbiological Parameters and Methods

The guidelines for the microbiological examination of ready-to-eat (RTE) foods (Food Standards Australia New Zealand [FSANZ], 2016) were used to choose microbiological parameters. Salmonella was identified as the FS indicator. *Escherichia coli* and *Staphylococcus aureus* were identified as the hygiene indicator. Furthermore, Total Yeast and Mould Count (TYMC) and Total Plate Count (TPC) were identified as the environmental and total microbiological qualities indicators, respectively. Plate Count Agar (PCA), Eosin Methylene Blue Agar (EMB), Xylose Lysine Deoxycholate (XLD) agar, and Buffered Peptone Water (BPW) beside Potato Dextrose Agar (PDA) were obtained from Oxoid (United Kingdom) and made corresponding to the guidelines provided by the producer. Petrifilm™ Staph Express Count Plate was obtained from 3M™ (USA).

Sample Preparation of Food Products

The International Commission on Microbiological Specifications for Foods (ICMSF) (2005) was used to enumerate TPC, *E. coli*, and *S. aureus* counts. Approximately 300 g of food samples were collected, and 25 g was mixed with Buffered Peptone Water (225 mL) in a sterilized stomacher bag, employing a stomacher for 2 min. The mixed samples were successively diluted with 1% peptone water equal to 10^{-6}. At every dilution factor, 0.1 mL of the liquid was transferred and applied uniformly

onto EMB, PCA, and Petrifilm™ Staph Express Count Plate test kits (USA). The detection of *Salmonella* was performed following International Organization for Standardization (ISO) 6579-1 (2017). The samples were pre-enriched in buffered peptone broth, and *Salmonella* was detected in XLD. Approximately 25–250 colonies were enumerated, utilizing a colony counter after incubation at 37 °C (18-24 h). As for the test kits, 15-150 colonies were counted. Then, the average colony count was determined and reported as $\log_{10}$ CFU/g. The isolates found were recognized as illustrated by the supplier of the media (Oxoid, United Kingdom; Biokar COMPASS®, France; and 3M™, USA). The experiments were conducted in duplicates.

Air Quality Sampling

The culture settling plating technique environment of serving and processing areas was examined (Salustiano et al., 2003). First, PDA plates were uncovered in the processing and serving areas for 15 min. Subsequently, the plates were covered after 15 min of air exposure and kept at 21 °C for 48-72 h. The resulting colonies in the range of 25-250 were calculated using a colony counter. Then, the average colony count was determined and reported as $\log_{10}$ CFU/m^3. Finally, the experiments were conducted in duplicates.

Swab Test's Hygiene

The swab test was executed before and after food handlers cleaned their hands, corresponding to ISO 18593 (2004). The sterilized swab was immersed in 1% peptone water and instantly swabbed in a region of about 25 cm^2. Subsequently, the head of the swab was lightly dipped in the peptone water and preserved in an icebox. Further, the samples were successively diluted, equal to 10^{-5} dilutions. Consequently, 0.1 mL of the sample at every dilution was pipetted and removed onto Petrifilm™ Staph Express Count Plate test kits (USA). The test kits were kept warm at 37 °C for 24-48 h. At the end of the incubation period, 15-150 colonies were calculated, utilizing a colony counter (Today's Instruments, Taiwan). The experiments were conducted in duplicates.

Food Contact Surfaces Sampling

The swab test was also conducted to sample the food contact surfaces after cleaning, as described in Swab Test's Hygiene sub-section above. The food-contact surfaces selected were the chopping board, working table, and serving tray. The swabbed stick was transferred to the laboratory using an icebox. The culture medium used was EMB to detect the occurrence of *E. coli*. The isolates attained were recognized as depicted by the media provided by the manufacturer. The experiments were conducted in duplicates.

Tap Water Sampling

Escherichia coli counts of the samples were completed, following Rosmawati et al. (2014). Serial dilutions equal to 10^{-6} were performed. Approximately 0.1 mL of sample was removed and spread evenly onto EMB plates at every dilution. The plates

were kept warm at 37 °C (8-24 h). Only 25-250 colonies were enumerated using a colony counter. Then, the colony count was determined and reported as $\log_{10}$ CFU/mL. The isolates obtained were identified as described by the supplier of the media (Oxoid, United Kingdom). The experiments were conducted in duplicates.

Microbiological Criteria and Interpretation

The microbial counts of chicken meals were evaluated in contrast to the guidelines for the microbiological examination of ready-to-eat (RTE) foods (FSANZ, 2016) and deemed unsafe for utilization if the count was higher than the allowable limit. According to FSANZ (2016), the permitted levels are *Salmonella* must not present in 25 g, *E. coli* < 3 CFU/g, *S. aureus* < 10^2 CFU/g, and TPC < 10^4 CFU/g. In addition, the enumerated microbial counts of food contact surfaces and hands were regarded as unacceptable when the count is equal to or higher than that present in the food samples (Oses et al., 2012). *Escherichia coli* in tap water must be absent in 100 mL (Laws of Malaysia., 1985). The maximum value for TYMC is suggested by Sveum et al. (1992) and must not surpass 90 CFU/m^3.

According to Jacxsens et al. (2009), the microbiological safety level can be categorized as low, medium, and high. An FS level of 1 to 3 was utilized at different CSLs for each microbiological parameter (Jacxsens et al., 2009). More specifically, levels 1 indicate "poor", level 2 indicates "moderate", and level 3 indicates "good" FS levels. Level 1 specifies that improvements are required on numerous control activities when legal conditions or guidelines are surpassed. Level 2 specifies that improvements are required on one control activity, especially when legal conditions or guidelines are surpassed. Level 3 specifies that no improvement is required; legal conditions or guidelines are followed. The total of the microbiological safety levels for each parameter might attain a maximum of 15 (5 × 3). The score of 1, i.e., "poor", was designated when the total of the levels was 5 to 7; a total of 8 to 9 ensued in a score of 1–2, i.e., "poor to moderate", a total of 10 to 11 ensued in a score of 2, i.e., "moderate", a total of 12 to 13 ensued in a score of 2–3, i.e., "moderate to good", and a total of 14 to 15 ensued in a score of 3, i.e., "good".

Statistical Analysis

The obtained data were processed and analyzed using Statistical Package for the Social Sciences (SPSS) (version 16). One-way analysis of variance (ANOVA) was used to assess the effects of the demographic variables (i.e., age group and length of employment) on the average score of KAP of food handlers. In addition, an independent-samples *t*-test was used to assess the effects of the demographic variables (i.e., gender and educational background) on the average score of KAP of food handlers. Tukey's multiple comparisons test was used to determine the significance of the differences in the average scores. Moreover, multinomial logistic

regression, which allows for a dependent variable with more than two categories, was used to determine the correlation between the overall percentage scores of KAP and the FS output of MAS. As mentioned, an arbitrary scale was used to interpret the overall percentage scores of KAP into good (> 80%), moderate (51% – 79%), or poor (< 50%) (Nyarugwe et al., 2018; Pacholewicz et al., 2016). These arbitrary scales were used as independent variables. In contrast, the FS outputs have five categories: 1 (poor risk), 1–2 (poor to moderate level), 2 (moderate-risk), 2–3 (moderate to a good level), and 3 (good level), were used as the dependent variable. A p-value ≤ 0.05 was considered significant.

RESULTS AND DISCUSSION

The present work assessed the relationship of food handlers' KAP on FS and hygiene on the microbiological performance of the foods served to the patients in government hospital kitchens. Table 1 shows the effect of demographic variables on the average score of KAP on FS and hygiene among food handlers. There was no significant difference ($p > 0.05$) in the average knowledge score on FS and hygiene between males and females. However, there was a significant difference ($p \leq 0.05$) among age groups, length of employment, and educational background. The tertiary education group's average FS knowledge and hygiene scores were at 41.5%, which were the highest ($p \leq 0.05$) and significantly different than other groups. In contrast, the ≤ 30 years age group is at 40.7%, and the ≤ 5 years length of employment group is at 41.9%. There was no significant difference ($p > 0.05$) in the average score of attitudes on FS and hygiene for the following demographic variables: gender, age group, length of employment, and educational background.

The average scores of knowledges on FS and hygiene for ≤ 30 years age group,

Table 1
*Effect of demographic variables on the average score (%) of knowledge on food safety and hygiene among food handlers (*n = *140)*

Demographic variables	Levels (*n*)	Average score % (SD)	df	F	*p*
Gender	Male (*n* = 26)	39.4 (3.61)	138	2.12	0.374
	Female (*n* = 114)	38.4 (3.32)			
Age group	≤ 30 years (*n* = 42)	40.7[a] (3.77)			
	31 - 40 years (*n* = 56)	38.9[a] (5.55)	138	9.59	0.000*
	≥ 41 years (*n* = 42)	36.1[b] (4.90)			
Length of employment	≤ 5 years (*n* = 30)	41.9[a] (3.21)			
	6 - 10 years (*n* = 50)	38.7[b] (4.82)	138	11.9	0.000*
	≥ 11 years (*n* = 60)	36.8[b] (5.18)			
Educational background	Tertiary (*n* = 51)	41.5[a] (3.77)	138	6.08	0.000*
	Secondary and below (*n* = 89)	36.9[b] (4.96)			

*$p \leq 0.05$
[a] Values = The average (standard deviation)
[a-b]Values within the same column with different letters are significantly different

≤ 5 years in the employment group, and food handlers with tertiary education were the highest and significantly different ($p \leq 0.05$) from the other groups (Table 1). The effective management of the FSAS can be improved by applying precautionary approaches and providing continuous training to food handlers on food hygiene and FS (Akabanda et al., 2017). Continuous training needs to be given, especially on the aspect of time and temperature controls, to food handlers with an educational background of secondary and below, in which they are typically aged ≥ 41 years old and have been employed for ≥ 11 years. Food handlers that belong to these identified groups shall be the target group for future food handler refresher training. According to Pacholewicz et al. (2016), consistent FS and hygiene compliance (brought about by continuous training) will improve product safety performance. Therefore, food handlers must be continuously motivated, guided, and educated to ensure FS and hygiene.

A similar trend was also observed for self-reported practices on FS and hygiene except for educational backgrounds. However, the average score of self-reported practices on FS and hygiene for the group with tertiary education was higher and significantly different ($p \leq 0.05$) as compared with the secondary and below a group of employees (data not shown).

Table 2 shows the FS outputs of the government hospital kitchens according to the Microbiological Assessment Scheme (MAS). It was observed that the score of FS output for HK1, HK3, and HK4 was "moderate to good", i.e., a score of 2–3, and "moderate", i.e., a score of 2 for HK2. Furthermore, multinomial logistic regression analysis showed that the correlations among the overall percentage scores of KAP and the FS output of MAS were not significant ($p > 0.05$) (data not shown).

It was found that the FS output of government hospital kitchens (HK1, HK3, and HK4) implementing stringent FSAS (GMP- and HACCP-certified) achieved a "moderate to good" level (score of 2-3). On the other hand, HK2, which implements less stringent FSAS (GMP-certified), recorded a "moderate" level (score of 2) (Table 2). The microbiological criteria selected were the hospitals' FS objectives. *Escherichia coli*, *S. aureus*, and TPC were not in chicken meals from HK1, HK3, and HK4. However, they were present at levels above the allowable levels in samples from HK2. The microbiological safety of government hospital kitchens implementing stringent FSAS was better than hospital kitchens implementing less stringent FSAS. Our findings align with the results of Nyarugwe et al. (2018), who evaluated the performance of microbiological safety of three Zimbabwean dairy companies with different levels of implemented FSAS. They reported that companies certified with HACCP had a better microbiological safety performance than those not HACCP-certified. Implementation of HACCP principles require the development of a HACCP plan. HACCP plan defines the procedures for maintaining control of

Table 2
The number of samples exceeding the limiting criteria for Staphylococcus aureus, Escherichia coli, Salmonella, *Total Yeast and Mould Count, and Total Plate Count over different critical sampling locations (CSLs), the food safety (FS) Levels attributed for all microbiological parameters, and the FS outputs at different government hospital kitchens*

CSL[1]	HK1[2]	HK2[3]	HK3[4]	HK4[5]
Escherichia coli				
Food product — Chicken meals (n^6 = 2)	ND[7]	2	ND	ND
Equipment: Chopping board (n = 2)	2	ND	ND	1
: Working table (n = 2)	ND	ND	2	ND
: Food tray (n =2)	ND	ND	2	ND
Tap water (n = 2)	ND	ND	ND	ND
FS Level[9]	2	2	1	2
Staphylococcus aureus				
Food product — Chicken meals (n = 2)	ND	2	ND	ND
Personnel hygiene: Before (n = 2)	2	2	1	2
: After (n = 2)	2	2	ND	2
FS level	1	1	2	1
Salmonella				
Food product — Chicken meals (n = 2)	ND	ND	ND	ND
FS level	3	3	3	3
Total Plate Count				
Food product — Chicken meals (n = 2)	ND	2	ND	ND
FS level	3	1	3	3
Total Yeast and Mould Count				
Air quality in processing and serving area (n = 2)	0[8]	0	0	0
FS level[9]	3	3	3	3
FS output[10]	(2-3)	(2)	(2-3)	(2-3)

[1]CSL = Critical sampling location
[2]Government hospital kitchen certified with Good Manufacturing Practices (GMP) and Hazard Analysis Critical Control Point Principles (HACCP)
[3]Government hospital certified with Good Manufacturing Practices (GMP)
[4]Government hospital certified with Good Manufacturing Practices (GMP) and Hazard Analysis Critical Control Point Principles (HACCP)
[5]Government hospital certified with Good Manufacturing Practices (GMP) and Hazard Analysis Critical Control Point Principles (HACCP)
[6]Total number of samples per CSL at different hospital kitchens
[7]Below detection limit (ND)
[8]Counts were found, but below the criteria
[9]Level 1 — Low result (legal criteria or guidelines are exceeded, improvements need to be made on multiple control activities of the FSAS). Level 2 — Medium result (legal criteria or guidelines are exceeded, improvements need to be made on a single control activity of FSAS). Level 3 — Good result (legal criteria or guidelines are respected, no improvements are needed — current level of FSAS is high enough to cover this hazard)
[10]The score of 1, i.e., "poor", was designated when the total of the levels was 5 to 7; a total of 8 to 9 ensued in a score of 1–2, i.e., "poor to moderate", a total of 10 to 11 ensued in a score of 2, i.e., "moderate", a total of 12 to 13 ensued in a score of 2–3, i.e., "moderate to good", and a total of 14 to 15 ensued in a score of 3, i.e., "good"

potentially hazardous food at the critical control points of food preparation or processing to ensure that the measurable FS objectives can be met (Standards Malaysia, 2007). On the other hand, GMP set regulations, codes, and guidelines that control the operational conditions within a food establishment, allowing for safe food production. GMP is also one of the pre-requisite programs for establishing the HACCP System (Standards Malaysia, 2013). Kokkinakis et al. (2008) showed that implementing stringent FSAS (GMP- and HACCP-certified) through the application of good practices (GMP and good hygiene practices) in addition to the HACCP plan can improve product safety. Due to the HACCP plan being maintained and periodically verified in government hospital kitchens implementing stringent FSAS (GMP- and HACCP-certified), their microbiological safety performance was better than in kitchens implementing less stringent FSAS (GMP-certified).

Nevertheless, none of the government hospital kitchens could accomplish a good level of FS performance, ultimately their FS objectives. The microbiological results attained at the CSLs in the hospital kitchens exceeded the permitted levels. The load of *E. coli* on the equipment and utensils above the allowable levels in several government hospital kitchens was in agreement with Yousif et al. (2013). They also reported that the equipment surface swabs in a hospital kitchen in Egypt were infected with *E. coli* above the allowable level. It might be due to poor hygiene and water disinfectants. Therefore, the focus on the cleaning procedure of the food contact surfaces should be given to minimize the microbial risk of contamination (De Souza, 2003). *Escherichia coli* was detected on the surface of the equipment for HK1 and HK4 (chopping board) as well as HK3 (working table and food tray) but not detected in the chicken meals of these government hospital kitchens (Table 2). The heating process appears sufficient to inactivate *E. coli* in the final product. These results are similar to those described by Fernandes et al. (2017), who showed that *E. coli* was detected in 6.7% of the surface samples but not detected in the final product. Cooking remains a primary means of eliminating pathogens with heat to achieve a specific lethality, and it continues to play a significant role in preventing future outbreaks in meat products (Murphy et al., 2004). On the contrary, *E. coli* was not detected on the surface of the equipment for HK2, but its levels were above the limit in the chicken meals in this hospital kitchen. In addition, as mentioned, *S. aureus* and TPC were detected in the chicken meals for HK2 at levels above the permitted limits (Table 2). HK2 is certified with GMP only and implements less stringent FSAS compared with HK1, HK3, and HK4. It is possible that the application of good practices (GMP and good hygiene practices) without implementation of the HACCP plan is insufficient to ensure the FS objectives can be met.

It was also found that *S. aureus* was present in the chicken meals above the permitted limit of 10^2 CFU/g and on the

food handlers' hands is equal to or higher than that present in the chicken meals. These findings are consistent with Dablool and Ghamdi (2011), who found that the hands of food handlers were contaminated with *S. aureus*, which is a major human pathogen capable of causing a wide range of infections, including food poisoning caused by the enterotoxin produced by the pathogen (De Sousa, 2008). Moreover, Dablool and Ghamdi (2011) highlighted that staphylococcal food poisoning (SFP) outbreaks in the retail industry are primarily due to the food handler's inappropriate food handling practices and poor personal hygiene. The literature mostly reported the SFP outbreak in restaurants, especially in Brazil (Carmo et al., 2003), Italy (Ercoli et al., 2017), and less in hospital kitchen settings. The incidents of SFP outbreaks in Malaysia are mainly reported in school canteens (Abdullah & Ismail, 2021; Lekhraj, 1983) and during the mass gathering (Rajakrishnan et al., 2022).

In addition, *E. coli* and *S. aureus* were selected as the hygiene indicators, and their results in all the government hospital kitchens were above acceptable levels. It was reported that food handlers that are working in government hospital kitchens have "good" knowledge as well as a "moderate to good" attitude and self-reported practices for hand and personal hygiene (Suhaila et al., 2020). However, it did not influence the levels of *E. coli* and *S. aureus* and, therefore, the performance of FSAS in the government hospital kitchens. Multinomial logistic regression analysis was performed to confirm the observation and found that the correlations among the overall percentage scores of KAP and the FS output of MAS were not significant ($p > 0.05$). Lee et al. (2017) assessed the KAP of FS and hygiene and microbiological hand hygiene of food handlers in university canteens. They reported similar findings in which "moderate" performance on FS knowledge was not reflected in the microbiological hygiene assessment of hands. Adesokan et al. (2015) showed that FS training is associated with improved knowledge and practices among food handlers. However, other factors besides knowledge, attitude, and practices in terms of FS and hygiene might affect the FS output, such as enabling conditions and actual behavior, as demonstrated by other researchers (Nyarugwe et al., 2018; Pacholewicz et al., 2016).

Suhaila et al. (2020) reported that the KAP of food handlers on time and temperature controls varied between "poor" and "moderate". They also reported that the KAP of food handlers on cross-contamination varied from "poor" to "moderate" and "good". However, *Salmonella*, selected as the FS indicator, was not detected in the food product in the present work. Therefore, it can be deduced that "poor" to "moderate" KAP of food handlers on time and temperature controls, as well as "poor" to "moderate" and "good" KAP of food handlers on cross-contamination, did not influence the levels of *Salmonella*. Our results, however, contradicted Lee et al. (2017). They reported that "good" self-

reported practices were not reflected in the microbiological assessment of food handlers' hands, in which *Salmonella* was detected in 48% of the food handlers' hands. Since the FSAS was enforced in all the government hospital kitchens tested in the present work, it was likely that quality control and assurance systems were already in place to control pathogens such as *Salmonella*, unlike the study by Lee et al. (2017), which was conducted in uncertified university canteens. Furthermore, Kokkinakis et al. (2008) have demonstrated the positive effects that HACCP had in an ice cream factory, which was reflected in the improved microbiological quality of the final products.

CONCLUSION

The present study showed that the FS outputs of government hospital kitchens implementing stringent FSAS demonstrated a better performance ("moderate to good") than the one with less stringent FSAS (only "moderate"). Nevertheless, none of the government hospital kitchens could accomplish a good level of FS performance; ultimately, their FS objectives. The multinomial logistic regression analysis showed that the correlations among the overall percentage scores of KAP and the FS output were not significant ($p > 0.05$). Therefore, it appeared that food handlers' KAP on FS and hygiene did not influence the FS outputs and, therefore, the performance of the FSAS. The present study identified the target group with the following specific characteristics: food handlers with an educational background of secondary and below, aged ≥ 41 years old, and have been employed for ≥ 11 years. This target group requires continuous training to improve the attitude and self-reported practices on FS and hygiene practices to ensure a good level of FS performance and, therefore, the FS objectives are achieved. The present study collected duplicate samples ($n = 2$) at the chosen CSLs in each government hospital kitchen. The sampling numbers could be increased in future research to increase data confidence.

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