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Association of Levels of Hygienic Practices and Microbiological Quality on Food Handlers Hands in Hulu Langat District, Malaysia

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The aim of this study was to investigate the potential relationship between the levels of hand hygienic practices of 85 food handlers from primary schools in Hulu Langat district, Malaysia and the hygienic status of their hands. The levels of hand hygienic practices among the food handlers were evaluated through questionnaires whereas the hygienic status of their hands was examined by using Aerobic Plate Count (APC), *Escherichia coli* (*E. coli*)/Coliform and *Staphylococcus aureus* (*S. aureus*) counts. Swab samples on the food handlers' hands were collected at three intervals; before, during and after, the food preparation. Overall, the significant models ($p = 0.05$) for the multiple regression analysis were APC before preparation of ready-to-eat foods ($p = 0.010$), APC after preparation of RTE foods ($p = 0.029$) and *S. aureus* during preparation of RTE foods ($p = 0.009$). Hand hygiene risk factors that influenced the bacterial counts on the food handlers' hands for the three intervals of RTE foods preparation were food poisoning knowledge, hand hygiene attitudes, hand washing practices, contamination prevention and glove use practices. Hence, attention should be focus on hand hygiene especially the aspects of practices among the food handlers from primary schools in Hulu Langat district.

Key words: Cross-contamination, Food Poisoning Knowledge, Glove use, Hand Hygiene attitudes, Hand washing, Personal hygiene.

A person's lifestyle factors including knowledge, attitudes/beliefs, and behavior patterns directly influence the choices that they made regarding food and physical activity[1]. For instance, understanding the advantages of usage of gloves can influence the frequency of wearing gloves by the food handlers when handling RTE foods and consequently control the contamination of pathogenic bacteria. Besides, the perception of a food handler towards food handling may also influence the quality of food that they served because food handler with negative thoughts may not have good manufacturing practice and consequently leads to the decreasing level of hygienic practices.

Extensive researches were found to be in the study of hand hygiene knowledge, attitudes and practices (KAP) of the food handlers[2-6] or the microbiological quality of the food contact surfaces (include hands of the food handlers)[7-11]. However, limited researches had been found to study on the relationship between KAP and microbial quality on food handlers' hands. Therefore, this research was conducted to determine the relationship between microbial quality and the levels of hand hygiene practices among the food handlers at primary schools in Hulu Langat district, Selangor.

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MATERIALS AND METHODS

Data collection

During September 2011 to January 2012, a total of 1020 samples were collected from the hands of 85 food handlers at 38 selected primary schools in Hulu Langat district, Selangor, for the three intervals of RTE foods preparation (before, during and after). Questionnaire data were collected in the afternoon after recess periods of the selected primary schools to avoid any interruptions at work.

Levels of hand hygiene practices

Knowledge, attitudes and self-reported practices on hand hygiene among food handlers were evaluated through written questionnaire modified from previous study[3] and also checklist based on SENAC's Safe Food Program (PAS) Table Checklist and Resolution RDC 275/2002 of the National Agency of Sanitary Surveillance (ANVISA) (as cited in[12]). The questionnaire includes hand hygiene knowledge (20 statements), hand hygiene attitudes (15 statements) as well as hand hygiene practices (20 questions). The aspects of hand hygiene knowledge are food poisoning, personal hygiene and cross-contamination whereas hand hygiene practices consist of hand washing, contamination prevention and glove use aspects.

Microbiological quality on food handlers' hands

Microbiological analysis was conducted on food handlers' hands to test for APC, *E. coli*/ Coliform and *S. aureus* counts by using Petrifilm Aerobic Count Plates, Petrifilm *E. coli*/Coliform and Petrifilm Staph Express Count Plates respectively (3M Microbiology, St. Paul, USA). Swab contact method on Petrifilm plates was used to evaluate APC, *E. coli* Coliform and *S. aureus* counts on food handlers' palms (Evancho *et al*., 2001).

Sampling was performed by swabbing the areas horizontally, vertically and diagonally by using aluminium templates. The whole procedures were done aseptically to minimize the risk of contamination. The collected samples were stored and transported in insulated boxes filled with crushed ice prior to analysis. The storage temperature was within 0-4 ºC while the transport duration to the laboratory was within 15 min to one h. Analyses were performed immediately upon arrival to the laboratory.

Statistical analysis

Statistical analyses were performed using SPSS Statistics 19. Statistical significance for all tests was set at the level of $p \leq 0.05$. Multiple linear regression analysis was used to model relationship between the levels of hand hygienic practices (hand hygiene knowledge, attitudes and practices) of food handlers and APC, *E. coli*/Coliform and *S. aureus* counts on food handlers' palms.

RESULTS AND DISCUSSION

Relationship between levels of hygienic practices and mean bacterial counts

Nine multiple linear regression models were used to determine the relationship between levels of hygienic practices and mean bacterial counts on food handlers' hands. The outcome was presented as Table 1. The independent variables for the models were fixed to be food poisoning knowledge, personal hygiene knowledge, cross-contamination knowledge, hand hygiene attitudes, hand washing practices, contamination prevention and glove use. For the dependent variables, it comprised of: before, during or after RTE foods preparation for APC, *E. coli*/Coliform or *S. aureus* counts. Among the nine models set, only three models were found to be significantly different by using enter regression method. The dependent variables for the significant models were APC before ($p = 0.010$), APC after ($p = 0.029$) and *S. aureus* during ($p = 0.009$) the preparation of RTE foods.

Table 2 shows the coefficients table for the dependent variable of APC before RTE foods preparation. The model was significant ($F = 2.869$, $p = 0.010$) and hand hygiene attitudes ($\beta = 0.270$, $p = 0.011$), contamination prevention ($\beta = 0.265$, $p = 0.025$) and glove use ($\beta = -0.307$, $p = 0.013$) had independent influence on it. The coefficient of determination (R-squared) of 0.207 implies that the seven predictor variables explain about 20.7% of the variance before RTE foods preparation for APC.

Attitudes of the food handlers had been shown to have positive influence before the preparation of RTE foods which means that increase in the attitudes of food handlers tend to increase the APC before the preparation of RTE foods. This observation showed that although food handlers had positive attitudes towards hand hygiene

before RTE foods preparation but they did not put into practice which then led to the increase of APC. This result was supported by Clayton *et al*. (2002) who mentioned that quite a high value of food handlers (63%) confessed that they did not always perform food safety practices although they were aware of it. Moreover, Ansari-Lari *et al*. (2010) also commented that increased food safety attitudes did not always result in the increased in food handling practices. For APC, glove use had negative influence before the preparation of RTE foods which means that bacterial counts were reduced with the increased use of gloves. Hands of food handlers comprised of microorganisms that cannot be seen by the naked eyes and for this reason; gloves should be worn before handling any foods to avoid cross-contamination happen.

For the second significant model, the dependent variable was after RTE foods preparation for APC and the coefficients table are shown in Table 3. The model was significant (F = 2.390, p = 0.029) and food poisoning knowledge (β = -0.241, p = 0.037) and hand washing practices (^{2}β= 0.292, p = 0.018) had independent influence on it. The R-squared of 0.179 implies that the seven predictor variables explain about 17.9% of the variance after RTE foods preparation for APC. Food poisoning knowledge had negative influence on the APC after the preparation of RTE foods. Therefore, increased in food poisoning knowledge

Table 1. Multiple linear regression of hand hygiene knowledge, attitudes and self-reported practices on mean bacterial counts

Model	Dependent variables (Mean ± SD[a])	Sig.	Independent variables
1	APC Before (1.56 ± 0.58)	*0.010	Food poisoning knowledge
2	APC During (1.41 ± 0.55)	0.102	(74.51 ± 22.21)
3	APC After (1.39 ± 0.63)	*0.029	Personal hygiene knowledge
4	*E.coli*/Coliform Before (0.22 ± 0.39)	0.108	(79.71 ± 13.36) Cross-contamination knowledge
5	*E.coli*/Coliform During (0.18 ± 0.36)	0.245	(93.99 ± 9.93) Hand hygiene attitudes
6	*E.coli*/Coliform After (0.24 ± 0.41)	0.566	(87.59 ± 8.45) Hand washing practices
7	*S. aureus* Before (0.47 ± 0.67)	0.062	(97.69± 6.88) Contamination prevention practices
8	*S. aureus* During (0.31 ± 0.53)	*0.009	(90.99 ± 5.07) Glove use practices
9	*S. aureus* After (0.43 ± 0.66)	0.847	(96.41± 8.37)

Note: [a], Standard deviation; *, Statistically significant at $p < 0.05$.

Table 2. Coefficients table for the dependent variable of APC before RTE foods preparation

Model	Unstandardized Coefficients		Unstandardized	t	Sig.
	B	Std. Error	Coefficients Beta		
(Constant)	-2.105	1.438		-1.464	.147
ma	.368	.142	.270	2.596	*.011
Food Poisoning	-.005	.003	-.194	-1.738	.086
Personal Hygiene	.006	.005	.141	1.247	.216
Cross-Contamination	-.001	.007	-.013	-.110	.913
Hand Washing	.014	.010	.163	1.377	.173
Contamination Prevention	.030	.013	.265	2.294	*.025
Glove Use	-.021	.008	-.307	-2.551	*.013

Note: *, Statistically significant at $p < 0.05$

caused the decreased of bacterial counts after the preparation of RTE foods. However, the increase of hand washing did not decrease the bacterial counts. The most likely reason may be the incorrect practices of hand washing procedures by the food handlers. They may be using hand towels which had been contaminated to dry their hands after washing them.

Tan *et al*. (2013)[13], reported that the self reported knowledge, attitude and practices of hand hygiene were were good among the food handlers in their studies but were lacking of basic knowledge and practices such as existence of bacteria and correct hand washing method. This was reflected in another study, Tan et al. (2013)[14] reported that only 23.5% to 34.1% of the food handlers were found compliant in the mean bacterial count for APC during a meal preparation which was a useful tool for evaluating the satisfactory of HACCP plan. Furthermore, their findings revealed that HACCP was not implemented in the premise.

The dependent variable for the final significant model was during RTE foods preparation for *S. aureus* counts and the coefficients table are shown in Table 4. The model was significant (F = 2.921, p = 0.009) and contamination prevention (β = 0.232, p = 0.048) and glove use (β = -0.277, p = 0.024) had independent influence on it. The R-squared was 0.210 which means 21% of the total variance during RTE foods preparation for *S. aureus* counts could be explained by the seven predictor variables. The present study showed that there was significant relationship between hand hygiene self-reported practices and the presence of *S. aureus* during RTE foods preparation. This finding was found to the opposite to the study from Soares *et al*. (2012) that affirmed no association (p > 0.05) were found between the knowledge, attitudes and practices of food handlers and the presence of coagulase-positive staphylococci on their hands. For *S. aureus* counts, increased the use of gloves caused the decreased of bacterial

Table 3. Coefficients table for the dependent variable of APC after RTE foods preparation

Model	Unstandardized Coefficients		Unstandardized	t	Sig.
	B	Std. Error	Coefficients Beta		
(Constant)	-1.714	1.606		-1.067	.289
ma	.311	.158	.208	1.967	.053
Food Poisoning	-.007	.003	-.241	-2.121	*.037
Personal Hygiene	.001	.005	.025	.214	.831
Cross-Contamination	-.014	.008	-.213	-1.738	.086
Hand Washing	.027	.011	.292	2.422	*.018
Contamination Prevention	.021	.015	.168	1.429	.157
Glove Use	-.011	.009	-.149	-1.215	.228

Note: *, Statistically significant at p < 0.05

Table 4. Coefficients table for the dependent variable of APC after RTE foods preparation

Model	Unstandardized Coefficients		Unstandardized	t	Sig.
	B	Std. Error	Coefficients Beta		
(Constant)	.143	1.329		.108	.914
ma	-.151	.131	-.120	-1.158	.251
Food Poisoning	-.005	.003	-.218	-1.956	.054
Personal Hygiene	-.008	.004	-.191	-1.696	.094
Cross-Contamination	.007	.006	.133	1.108	.271
Hand Washing	.007	.009	.085	.721	.473
Contamination Prevention	.024	.012	.232	2.012	*.048
Glove Use	-.018	.008	-.277	-2.301	*.024

Note: *, Statistically significant at p < 0.05

counts during RTE foods preparation. Aycicek *et al*. (2004) had mentioned that the bacterial loads on gloved hand samples were found to be significantly lower ($p < 0.05$) than ungloved hand samples. Thus, food handlers were advised to wear gloves to decrease the load of bacteria. In contrast, the increase in contamination prevention did not decrease the bacterial count. This could be the food handlers did not report the real situation during handling of RTE foods.

CONCLUSIONS

Overall, hand hygiene risk factors that influenced the bacterial counts on the food handlers' hands for the three intervals of RTE food preparation were food poisoning knowledge and hand hygiene attitudes and practices (hand washing, contamination prevention and glove use). Hand hygiene particularly the practices of food handling among the food handlers should be emphasized.

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