

Incidence of Food Poisoning Outbreaks in Pahang, Malaysia, for Six-Year, from 2013 to 2018

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ABSTRACT

The Food Safety and Quality Division (FSQD) in Malaysia is the competent authority tasked with ensuring food safety throughout the food supply chain within the country. Despite implementing various regulations toward improving food hygiene standards in Malaysia, outbreaks of food poisoning cases continued to occur in Malaysia. This cross-sectional study was designed to explore the occurrence of food poisoning incidents in Malaysia, within the Pahang state, from 2013 to 2018 via both reported passive case detection (PCD) and active case detection (ACD) food poisoning incidents. Upon detecting all the food poisoning cases using both PCD and ACD, the people identified to have

suffered from food poisoning underwent a structured interview for investigators to elicit all relevant information about the food poisoning incident. Results showed that in Pahang, the number of reported episodes fluctuated from 2013 until 2018, with an average of 21 food poisoning episodes occurring yearly, reaching a maximum in August and a minimum in May. Furthermore, Kuantan, being the state capital, had reported an exceptionally high total number of reported incidents of food

ARTICLE INFO

Article history:

Received: 13 April 2022

Accepted: 03 June 2022

Published: 09 August 2022

DOI: <https://doi.org/10.47836/pjtas.45.3.17>

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poisoning with a total of 48 episodes over six years from 2013 to 2018, while Kuala Lipis had only one incident reported during the same period (which was reported in 2016). Finally, this study concluded that adequate measures must always be taken to minimise the occurrence of food poisoning, especially when preparing foods in large quantities.

Keywords: Foodborne diseases, foodborne illnesses, food poisoning, Malaysia, Pahang

INTRODUCTION

Food poisoning often results from consuming any food or water which is contaminated. These contaminants are usually bacteria and/or their toxins, parasites, viruses, or chemicals. It can be infectious or non-infectious. Infectious food poisoning occurs after consuming food or water contaminated by microorganisms (including bacteria, viruses, and parasites) or their toxins. In contrast, non-infectious food poisoning occurs after consuming any food contaminated with chemicals or toxins. A food poisoning outbreak is said to have occurred whenever there are at least two cases of a similar foodborne disease (FBD) that have arisen from different people consuming a common food together (World Health Organization [WHO], 2008). The symptoms of food poisoning can often have varying degrees of symptoms, which include abdominal pain, vomiting, diarrhoea, and headache. Depending on its causative agent, food poisoning episodes will usually last from a few hours to several days after an oral

intake of contaminated food or fluid. Serious cases may result in severe, life-threatening complications involving liver, kidney, and nerve functions leading to permanent disability or death. Mild food poisoning episodes are usually self-limiting, and patients will recover without receiving any specific treatment; however, severe forms of food poisoning may require antibiotic treatment and hydration within a hospital setting (Pardal et al., 2020).

Human hands contribute the most to food poisoning incidents as they are always in contact with the ambient environment; and the ubiquitous nature of pathogenic food microorganisms can often be transmitted from the hands to reach the mucous membranes throughout the body (Hawker et al., 2012), including those found in the mouth, nose, and eyes. Common pathogens responsible for most food poisoning cases are norovirus, *Campylobacter* spp., enterotoxigenic *Escherichia coli*, diarrheal disease due to non-typhoid *Salmonella enterica*, and *Shigella* spp. (Kirk et al., 2015); most hospitalisations have resulted from food poisoning episodes caused by *Salmonella* spp., norovirus, *Campylobacter* spp., *Toxoplasma gondii*, and *E. coli*. It is noteworthy that food poisoning caused by *Salmonella* spp., *Toxoplasma gondii*, *Listeria monocytogenes*, norovirus, and *Campylobacter* spp. can occasionally be fatal. Besides, it is a worrying trend for the reported incidence of food poisoning globally to increase yearly (Abdul-Mutalib et al., 2015). According to World Health Organization (WHO, 2015), contaminated

food has resulted in more than 50% of diarrhoea cases worldwide, causing 550 million sick people and 230,000 deaths, together with 125,000 deaths in young children below five years old. Data obtained from several studies reported worldwide have shown that there are already 48 million people suffering from food poisoning annually, which results in 128,000 hospitalisations and 3000 deaths within the USA (Centers for Disease Control and Prevention [CDC], 2018). Developing countries have the most recorded number of food poisoning cases and fatalities (Elshafie, 2017). Globally, a high incidence and fatality rate of foodborne diseases is reported within Africa and Southeast Asia (WHO, 2015). The Foodborne Disease Burden Epidemiology Reference Group (FERG) of the WHO reported that the Southeast Asia region has the second-highest reported foodborne illnesses globally (Kirk et al., 2015). It was widely reported worldwide that cross-contamination due to the unhygienic handling of raw meat (Ansari-Lari et al., 2010) caused most food poisoning cases in many developing countries.

Likewise, in Malaysia, food poisoning is a perennial health problem. Its incidence rate was 44.18/per 100,000 population in 2010, which then increased to 50.42/per 100,000 in 2014 and decreased slightly to 47.2/per 100,000 in 2016. In Malaysia, the fatality rate of food poisoning was approximately 0.041/per 100,000 population in 2016 (Ministry of Health [MOH], 2016). Malaysia's high incidence of food poisoning is partly attributed to its climate conditions

and typical Malaysian cuisine features. The hot and humid climate conditions in Malaysia and the combination of various raw ingredients in a typical Malaysian cuisine can enhance the likelihood of food contamination and spoilage, which often result in an increased incidence of food poisoning in Malaysia. Therefore, this study was designed to identify those factors that may play a specific role in contributing to food poisoning in Malaysia, especially in Pahang. To this end, the study team made the necessary arrangements for this cross-sectional study to be conducted simultaneously with routine surveillance of all the reported food poisoning incidents within Pahang from 2013 to 2018 because previous data provided by the Malaysian Ministry of Health (MOH) in 2014 had reported that incidence of food poisoning in Malaysia decreased in 2012 but increased slightly in 2013 (Abdul-Mutalib et al., 2015), which had also shown to increase mortality in Malaysia (Abdul-Mutalib et al., 2015).

Pahang is the largest state by area within Peninsular Malaysia, and its total land area is 35,965 km², with a total population of 1.68 million people (Department of Statistics Malaysia [DOSM], 2021); it consists of a total of 11 districts. In addition, it usually experiences two monsoon seasons per year. Therefore, certain low-lying areas within the Pahang state have frequently experienced flooding, which might result in water supplies and food ingredients contamination in these areas. This investigation aimed to verify each suspected outbreak's cause, determine

its magnitude identify possible causes, and implement necessary control and preventive measures. Thus, findings from this study can be utilised by stakeholders to introduce effective and/or novel interventions for mitigating the risk of food poisoning and for safeguarding consumer health by strengthening food control; as well as FBD surveillance systems (including those for food poisoning) to reduce the burden of food poisoning within Malaysia.

MATERIALS AND METHODS

Study Design and Population

It is a retrospective, observational, and quantitative study involving collecting all relevant data on the incidence of food poisoning within all the 11 districts of Pahang, including Bentong, Bera, Cameron Highlands, Jerantut, Kuantan, Lipis, Maran, Pekan, Raub, Rompin, and Temerloh. The source populations for this study provide all the reported cases of food poisoning outbreaks in Pahang from 2013 to 2018, which are based on data collected by the food poisoning outbreak report FWBD/KRM/BG 001 (2006 amendments).

Source of Data and Data Collection Method

This study applied passive case detection (PCD) and active case detection (ACD) to report food poisoning incidents in Pahang state via routine surveillance within all the 11 districts of Pahang from 2013 to 2018. For this study, a case of food poisoning is defined as persons within the state of Pahang who had presented with abdominal pain,

vomiting, and/or diarrhoea from 2013 to 2018 and who also consumed local food.

Typical laboratory-based surveillance is “passive”, in that detecting food poisoning incidents only relies on the laboratories to report them to public health authorities (WHO, 2008). However, more often, such passive surveillance for case detection may not be adequate; particularly when there is suspicion of the occurrence of food poisoning; hence, “active” surveillance is recommended for a pre-determined duration during an outbreak to supplement the findings obtained from passive surveillance alone (WHO, 2008). Under such circumstances, the food safety or public health authorities will regularly contact the laboratories to constantly seek updates about recent positive tests indicative of potential FBDs (WHO, 2008).

The same principles above shall apply to this study. While PCD represents typical routine surveillance that is “passive”, which relies totally on the sources of food poisoning incidents to report them to public health authorities, such reported cases likely comprise only a minority of the total number of people affected. Therefore, exploring the full extent of the problem is often recommended by conducting thorough surveillance of the population at risk of foodborne illness via an active search for additional cases using ACD. The appropriate methods for detecting any other unreported cases will usually depend on the overall distribution and scale of such an outbreak, which varies according to the circumstances of a particular outbreak. Many FBD

outbreaks will usually involve groups of people who can easily be identifiable (for example, all persons attending the same wedding party), making case-finding via ACD simple.

Each of these cases of food poisoning was initially identified during the first phase of case detection via PCD, conducted by Infectious Disease Control Unit (IDCU) in Pahang via its routine surveillance activities. The second phase of case detection, known as ACD, was undertaken by authorised healthcare personnel from the Food Safety Quality (FSQ) Unit when they conducted interviews to ensure that all cases of food poisoning had been duly identified.

Results of Microbiological Analysis

All the laboratory test methods were performed according to the established national methods of food hygiene analysis (WHO, 2008). Results on microbiology identification of reported food poisoning incidents in Pahang from 2013-2018 were obtained from the Food Microbiology Laboratory at FSQ in Mentakab, Pahang. The identification and isolation of *Vibrio parahaemolyticus*, *Salmonella* spp., *E. coli*, *Staphylococcus aureus*, and *Bacillus cereus* within these contaminated food samples were further analysed in conjunction with these food poisoning incidents to determine their association with such food poisoning outbreaks. This association can then be useful for assessing the roles of these food pathogens as potential causative factors for these outbreaks.

Data Analysis

Specifically, the total incidence rates of all confirmed food poisoning cases from 2013 to 2018 were described, and cases within each of the 11 districts of Pahang were spatially mapped. In addition, descriptive analyses were performed to determine the sociodemographic and temporal characteristics of food poisoning cases (such as the locations and premises in which these cases occurred and the period within a year during which these cases occurred) within the state of Pahang. Finally, a list of contributory factors of all these food poisoning cases was identified, and each frequency (to be expressed in percentages) was tabulated. All these descriptive statistics were performed using Microsoft Excel (version 2016).

Ethical Clearance

This study was registered in National Medical Research Register (NMRR), Malaysia, and the NMRR ID for this study is NMRR-19-2979-51363. The Medical Research and Ethics Committee (MREC), Ministry of Health Malaysia, has also given ethical approval for this study. Apart from making an adequate effort to ensure that this study collected no personal identifiers. The study would not jeopardise any individuals' rights and/or interests; the investigators were closely adhering to the institutional research guidelines (upon which this study approval was based) to maintain its scientific soundness and ethical conduct.

RESULTS AND DISCUSSION

Food Poisoning Incidents and Their Distribution

Present results showed that the number of reported cases fluctuated from 2013 until 2018, with an average of around 21 cases per year. No significant deterioration or improvement was seen over these years. However, a breakdown of the reported cases for each month of the year identified August as the month having the most such reported cases and May as the month having the fewest reported cases (Figure 1). It is interesting to note the high case in May of 2014 throughout the six years analysis.

Food poisoning occurred mostly during the third and fourth quarters of the year, with fewer reported cases occurring during the earlier part of the year (Table 1). It has probably arisen from the fact that the climatic conditions in Kuantan, the state capital of Pahang, are affected by the north-east monsoon wind, which initiates the monsoon season, which lasts for three months from November until January (Malaysian Meteorological Department [MetMalaysia], 2014), during which there is an unusually high level of rainfall. This heavy rainfall in Kuantan, which occurs during the monsoon season, tends to bring

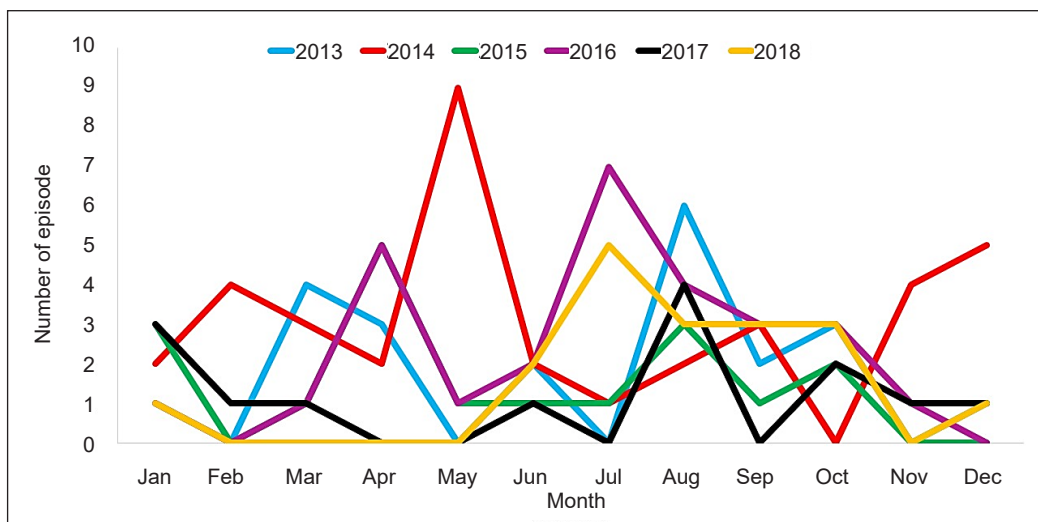


Figure 1. The trend of food poisoning episodes was reported every month in Pahang state from 2013 until 2018

Table 1

Food poisoning episodes that were reported in Pahang state from 2013 until 2018

Year	2013	2014	2015	2016	2017	2018
1 st	5	9	4	2	5	1
2 nd	5	4	7	8	1	2
3 rd	8	6	5	14	4	11
4 th	4	9	2	4	4	4

about flooding within the surrounding regions in Pahang; it could also increase the risk of both foodborne and waterborne diseases occurring in Pahang, including food poisoning.

Close examination of the geographical distribution of food poisoning (Figure 2) found that Kuantan, as the state capital had an exceptionally high number of food poisoning incidents with a total of 48 episodes over the past six years, while only one episode was reported in Kuala Lipis in 2016, with sporadic episodes in the other districts such as Pekan and Raub.

Alternatively, a district with a larger population like Temerloh had reported more episodes of food poisoning cases when compared to others, with a total of 13 episodes over the past six years. Likewise, Rompin had similar observations with a higher count of food poisoning cases than other districts with 22 episodes. In addition, the most common locations where food poisoning was reported to occur were public schools (Table 2), with the highest number of cases reported in the boarding school kitchen, followed by the school canteen, and only one reported in a local restaurant.

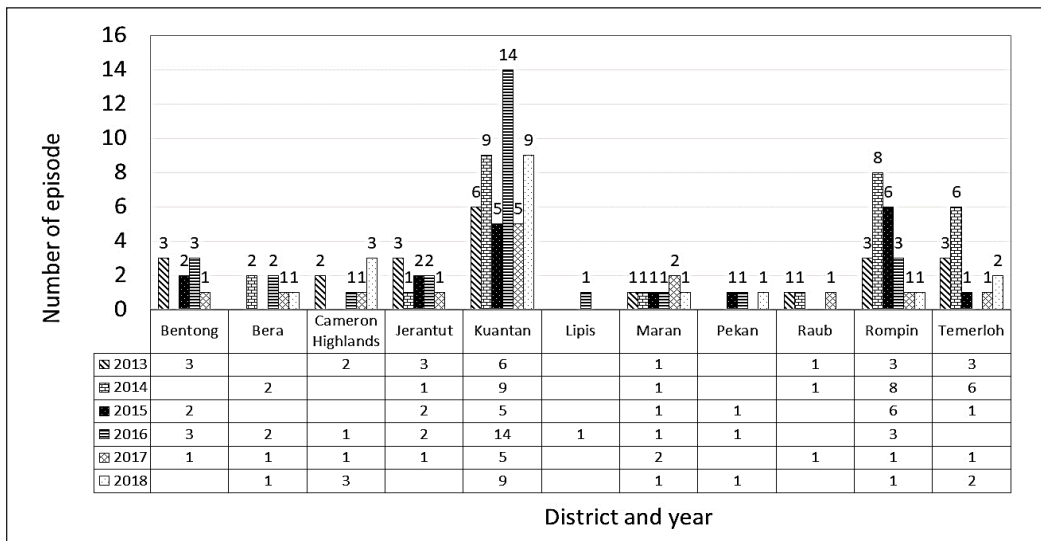


Figure 2. Food poisoning episodes that were reported in Pahang state districts from 2013 until 2018

Table 2
Food poisoning incidents that were reported in Pahang state, according to the facility, from 2013 until 2018

Facility	Year					
	2013	2014	2015	2016	2017	2018
Public schools	15	17	10	18	6	15
Facility for National Service Training Program	-	-	-	-	1	-
Facility for matriculation program and higher learning	1	2	-	1	1	1
Others	6	9	7	9	6	3
Total	22	28	17	28	14	19

Previous studies had reported that whenever food items are cooked before consumption, leftover from a previous meal, or left overnight; then additional food processing steps include prolonged storage of food and, if necessary, reheating before serving (Griffith & Worsfold, 1994); can potentially lead to outbreaks of bacterial FBD if appropriate food safety measures have not been taken (Bryan, 1988; Knabel, 1995; Pelczar Jr et al., 1993). Hence, this rationalises the occurrence of food poisoning outbreaks in the canteens of boarding schools. Potential factors are associated with a heightened risk of food poisoning outbreaks within a large-scale food preparation operation.

The following section provides a detailed review of the entire food preparation process, which starts from the procurement of raw materials and fresh produce and subsequent storage of these materials for cooking, which will then be followed by a careful delineation of factors that can potentially affect the level of food hygiene during the handling of raw materials and cooked food during the daily routines of cooking, transporting, and storing the cooked food.

Procurement and Storage of Raw Materials and Fresh Produce

For large-scale production of cooked foods, it is first necessary to purchase the raw materials for the foods in bulk. Once these raw materials for the bulk foods have been transported to the kitchens, it is necessary to store them at optimal temperature and

humidity conditions to prevent premature spoilage by ensuring that each type of food is kept at its ideal temperature and the proper light and moisture level. Raw meat and poultry are mostly supplied in a chilled or frozen state (to preserve their shelf-life) and are often regarded as high-risk food. If it becomes necessary to maintain such low temperatures throughout its handling time, then its transport time should be minimised, and an insulated cool bag should be used to carry and transport these food items around; to limit the growth of food spoilage bacteria (Griffith & Worsfold, 1994; Jay et al., 1999). Therefore, some of the food items being transported are likely exposed to the growth of pathogenic spoilage bacteria. At the same time, en route to the kitchen, which could potentially result in an incident of food poisoning. Therefore, as a precaution, all food handlers should take adequate measures to store and handle these food items hygienically upon transporting them to the kitchen to minimise the risk of contamination and prevent microbial overgrowth (Gorman et al., 2002; Griffith & Worsfold, 1994). Many studies conducted in the United Kingdom and Australia had indicated that consumers often failed to adhere to bacterial FBD prevention guidelines for ensuring food safety, such as storing high-risk food products at or below 4°C to prevent microbial overgrowth, storing raw and ready-to-eat food products separately to minimise the risk of cross-contamination, and following the correct food safety procedures when thawing frozen food items to keep out of the “danger zone”

of temperatures to prevent food pathogens from thriving (Jay et al., 1999). If any of these safe food-handling practices are not implemented, then it becomes possible for an outbreak of food poisoning to occur.

General and Personal Hygiene During Food Preparation

The WHO data indicate that most FBD episodes that occur throughout the world are attributed to a small number of factors related to food handling; and two of the common errors include allowing people with poor personal hygiene to handle the food and adopting unhygienic practices that can potentially result in cross-contamination (WHO, 2008). One common way for causing cross-contamination results in food poisoning within the food industry is poor hygiene levels when handling and processing food by the food service providers, especially the food handlers (Sani & Siow, 2014). Therefore, prevention of food poisoning always refers to the adherence to safe practices during the daily routines in preparing, handling, and storing food. Hence, as a scientific discipline, the scope of food safety shall draw its perspectives from a wide range of academic fields, including food chemistry, food microbiology, and food engineering. Furthermore, from farm to factory to plate, it is likely for these food products to be exposed to many health hazards at every step during their journey through the whole supply chain. Thus, it is advisable to carefully implement safe food handling procedures at every stage of the food production supply chain to curb the

spread of foodborne pathogens and prevent harm to consumers.

Most epidemiological data indicate that cross-contamination during food preparation and transport can result in FBDs (Forsythe & Hayes, 1998). Therefore, the manipulators (WHO, 2022) and the food will have to be carefully monitored at every step of handling, preparing, and transporting food (Gilling et al., 2001) to ensure that food remains microbiologically safe. There are several sources of microbial contamination, which are commonly identified as (a) unhygienic practices in handling food; (b) raw materials for cooking food and raw meat; (c) failure to implement adequate cleaning of the machines and equipment used to cut the food, and of those contact surfaces used to prepare the food (including the food handlers' and food manipulators' clothes and hands); and (d) airborne contamination (de Sousa, 2008). It underscores the high importance of a satisfactory level of hygiene to be observed by food manipulators during food preparation.

Handling of Cooked and Leftover Food

WHO data also indicate that two of the common errors include (a) preparation of food several hours before consumption and storing of cooked food at temperatures that favour overgrowth of food microbes and/or formation of their toxins; and (b) failure to allow sufficient cooking or reheating of food. Since food safety is a systematic approach to food hygiene that shoulders a responsibility that addresses every aspect of the global food industry, it is thus an important aspect

of public health linked to agriculture and other food production sectors (Schlundt, 2002). Several factors mainly lead to an outbreak of food poisoning, including (a) inadequate food manipulation to maintain high hygiene levels and prevent cross-contamination; (b) inappropriate holding temperatures (failure to refrigerate food at a sufficiently low temperature); (c) inadequate cooking and/or reheating; (d) contaminated equipment for food preparation and storage (the omission of cleaning and disinfecting kitchen or processing plant equipment); and (e) poor personal hygiene. Other factors that may contribute to the occurrence of food-borne illness include: (f) preparing food a day or more in advance before serving along with unsafe procedures for holding and reheating; (g) cross-contamination (from raw to cooked products); and (h) inadvertently introducing contaminated ingredients to cooked food. After foods have been contaminated, the main factor which greatly contributes to the occurrence of food poisoning outbreaks is allowing them to remain at a temperature that promotes the growth of the potentially hazardous microorganisms or their toxin production in the food (de Sousa, 2008). It highlights the significance of properly handling cooked and leftover food on the kitchen premises.

It is noteworthy to mention several important considerations from the perspective of a large-scale operation for food preparation. Apart from the usual hygienic practices that all food handlers must adopt, they should also be aware of the importance of safe storage of cooked food

and leftover food, especially concerning its temperature and humidity conditions. Food handlers must remember that improper food storage may pose a health hazard to consumers. Furthermore, they will also need to understand the effect of optimal temperature for cooking and storing foods which can potentially influence bacterial growth. It underscores the importance of providing adequate training for food handlers in all aspects of safe handling of cooked and leftover food, such as storage and reheating. Previous studies reported that training for food handlers might improve their knowledge, practice, and hygiene awareness in food safety (Thompson et al., 2005) because it was reported that improving food safety knowledge through training positively affected food handling practices (Medeiros et al., 2011).

However, such training may not always bring about a positive change in food handling behaviour (Clayton et al., 2002; Seaman & Eves, 2006). One plausible explanation for this is provided by Clayton et al. (2002), who pointed out that food handlers may understand the need to conduct certain practices, but it would be too difficult, if not impossible, to implement them without having adequate resources. A recent study conducted in the food courts at Putrajaya revealed many issues about the food safety knowledge, attitude, and practices (KAP) of food handlers and the level of cleanliness of food courts in Putrajaya. This study's results showed that a mean score of 84.1% and 91.4% for food handlers' knowledge and attitudes levels

can be regarded as “high”. However, a mean score of 79.5% for both knowledge and attitude would not necessarily be able to turn into safe practices (Siau et al., 2015).

This finding concurred with those from a previous study conducted in a school food service, and it was established that although the food safety knowledge was high, the safe food handling procedures were still not being implemented during food preparation (Henroid Jr & Sneed, 2004). It is apparent that although food handlers have an adequate mastery of knowledge on food safety, the lack of physical facilities and/or resources might be an obstacle to implementing proper food safety practices. Thus, when implementing safe food handling procedures, there is a need to ensure appropriate physical facilities and adequate resources are available to these food handlers.

Identified Food Pathogens and Their Associated Vehicles

Foodborne microbes cause a major problem of adversely affecting food safety and cause human infections after consuming animal products contaminated with microorganisms or their toxins (Heredia & Garcia, 2018). Previous studies had reported that Gram-negative bacteria accounted for approximately 69% of the cases of bacterial food-borne disease (Kebede et al., 2014). Although a total of 31 pathogens were identified as causing FBDs (Zhao et al., 2014), the more common causes of food-borne diseases and their related deaths in the world are mainly reported to be attributed to bacterial pathogens including *S. aureus*,

Salmonella spp., *Campylobacter* spp., *L. monocytogenes*, and *E. coli* (Assefa & Bihon, 2018; Bantawa et al., 2018; Elmonir et al., 2018; Hemalata & Virupakshaiah, 2016; Zhao et al., 2014).

Many previous studies suggested that emphasising preventative food safety could contribute significantly to reducing the occurrence of food poisoning outbreaks (Osimani et al., 2011). Such an emphasis on the adoption of appropriate hygienic practices was based on published evidence of food safety, and these are documented in various aspects of food hygiene, such as on ready-to-eat meals, as well as on knowledge and attitudes on the implementation of effective hygiene intervention strategies (Buccheri et al., 2010). Thus, adequate measures should consistently be taken throughout food preparation to adopt a satisfactory level of hygienic practices to implement preventative food safety.

Among the suspected causative agents of food poisoning for the year 2018, *B. cereus* was one of the most frequently identified microbial pathogens, which had been reported to be linked to 8 cases of food poisoning (Table 3).

Table 3
Frequency for isolation of the identified microbial pathogen from food poisoning incidents in Pahang in 2018

Food pathogen	Frequency of cases of food poisoning (n) (%)
<i>Bacillus cereus</i>	8 (88.8%)
<i>Staphylococcus aureus</i>	6 (66.6%)
<i>Salmonella</i> spp.	5 (55.5%)
<i>Vibrio parahaemolyticus</i>	2 (22.2%)

It is already well-known that infection by *B. cereus* during food poisoning can cause either diarrhoea syndrome or emesis syndrome because it produces two types of toxins: emetic (vomiting) and diarrhoeal, which can result in two types of illnesses, which probably explains its particularly high incidence of food poisoning cases. In addition, another six cases of *S. aureus* infection were reported, followed by five cases of *Salmonella* spp. infection and two cases of food poisoning caused by *V. parahaemolyticus* were detected in 2018. Present findings agree with Su et al. (2005). They further reiterated that the trends of indigenous FBD within the Asian area had shown that the most important foodborne pathogens are *V. parahaemolyticus*, *S. aureus*, and *Salmonella* spp. based on their association with a high disease burden (Su et al., 2005).

Although *B. cereus* is not usually regarded as a common food pathogen that is isolated from food poisoning incidents, however, *B. cereus* food poisoning often results from its thermophilic endospore, which enables it to survive in cold temperatures and doubles its population within a short period of times depending on the food product (Kotiranta et al., 2000). Therefore, it is necessary to either avoid consuming any contaminated food, which contains large numbers of bacterial cells and/or spores of *B. cereus* or avoids consuming food contaminated with the pre-formed toxin of *B. cereus* by implementing proper procedures for food handling/storage and cooling of cooked food (Schneider et al.,

2004). Furthermore, for both the diarrhoeal and emetic types of *B. cereus* food poisoning, the food involved has usually been pre-treated by heat; hence, the heat-resistant spores or thermophilic endospores are the sources of food poisoning (Granum & Lund, 1997). Therefore, it again highlights the high significance of properly handling all cooked and leftover food.

Based on the perspectives of the operation for large-scale food production within premises such as boarding school kitchens or school canteens, the food can be served by these establishments to be contaminated with foodborne pathogens, which are the leading cause of acute diarrhoea, an initial presenting symptom of food poisoning. In a large-scale food preparation premise such as a boarding school kitchen or school canteen, the pathogen—food category pairs identified to be responsible for most single-pathogen food poisoning outbreaks will depend on the type of food being cooked and served. The main reason for this dependency is the eating habit. In Malaysia, the staple food for a typical daily diet will mostly consist of rice; hence this staple food which typically consists of rice and bean products is often identified as the main vehicle of *B. cereus* (Liu et al., 2017). Hence, it is likely that the contaminated rice serves as a vehicle for the transmission of *B. cereus* food poisoning in Malaysia. It also probably explains why *B. cereus* was one of the most identified microbial pathogens among all the suspected causative agents of food poisoning within Pahang, Malaysia, for the year 2018.

Other Contributory Factors to Food Poisoning Outbreaks

In Malaysia, the Malaysia Standard 1514:2001 is coded as the standard for users to define all the essential principles of food hygiene that apply to the whole supply chain, including the entire processing step, which begins from primary production to completion, where the finished product will be served to the final consumer (Talib & Ali, 2009). Since it will also guide different sectors of the food chain processes or commodities to amplify and further tailor each of these hygiene requirements to these sectors, therefore the main purpose of this standard is to serve as a benchmark for all the food handlers to adhere to it for ensuring that food is safe for human consumption (Talib & Ali, 2009).

According to Talib and Ali (2009), some of the hygiene principles covered include (a) environmental hygiene of primary production; (b) design of establishment and facilities; (c) control of operations; (d) maintenance and cleaning of the

establishment (including pest control); (e) personal hygiene; (f) transportation; (g) labelling and lot identification of product information; and (h) training and supervision. Therefore, any breaches in the eight hygiene principles (as listed above) are likely to contribute to a food poisoning outbreak. Table 4 illustrates all the contributing factors to food poisoning outbreaks in Pahang from 2013 until 2018.

It shows that a lack of pest control is a major contributing factor with a high frequency of 18.64%, followed by cross-contamination and inadequate food manufacturing process control as a secondary contributing factor, each with a frequency of 13.56%. As alluded to earlier, the total number of food poisoning incidents that occurred in the boarding schools was much higher than that in non-boarding schools, and since the communal kitchens in these boarding schools were designed to store large amounts of raw materials for cooking (since the cooks were cooking in large quantities in these communal kitchens

Table 4
Eleven food poisoning-causing factors

Contributing factor	Percentage (%)
Lack of pest infestation control	18.64
Cross-contamination during food preparation	13.56
Inadequate control of the food manufacturing process	13.56
Poor maintenance of equipment or building	11.3
Contamination by food handlers	10.17
Lack of cleaning program	8.47
Lack of hand washing facility	7.91
Various uncontrolled factors	7.91
Lack of proper storage	6.78
Contamination with chemicals	1.13
Lack of vehicle suitable for foods	0.56

when they prepare meals for a large number of boarding school residents at any one time); there is a tendency for the problem of pest infestation to crop up.

It is a common problem in the storage of raw materials for food because contamination of such raw materials during storage can often occur as a result of pest infestation and/or failure to keep them in wrapped or closed containers (Wisner & Adams, 2002), which explains why the practice of effective pest control for the storage of these raw materials is regarded with high importance. In this regard, the Food Hygiene Regulations 2009 contains several provisions which can be highly relevant for ensuring a high level of hygiene and sanitation in the food industry, promoting hygienic practices among food handlers, and maintaining a satisfactory standard of cleanliness within the food premise (Ismail, 2011), which included any premises used for or concerned with preparing and handling all types of foods; including their relabelling, reprocessing or reconditioning (Food Act 1983, 2012). These provisions can be very useful for instituting adequate pest control within institutions where large-scale food preparation is undertaken.

Likewise, many studies had already pinpointed the fact that many types of food pathogens might be transferred to the food items by cross-contamination through hands, surfaces, utensils, and other equipment that was not adequately cleaned and disinfected during the process for the preparation of different types of food, or between the different steps during

the preparation of the same type of food (Roberts, 1990; Scott & Bloomfield, 1990); which would partially rationalise the finding that cross-contamination was identified to be a secondary contributing factor towards such food poisoning outbreaks in Pahang. Such a finding concurred with what was reported by many studies that cross-contamination can easily occur during processing, preparation, delivery, and service steps (Carrasco et al., 2012). In addition, previous studies reported that food handlers who failed to implement appropriate food handling practices often contributed to outbreaks of FBD in the food industry (Bryan, 1988).

In addition, the European Food Safety Authority (EFSA) and the European Centre for Disease Prevention (ECDC) stated that food handlers are one of the two common contributory factors of FBDs, including food poisoning (European Food Safety Authority [EFSA] & European Centre for Disease Prevention and Control [ECDC], 2015). EFSA and ECDC (2015)'s scientific report shows that food handlers infected with food-borne disease pathogens had contributed to 7.3% of reported food-borne disease outbreaks. Furthermore, the report also stated that food handlers mishandling food (whether raw or cooked) concerning their storage temperatures had also contributed to 3.9% of reported FBD outbreaks. Cross-contamination from inappropriate and unhygienic food handler practices contributed to 3.2% of reported FBD outbreaks in 2014 (EFSA & ECDC, 2015).

In the third place, contributing factor to food poisoning outbreaks in Pahang was inadequate food manufacturing process control. The Malaysian Food Safety and Quality Division Annual Report 2012 states that “the measures for food safety assurance were developed, implemented, and monitored to further improve food safety by reducing food contamination and the occurrence of food poisoning”. As such, many training programs and teaching activities related to the institution of food safety assurance were launched to train and impart the importance of food safety to all these employees working on food premises (Food Safety and Quality Division [FSQD], 2012). Examples of steps taken by food handlers to maintain food safety include the need to maintain good personal hygiene, to be aware of crucial aspects of food safety which link to temperature values with cooking temperature necessary for the control of microbiological hazards to limit the microbial overgrowth, and to take proactive steps to minimise any possible adverse effect of temperature during cooking of foods which can promote bacterial growth in food. All these are directly related to the adequacy of instituting control measures during food preparation. In a large-scale commercial food production where food is prepared in large quantities, especially within an institution such as the boarding school kitchen or school canteen; the food handlers might often be the agent or vector in spreading viruses if they fail to observe or adhere to any of the appropriate food safety and good food handling practices (Seaman & Eves, 2010).

Moreover, it can often happen during the short period to prepare dishes from raw foods; because food handlers might have forgotten to follow good food handling practices when they leave dish uncovered for an excessively long time or fail to clean their hands between handling raw and cooked foods (Toh & Birchenough, 2000). Indeed, previous research findings had also reported that a lack of awareness of the importance of temperature control was the main critical control point in the food preparation process, which could often hinder the successful implementation of an effective food safety program (Siau et al., 2015).

CONCLUSION

The findings from this study have provided an overview of the total number of food poisoning incidents that had occurred within Pahang over this 6-year period, which had greatly escalated during the period from September to November each year; and also identified *B. cereus* and *S. aureus* to be the two most common agents who were implicated in food poisoning cases within the Pahang state. These findings shall enable us to pay attention to particular months during the year when there will be a higher probability of food poisoning incidents. In addition, inadequate measures were taken for pest control and the heightened risk of cross-contamination during food handling (which includes transport and delivery of both raw materials and cooked food), as well as inadequate control of the food manufacturing process (including

adequate temperature control and proper storage conditions) were identified as critical factors with a major contribution towards such food poisoning outbreaks in Pahang. Finally, better quality research shall also be conducted in the future by using a more rigorous survey methodology to elicit a more thorough understanding of the potential causes of these food poisoning outbreaks and then to heighten the overall level of awareness by alerting the relevant authorities to focus their efforts in mobilising greater quantity of resources for mitigating this problem.

ACKNOWLEDGEMENTS

The authors want to extend their gratitude to the Director-General of Health, Malaysia, for permission to publish this article.

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