

From pathogen to practice: A multi-theoretical review of foodborne diseases and consumer behavior in Malaysia

^{1,*}Genevie, E.R. and ²Ungku Fatimah, U.Z.A.

¹Sarawak Matriculation College, 93050 Kuching, Sarawak, Malaysia

²Department of Food Service and Management, Faculty of Food Science and Technology, Universiti Putra Malaysia, 43400, Serdang, Selangor, Malaysia

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Abstract

Some of the notable foodborne disease (FBD) outbreaks caused by poor hygiene include those caused by *Vibrio cholerae*, *Salmonella* Typhi, *Bacillus cereus* and hepatitis A virus. Although consumers are generally knowledgeable about personal hygiene and food safety, there are vital areas that need improvement in regard to the proper reheating of food, thawing, temperature control and prevention of cross-contamination. As a result, the implementation of risk-reduction measures is either delayed or absent, which poses a threat of foodborne diseases. Behavioral theories such as the Health Belief Model and Protection Motivation Theory show that perceived barriers and self-efficacy significantly affect the intention to adopt safe food handling. Research shows that consumers' food safety behaviors are mediated by demographic factors such as gender and education. There is a gap between the level of knowledge and behavior among consumers toward food safety, which calls for more studies to address the attitudes and practices of people. Food safety education at an early age and the use of a trusted certification program will further lower the cases of FBDs, thus improving public health in Malaysia.

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1. Introduction

Food contamination can occur at any stage in a food supply chain system due to chemical, physical or microbiological hazards. Among these hazards, the microbiological hazard is a significant FBD contributor which includes microorganisms such as bacteria, viruses, yeasts and molds. The microorganisms can be found everywhere and can be a source of contamination a system which is of public health concern globally.

The outbreak of cholera due to infection of *Vibrio cholerae* was once reported across almost all regions in Malaysia. In early 1990, 109 cases were reported with 85 carriers and one death in Tumpat, Kelantan, while in 1996, 476 cases were reported in Penang (Isa *et al.*, 1990; World Health Organization, 1996). In another epidemic, *Vibrio cholerae* El Tor from Ogawa serotype was identified as the culprit, which led to isolation of 21 local Kelantanese and 12 workers from Thailand between November and December 2009 (Ang *et al.*, 2010). The transmission took place as a consequence of poor hygiene practices among food vendors and the habit to consuming raw food, such as freshwater clams and leafy vegetables.

The *Vibrio cholerae* El Tor also caused cholera outbreak that took place in Terengganu, which contributed to 187 cases and 1 death (Teh *et al.*, 2012). Unhygienic premises, poor water sanitation, and improper personal hygiene had contributed to the cholera outbreak in Tanjung Keling, Melaka and Bintulu, Sarawak (Ujang *et al.*, 2011; Bilung *et al.*, 2014). Washing hands after bathroom visit is of utmost important practice due to the presence of *Escherichia coli* as the indicator of fecal contamination was noted at three villages affected by cholera in Beluran, Sabah. Food is at risk of being contaminated by pathogens if handled with unhygienic hands (Zin *et al.*, 2015).

Consuming food that has been prepared in an unhygienic manner may lead to amoebiasis. A decade of retrospective study carried out by the University Hospital located in Kuala Lumpur discovered that 59% out of 51 amoebiasis cases were diagnosed with amoebic dysentery. Most patients (83%) with amoebic dysentery suffered from diarrhea or dysentery, and followed by abdominal pain (Jamaiah and Shekhar, 1999). The pathogens commonly associated with dysentery are *Shigella*, *Campylobacter*, *Salmonella* spp., and

*Corresponding author.

Email: genevieleonor@gmail.com

Escherichia coli. A dysentery case reported in Saratok, Sarawak was due to *Shewanella putrefaciens* after consuming contaminated freshwater red tilapia fish (Jeffery, 2014). Meanwhile, in Kuala Lumpur, a patient who experienced abdominal pain and passed out stool mixed with fresh blood was diagnosed with acute dysentery due to consumption of contaminated sushi. This was particularly caused by *Anisakis* parasites that are abundantly found in raw or undercooked food (Amir *et al.*, 2016).

An incidence of food poisoning was reported at a primary school situated in Kapar, while another case in Bangi, Selangor after consuming contaminated food from the school canteen. The laboratory results revealed that the unhygienic canteen food handler was a carrier of *Staphylococcus aureus* and became the suspect as the source of the outbreak (Rampal, 1983; Baharudin and Mohd Ishak, 2017). The hygiene of food vendor was also accentuated when *S. aureus* was detected in cooked food samples at street food vending in Kota Kinabalu, Sabah (Chye and Lim, 2002). Another pathogen that had been identified to cause food poisoning was *Vibrio parahaemolyticus*, which caused an outbreak in Bangi and Sabak Bernam, Selangor, as well as another case in Kuala Lumpur between July and September 2010 (Rahayu *et al.*, 2011). Water contaminated by *Escherichia coli*, improper food handling, and poor personal hygiene practiced by food handlers were identified as the causes of food poisoning cases at boarding schools located in Samarahan, Sarawak and Teluk Keke (Liza *et al.*, 2015). Cases of food poisoning due to *Bacillus cereus* are rather rare in Malaysia. The first *Bacillus cereus* food poisoning outbreak was reported in 1984 involving 114 students from a religious secondary school located in Klang, Selangor with abdominal cramp, nausea, and vomiting symptoms. The bacteriological assessment revealed that the students were infected by *B. cereus* from contaminated fried noodles prepared at the hostel, primarily as a result of frequent transfer from unhygienic container to another (Rampal *et al.*, 1984).

On 15th February 2012, another food poisoning outbreak was reported to involve a primary school situated in Sabah, stemming from turmeric rice (nasi kuning) prepared by the school canteen. The affected students experienced several common symptoms, namely vomiting, abdominal pain, headache, and diarrhea. The bacteriological assessment indicated *B. cereus* isolated abundantly from the serving table, the towel used by food handler, and the tank that served as water source in preparing the contaminated turmeric rice. Here, the food poisoning case was caused by cross-contamination, apart from other risk factors including rice cooked below 20 minutes, unhygienic kitchen, and dirty clothes worn by

the food handlers, all failing to comply with the procedures (Jeffrey and Mihat, 2016). The *B. cereus* was also identified as among the pathogens that contaminated unwashed eggs used to make lace pancakes (roti jala), which were transferred from the hands of food handler and caused food poisoning at a secondary school in Tapah, Perak (New Straits Times, 2016).

The *B. cereus* is a pathogen linked with food poisoning outbreak in Malaysia mainly due to improper food handling. This pathogen has been prevalent in local cooked and raw rice samples collected from Selangor and Sarawak (Sandra *et al.*, 2012; Bilung *et al.*, 2016).

A hepatitis A outbreak was reported at Mukim Hulu Langat, Selangor in 2002 stemming from poor sanitation. A total of 51 patients diagnosed were among Malays and the Orang Asli residents with mostly school children because this age group does not have the immunity to hepatitis A virus (Venugopalan *et al.*, 2004; Raihan, 2016). Another case reported in 2012 involved 78 residents from Manjung, Perak was due to unhygienic toddy processing premises, in addition to the pH of toddy that is suitable for the growth of hepatitis A virus (Yusoff *et al.*, 2015).

Poor personal hygiene while handling food had contributed to typhoid fever, especially among children who are vulnerable to *Salmonella* Typhi (Merican, 1997; Yap and Puthuchery, 1998; Baddam *et al.*, 2012; Chua *et al.*, 2015). The highest number of typhoid cases had been reported in Kelantan. A total of 137 cases in 1988 and 102 cases between October 1993 and August 1998 were admitted to Hospital Universiti Sains Malaysia, while 855 cases were referred to Kota Bharu District Health Department from year 2001 until June 2005 (Malik and Malik, 2001; Safian *et al.*, 2008). Besides, 14 cases of relapse typhoid fever were admitted to Hospital Universiti Sains Malaysia during the outbreak in 2005 after complaining symptoms of fever, diarrhea, headache, abdominal pain, and constipation (Zakuan *et al.*, 2010). The Kelantan State Public Health Department registry had recorded about 1394 typhoid cases admitted to hospitals across Kelantan between 2004 and 2009 (Ja'afar *et al.*, 2013).

2. Food safety knowledge, attitude and practices (KAP)

Many studies regarding food safety have looked into food safety KAP amidst certain groups involved in food handling. These KAP studies had been mostly based on what the participants know, feel, and how frequent they adhere to basic food safety, inclusive of the concepts of cleanliness, separating food types, as well as cook and chill temperatures (Lum *et al.*, 2013; Dong, 2015). Additionally, studies have also probed into consumers from other countries on aspects of food safety.

2.1 Food safety knowledge

In light of safe food handling, consumers have displayed rather good knowledge level. Several studies have pointed out that consumers had a high level of knowledge about hygiene, particularly personal hygiene (Alrabadi *et al.*, 2013; Farahat *et al.*, 2015; Tabrizi *et al.*, 2017). Most consumers are aware about the importance of washing hands to avoid spreading microorganisms to food. However, consumers are still at high risk in contributing to food contamination. Gong *et al.* (2016) asserted that consumers still lack awareness regarding personal hygiene due to negligence towards food preparation when they are infected by diarrhea or fever.

Consumers also lack knowledge about reheating leftover food (Worsley *et al.*, 2013). The heating process must be carried out to kill microorganisms, thus preventing food contamination. Akonor and Akonor (2013) reported that consumers have good knowledge about temperature abuse and the cause of food poisoning due to use of canned food packaging stemming from tin and iron solubility. In order to slow the proliferation of microorganisms, canned food should be stored in the refrigerator at a temperature below 5°C. However, their study found that consumers did not sufficient knowledge about foodborne pathogens. Most of them were only familiar with *Salmonella*, but seemed to be uninformed about *E. coli*. The outcomes are in line with those reported by Gkana and Nychas (2017), whereby consumers disagreed that microorganisms found in foods are harmful, hence the use of sensory assessment to detect food contamination.

The growth of microorganisms is related to temperature control. In light of controlling food poisoning, Tomaszewska *et al.* (2017) found that consumers knew that storing food in the refrigerator can hamper the growth of microorganisms. However, past studies showed that consumers failed to identify the optimum cooking and cooling temperatures (Alrabadi *et al.*, 2013; Burke *et al.*, 2016). Failure to identify optimum temperature stems from lack of consumer knowledge on the use of thermometer when cooking or storing food in the refrigerator (Hassan *et al.*, 2018).

Consumers have been reported to have limited knowledge about the proper way of thawing. Only a handful of consumers know that putting food in places exposed at room temperature, for example on a cutting board, is an unsafe thawing method. In fact, thawing can be done in a refrigerator, microwave oven or even placing the food in a sealed package before soaking it in cold water (Moreb *et al.*, 2017). Most of the consumers did not know about the proper thawing method by placing the frozen meat or poultry on the lower shelf of the refrigerator (Naeem *et al.*, 2018).

2.2 Food safety attitude

A positive attitude reflects that a consumer understands the importance of food safety and complies with it. As awareness about the spread of microorganisms that can occur via contact, consumers need to hinder cross-contamination. Regarding this matter, consumers were reported to have a good attitude in food safety, such as not leaving cooked food for more than two hours at room temperature, washing eggs before using them, and separating cooked food from raw food (Talas *et al.*, 2010). Whiley *et al.* (2017) discovered that consumers displayed negative attitude linked with handling eggs. Although they did not consume raw egg, they had the tendency to perform risky behavior by licking utensils that contain raw egg. This is due to the perception that it is not harmful, hence such hygienic matter gets underestimated.

In preventing cross-contamination, consumers also believed that wearing proper attire, such as apron and gloves, could minimize the risk of food contamination (Talaie *et al.*, 2015). Such practice assures food hygiene, as the microorganisms cannot be transferred directly to the food. Robinson *et al.* (2016) confirmed that the number of bacteria transferred can be greatly reduced when using gloves during food slicing, when compared to using one's bare hand. On the contrary, Odeyemi *et al.* (2018) found that consumers did not like using apron. Consumers should realize that the use of apron ascertains hygiene, which should be taken into account when handling food.

Although consumers tend to have a positive attitude regarding hygiene, Naeem *et al.* (2018) found the opposite attitude in light of hand hygiene and also the perception that wearing jewelry did not give any harmful effect while handling food. There was also the possibility of consumers having less positive attitude due to lack of knowledge on food safety (Vlasin-Marty *et al.*, 2016). For example, despite being aware on the importance of the refrigerator for proper food storage, some consumers were unaware of the optimum temperature and had never checked the temperature of their refrigerator at home (Evans and Redmond, 2016).

2.3 Food safety practices

Food safety practices should be taken seriously by consumers while handling food. Some studies have reported several inappropriate practices performed by consumers when preparing food, such as using the same cutting board for raw and cooked foods, using a cutting board made of wood, and thawing frozen food at room temperature (Langiano *et al.*, 2012; Parra *et al.*, 2014). Gkana and Nychas (2017) found that consumers preferred thawing food in refrigerated conditions, which is a good practice to prevent cross contamination and to

hamper the growth of microorganisms. Another good practiced is ensuring that the food preparation area is always kept clean (Odeyemi *et al.*, 2018).

The use of thermometer while cooking is among the least practices adopted by consumers because most of them reported that visual observation was more convenient (Murray *et al.*, 2017). Other methods that have always been practiced to determine if the food is cooked are, tasting the food and using a fork to prick the food. Consumers also did not set their refrigerator temperature at 4°C and below, as recommended, as this condition could cause the food to turn bad rapidly. However, consumers have always maintained the hygiene of their food preparation areas, such as kitchen and sink by using sponges and cleaning agents (Jevnik *et al.*, 2013).

Rabbi and Dey (2013) found that consumers had good knowledge on hand hygiene. However, washing hands with soap before eating and after visiting the bathroom were the least practiced by them. Washing hands before feeding their babies was also an uncommon practice for the consumers, which require plenty of improvement for better hygiene practice. On the contrary, the findings by Agustina *et al.* (2013) indicated that certain hygienic practices, such as washing hands, cleaning utensils, and food holding time, had insignificant link with diarrhea, except for groups of children below 2 years old.

A study by Samina *et al.* (2017) also found the gap between food safety knowledge and practices. Despite scoring high for food safety knowledge, some consumers did otherwise in practice. For example, 88% of consumers acknowledged that hands must be washed after touching body parts, but only 54% who actually practiced that. Some aspects of food safety were low in score, thus displaying poor knowledge and practice. As for wearing the apron, only 30% of the consumers knew about its importance, but none actually wore any while handling food.

3. KAP of food safety among consumers in Malaysia

Past studies reported that educated and informed consumers were better at food handling as they handled cooked or to be eaten raw food properly, prepared food in clean and sanitized environment or equipment, washed hands, and ensured clean food is served (Seward, 2003). However, consumers with a different background may respond differently to food safety. The KAP of consumers dictate preparation of food daily at home without undergoing any training (Nesbitt *et al.*, 2014).

3.1 Food safety knowledge among Malaysian consumers

Overall, consumers seem to have good knowledge about food hygiene, despite several shortcomings in some aspects. Although consumers may be

knowledgeable about hand hygiene, they lack awareness on the causes of and measures to prevent FBDs (Norazmir *et al.*, 2012).

As for the knowledge on preventing FBDs, consumers were found to be less knowledgeable about the frequency of cleaning the sink and washing food (e.g., fruits) correctly under flowing water. Consumers also tend to wrongly consider that high body temperature as part of FBD symptoms (Low *et al.*, 2016).

Nonetheless, all past findings tend to contradict the study results. The study by Lim *et al.* (2016) claimed that consumers lacked knowledge about personal and utensils hygiene as most respondents had low score about the proper way to wash hands in the attempt of preventing FBDs.

3.2 Food safety attitude among Malaysian consumers

The attitude of consumers is related to knowledge about food safety. Knowledge about cross-contamination and risky source of food could lead to positive food safety attitude among consumers. Consumers with a positive attitude are bound to have the initiative to improve their knowledge regarding food safety without undue reliance on authority alone (Abd Patah *et al.*, 2009).

Lim *et al.* (2016) demonstrated that consumers had negative attitude towards the use of cutting boards, washing knives, and storage of cooked food. The study revealed that most of the consumers placed their food on the floor as they could not afford a dining table. Such practice escalates the risk of food contamination.

A study by Foong *et al.* (2018) showed that consumers were concerned about the outbreak of FBD, which promoted safe food handling. Consumers were likely to try out new recipes with a variety of cooking methods to share their food with friends and family members (Chang and Wong, 2015). Hence, safe food handling should be practiced to prevent cases of food poisoning. This attitude minimizes the risk of food poisoning as the food gets prepared by the consumers at home. Nonetheless, safe food handling should be emphasized as slight negligence may cause food poisoning and this may turn worse as it involves food sharing.

3.3 Food safety practices among Malaysian consumers

Prior studies found that consumers often performed safety practices when handling food. They always ensured the hygiene of their hands before handling food and the cleanliness of a place before eating (Norazmir *et al.*, 2012; Foong *et al.*, 2018). Such practices can maintain food hygiene, while reducing the risk of exposure to pollutants from unclean environment. Nevertheless, some personal hygiene aspects may be

neglected. Exposing hands bandaged or injured without using gloves when handling food is the most common risky practices performed by consumers (Foong *et al.*, 2018).

Some consumers tend to omit good practices when handling food. Norazmir *et al.* (2012) claimed that some would consume raw or uncooked eggs and any food originating from raw eggs. This practice is rather risky because raw eggs can be highly contaminated with pathogens, especially *Salmonella* (Nyabundi *et al.*, 2017). Sánchez *et al.* (2019) suggested that eggs should be cooked at a temperature above 100°C and stored in the refrigerator to hamper the growth of *Staphylococcus*.

Good practice starts at home. Therefore, parents should display proper food safety practices that can be emulated by their children. Awang Teh *et al.* (2016) had proven that food safety practices among children are greatly affected by their parents. Young consumers tend to suffer more from FBD due to consumption of contaminated food in canteen or cafeteria prepared by unhygienic food handling methods. Despite having knowledge about food safety, this group of young consumers failed in displaying positive attitude in light of personal hygiene and temperature control. Lack of monitoring causes them to ignore those aspects despite the fact that they are well aware of its importance. Parents being the closest persons to them should be an effective model in food safety awareness, apart from gaining exposure from the mass media, such as advertisement on the proper way of washing hands (Abd Patah *et al.*, 2009; Nor Faradillah *et al.*, 2014; Awang Teh *et al.*, 2016).

Making hygiene a priority in food selection is another positive attitude displayed by young consumers. They should prefer making choices based on brands and manufacturers, mainly products certified with Food Safety Certificate, such as Hazard Analysis Critical Control Point (HACCP) and Halal. Such positive attitude creates trust on food safety among consumers, thus the preference to prepare food at home and enjoy it with family or friends without having doubts about its hygiene (Mohd Nawi and Mohd Nasir, 2014; Chang and Wong, 2015; Foong *et al.*, 2018).

Although food safety knowledge among young consumers appears to be good, they frequently misinterpret high body temperature as a common symptom of FBD and were clueless that *Salmonella* could cause food poisoning. Upon making comparison, those who had experienced food poisoning and those from the science stream were more vigilant about food safety (Norazmir *et al.*, 2012; Low *et al.*, 2016). Lim *et al.* (2016) used the model of food safety knowledge, attitude, and behavior to assess elderly consumers. The

study concluded that the consumers' attitude regarding the usage of cutting boards, knife washing, and food storage has a positive impact on the frequency of applying good practices when handling food. Despite having good knowledge in hand and kitchen utensils hygiene, they failed to translate it as their behavior (Lim *et al.*, 2016).

As an initiative to raise awareness among students, several measures have been implemented, including the launch of e-Community Food Safety Interactive Sites Club portal, food safety campaign such as "Healthy Lifestyle Campaign", enriching the Health Education curriculum, and rampant surveillance of the authorities. Social media as agents of dissemination of information are also encouraged to promote food safety. Dissemination of information via social media is more systematic, relevant, and valuable, which may further expose the consumers about food safety (Nichols and McConnell, 2012; Yang *et al.*, 2016). Nonetheless, information shared on social media demands monitoring by qualified experts to prevent the spread of rumors that could lead to misconception of some food safety measures (Nordin *et al.*, 2015; New *et al.*, 2017).

4. Models of intention in safe food handling

Outbreak of FBDs stemming from improper food handling is equated to health issues due to its adverse impact on the health of consumers, such as diarrhea, vomiting, and fever. In addressing FBD, the various health behavior among those involved in food handling potential should be investigated. Several theories have been applied by past studies to predict the intention in health behaviors, namely Health Belief Model (HBM), Protection Motivation Theory (PMT), Health Action Process Approach (HAPA), and Theory of Planned Behavior (TPB).

4.1 Health belief model (HBM)

The HBM was developed in the 1950s and has been widely used in the field of public health to identify the type of disease, as well as to serve as a guide for intervention. Belief about the occurrence of a problem is a fundamental aspect in this model. Researchers have described that beliefs have a strong correlation with social interaction in shaping one's behavior. This belief is flexible and can distinguish between individuals with similar backgrounds. The three characteristics that form the basis of this model are each believed on the susceptible to the risk of particular health problem, experienced in health problem at moderate severity level in some parts of their life, and the benefit from the action to prevent the issues. The HBM dimension is composed of perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action, and self-efficacy (Janz and Becker, 1984; Abraham and Sheeran,

2005; Green and Murphy, 2014). A brief description of each HBM component is presented in Table 1.

Table 1. Definition of HBM components.

Components	Definition
Perceived susceptibility	Belief about the chances of experiencing a risk or getting a condition or disease
Perceived severity	Belief about how serious a condition and its sequelae are
Perceived benefits	Belief in the efficacy of the advised action to reduce the risk or seriousness of the impact
Perceived barriers	Belief about the tangible and psychological costs of the advised action
Cues to action	Strategies to activate “readiness”
Self-efficacy	Confidence in one’s ability to take action

[Source: Champion and Skinner (2008)]

Previously, HBM was used to study the intention of food safety practices and suggested to be applied in food safety intervention. It demonstrated that self-efficacy has a significant effect on generating safe food preparation, instead of health motivation. The researchers concluded that consumers with firm self-efficacy believe that mishandling food can threaten their health, thus become more confident in intended food safety behavior (Schafer *et al.*, 1993; Quick *et al.*, 2013).

Clayton *et al.* (2003) proposed that in order to improve food safety practices, the implementation of perceived barriers and perceived risks should be enhanced to ensure that the consumers can translate their intended behavior into actual behavior. These barriers, although may affect the perceived susceptibility of consumers as they believe that food safety practices can reduce the risk of FBD, the inherent constraints to some extent are bound to hinder their intentions to perform food safety behavior (Abdul Aziz and Mohd Dahan, 2013).

The food safety behavior can be affected by perceived benefits and cues to action in a direct manner.

When one has awareness on the benefits of keeping hygiene while food handling and has experienced the adverse impact of FBD, he or she becomes motivated to increase the intention in practicing food safety behavior. Frequent dispersion of information on FBD via mass media, which serves as media cues, is also effective in enhancing awareness among consumers on the importance of safe food handling (Hanson and Benedict, 2002; Nesbitt *et al.*, 2009; Cho *et al.*, 2010).

In some areas, perceived benefits were linked with perceived barriers and self-efficacy. Consumers, especially parents, are willing to practice safe food handling to prevent their children from FBDs. Despite some constraints, such as lack of time due to other chores at home and faulty kitchen equipment, the parents were confident in handling food safely (Vlasin-Marty *et al.*, 2016).

Safe food handling must be exposed to consumers more often to enhance their perceived susceptibility and severity of FBD, as well as increase the perceived benefits of and reduce barriers to following safe food handling practices. Consumers are confident that the food they prepare at home is safer than food purchased from outside. Nevertheless, confusion and misinterpretation due to conventional beliefs can lead to improper food handling. Personal experience also forces consumers to be extra cautious when preparing food, even if some felt that FBD is not a threat to them (Meysenburg *et al.*, 2014; Siebert *et al.*, 2014; Stenger *et al.*, 2014).

Nejad *et al.* (2005), Mcclenahan *et al.* (2007), Gerend *et al.* (2012), and Livi *et al.* (2016) reported that the ability of HBM in predicting intentions towards certain behavior as unsatisfactory. The HBM is limited in predicting intentions of consumers to practice safe food handling due to the high potential that this practice is not a priority despite the positively perceived susceptible towards FBD (McArthur *et al.*, 2006).

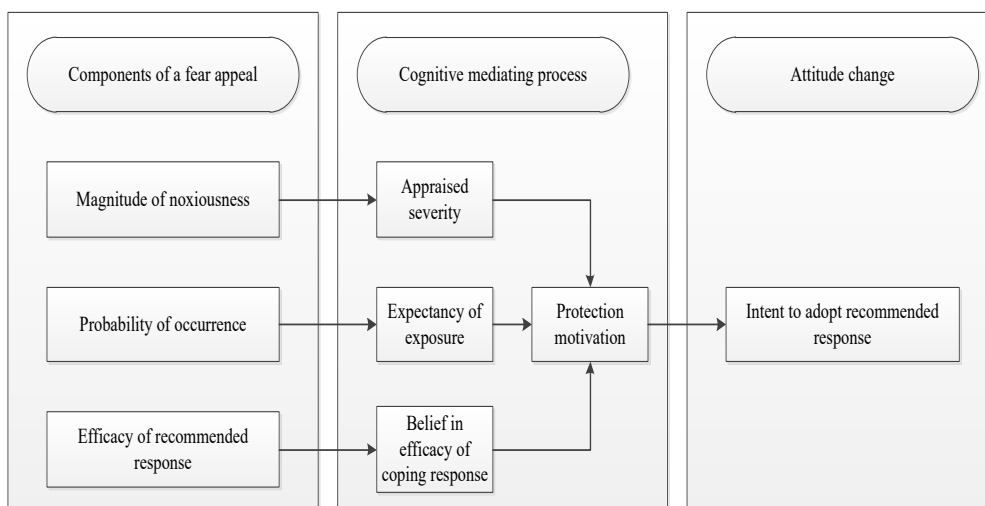


Figure 1. Components of PMT (Source: Rogers, 1975).

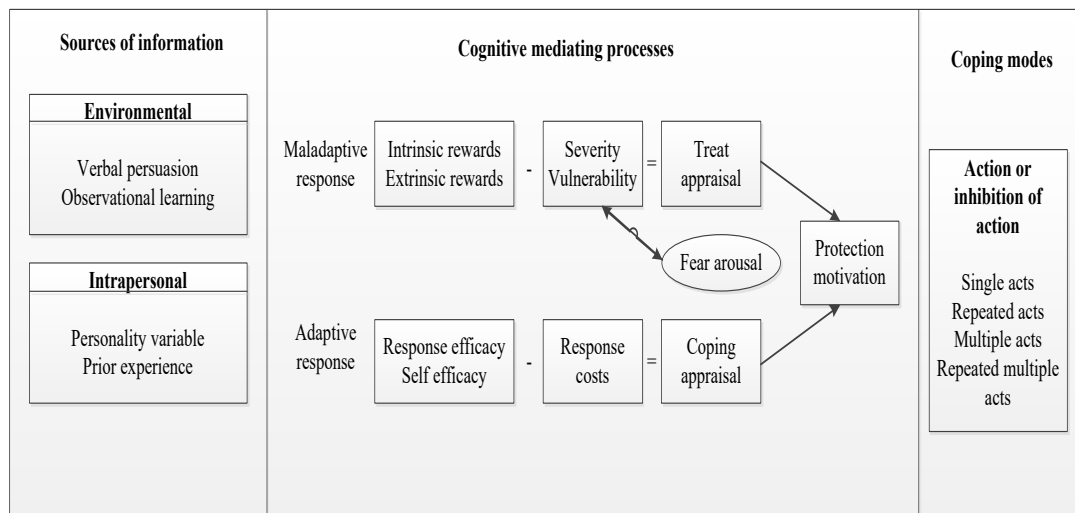


Figure 2. Revised PMT model (Source: Rogers, 1983).

4.2 Protection motivation theory (PMT)

Figure 1 illustrates that change in one's attitude may stem from fear appeal that is mediated by cognitive process. The three components of fear appeal are noxiousness, probability, and efficacy, which respectively stimulate appraised severity, expectancy of exposure, and belief in the efficacy of a certain coping response that can arouse protection motivation (Rogers, 1975).

The PMT revised by Rogers (1983) is displayed in Figure 2, along with its three primary elements; source of information, cognitive mediating process, and coping modes by maintaining fear appeal as part of verbal persuasion within the source setting. The major components of intrapersonal source refer to personal variable and prior experiences. Any source of information; environmental or intrapersonal, can trigger the mediating process and affect the change of behavior.

Based on Figure 2, treat and source of information are meant to initiate coping appraisal. In treat appraisal, the maladaptive response can be increased due to intrinsic and extrinsic rewards, whereby its probability would decrease due to both the severity and vulnerability of the threat. In this revised PMT model, fear arousal can indirectly affect the change of attitude and behavior through severity appraisal, when compared to the original PMT model.

One's ability to cope and avoid the danger posed by threat can be evaluated by response efficacy, self-efficacy, and costs for preventive response. The combination of treat and coping appraisal generates protection motivation. Rogers (1983) proposed that PMT is composed of five main variables to predict one's intention towards certain behavior, namely; perceived severity, vulnerability, response efficacy, self-efficacy, and response costs.

The PMT model results in five potential coping modes as one reacts only once (permanent or protective

response (single acts)), involving the routing for a certain protective response (repeated acts), carrying out more than one potential protective response (simultaneously or periodically (multiple acts)), and adoption of more than one protective response (repeated multiple acts).

The PMT has been used as a theoretical framework in many studies related to health behavior, including HIV prevention, adherence to orthopedic rehabilitation facility, functional food consumption, as well as alcoholic and smoking addiction (Rajendran and Shenbagaraman, 2017). The reported findings showed that self-efficacy was the strongest predictor of intention for compromising and promoting health behaviors, while threat appraisal increased the probability of adaptive and maladaptive coping responses. On the contrary, Milne *et al.* (2000) claimed that coping appraisal was the most significant predictor of health-related intentions, when compared to threat appraisal. However, this model is significant only for predicting concurrent behavior, but not future behavior.

Some studies had used the PMT to identify the influential factors for behavior of food safety, despite relatively limited. Mullan *et al.* (2016) found that intention in safe food handling was only affected by some PMT variables. Self-efficacy was an integral predictor for all safe food handling behavior in the study that comprised of proper food cooking, temperature control for food storage, awareness on risky food consumption, as well as hand and surface hygiene. Consumers would frequently adopt food safety behavior if they find it easy to practice; depending on their desire and ease of control. Thus, PMT accounted for 40-48% of the variability in safe food handling behavior.

The intention to engage in hand hygiene as a measure to control the outbreak of Norovirus was assessed using PMT that explained 58% of the variance (Fisher *et al.*, 2018). Coping appraisal had a significant relationship with intention of hand washing, where cost

appeared to be the strongest predictor, when compared to response and self-efficacy. Due to awareness of the existence of Norovirus, consumers always washed their hands without time and location of sink as deterrent.

Both studies depicted above only assessed first-year university students and passengers of a cruise ship. The selection of respondents excluded adult consumers directly, who are the main food handlers at home. The PMT, which gave less impact on R² value (coefficient of determination), displayed limitation in measuring safe food handling behavioral intentions (Young *et al.*, 2017).

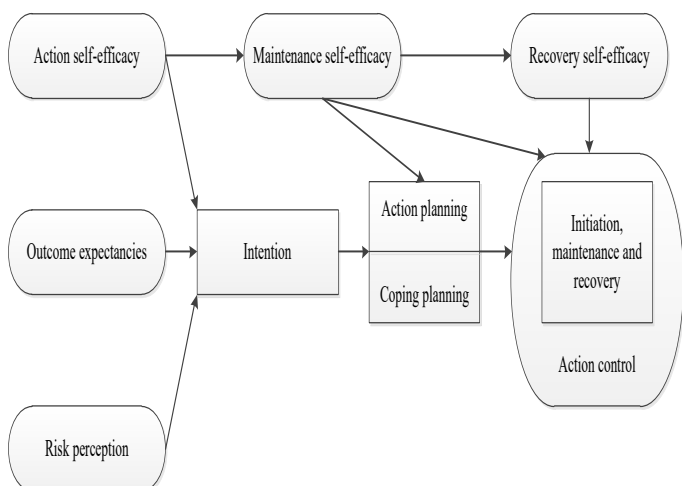


Figure 3. HAPA model (Source: Schwarzer, 2008).

4.3 Health action process approach (HAPA)

In the social-cognitive theory, intention is regarded as the most accurate predictor of one’s behavioral change. However, one’s behavior, at times, is not in line with the intention. Thus, the HAPA was developed to bridge the gap between intention and behavior that consists of motivational stage and volitional stage (Schwarzer, 2008). Figure 3 presents the components of HAPA.

In the motivational stage, the development of intention is determined by self-efficacy, outcome expectancy, and risk perception. Meanwhile, the volitional stage reflects a translation between intention and behavior. The motivational stage starts when one becomes aware of the risks (risk perception) and this would cause him or her to consider the pros and cons of behavior change to address the risk (outcome expectancy). After that, one must perceive the capability of performing the intended behavior (action self-efficacy).

In the volitional stage, after intent becomes the desired behavior, the action is maintained by maintenance self-efficacy and recovery self-efficacy. Maintenance self-efficacy is one’s capability to cope with any barrier during the term of maintenance, whereas recovery self-efficacy refers to one’s ability to bounce back after failure.

One’s intention is more likely to translate into behavior due to the existing action and coping plans. An action plan includes situational cues and details regarding when, where, and how an action can be executed, whereas coping plans is an alternative plan if the action plan cannot be executed due to unfavorable condition so that one can continue to focus on the action (Schwarzer, 2016).

The HAPA was applied to predict intention on safe food handling among first-year university students in Australia, wherein action self-efficacy emerged as the strongest predictor (Mullan *et al.*, 2010). Nonetheless, self-efficacy was no longer the most significant predictor when the subjective norm variable was embedded into the HAPA model. This is because; its presence increased the proportion of variance explained in food safety intention (Chow and Mullan, 2010). This finding indicates that those sharing a close relationship with the consumers, such as families and friends, might actually affect the development of their intention to adopt safe food handling.

Mullan *et al.* (2013) found that HAPA had low predictive utility, apart from being a poor model in predicting intention or behavior, mainly because the data failed to meet the requirement of fitness indices for structural equation modeling (SEM) analysis, when compared to TPB. Besides, action and coping planning did not display any correlation with both intention and behavior, as evidenced by bivariate correlations between the variables concerned. The HAPA is not supported by fit statistics and demands parsimonious model to predict safe food handling intention.

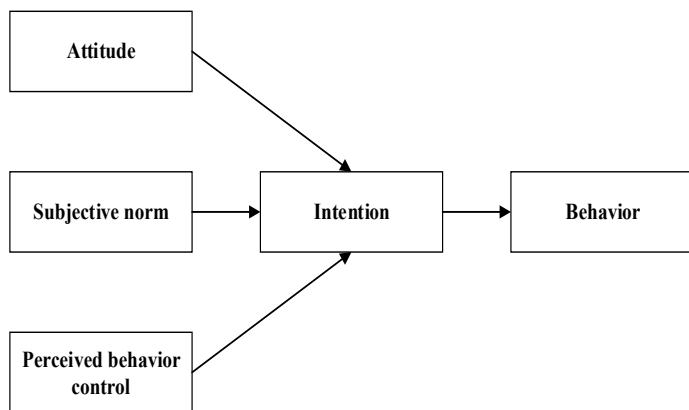


Figure 4. Theory of planned behavior.

4.4 Theory of planned behavior (TPB)

The TPB originated from the Theory of Reasoned Action (TRA), which posits that behavior is determined by behavioral intention. Intention to act captures motivational factors that affect one’s behavior and serve as indications of the extent of effort one is planning to exert the behavior. Based on Figure 4, behaviors are determined by intention through attitude, subjective

norm, and PBC (Ajzen, 1991; Ajzeb, 2015) (Figure 4). The TPB has been used in many studies on consumers' food purchasing intention (Kim and Chung, 2011; Tan, 2013; Yazdanpanah and Forouzani, 2015; Chaudhary and Bisai, 2018; Spence *et al.*, 2018; Zhang *et al.*, 2018), and food consumption (Chan and Tsang, 2011; Dunn *et al.*, 2011; Gronhoj *et al.*, 2013; Rezai *et al.*, 2012; Seo *et al.*, 2014; Yeong, 2014; Scalco *et al.*, 2017). To date, the TPB has been applied in many intention and behavioral studies related to motor vehicle and service industry (Abu Bakar *et al.*, 2017), intervention for organ donation (Ghaffari *et al.*, 2018), student retention (Dewberry and Jackson, 2018), green hotel visit (Verma and Chandra, 2018), transportation issues (Acheampong, 2017; Jiang *et al.*, 2017; Gao *et al.*, 2018; Sullman *et al.*, 2018), sick leave prescription (Swarna Nantha *et al.*, 2018), and many others.

The TPB is the most frequently applied theory in studies associated with safe food handling by consumers, in which a range of constructs have been embedded to measure both intention and behavior, despite plenty of variance percentages for the vast factors studied (Young *et al.*, 2017).

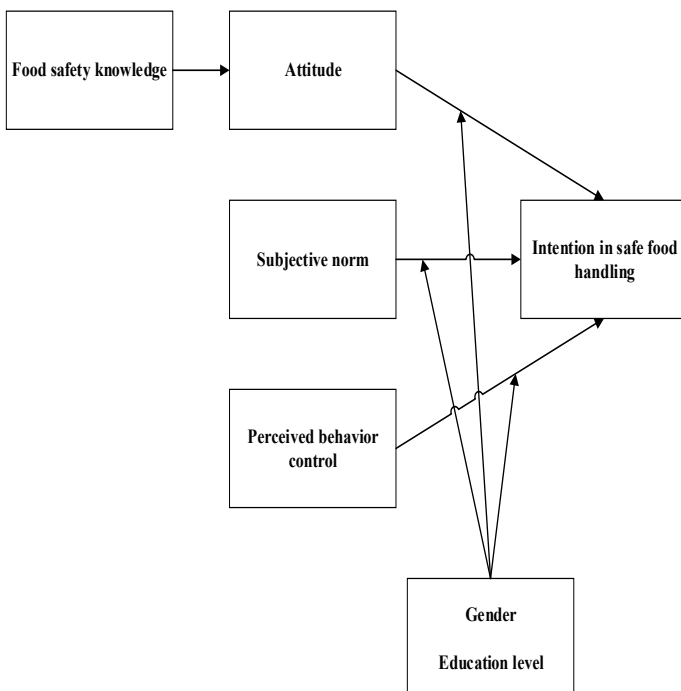


Figure 5. Conceptual model.

5. Theoretical framework

The TPB is not limited to its three original components, but can be expanded by adding other external predictors to enhance its predictive ability on intention (Hasbullah *et al.*, 2014). In this study, food safety knowledge was embedded to identify its effect on attitude with the present of gender and education level as moderator between all TPB variables and intention in safe food handling, as given in Figure 5.

5.1 Attitude

Attitude refers to the degree at which one has a favorable or unfavorable evaluation or appraisal of the behavior in question (Ajzen, 1991). Personal importance related to attitude relies on one's interest, social identification, and values. The collaboration between attitude and personal importance can enhance one's behavioral intention.

Attitude also describes the extent of effort one puts in to adhere to safe food handling practices (Burusnukul, 2011; Bai *et al.*, 2014; Howe and Krosnick, 2017). If the consumers in this study perceive that handling food safely at home is an effective way to stay away from FBDs, they are more likely to intend in food safety engagement.

5.2 Subjective norm

Subjective norm is a social factor that reflects the perceived social pressure to perform the behavior or otherwise (Ajzen, 1991). One with close relationship with those in-charge of handling food has a significant role in affecting the provision of hygienic food. Food handlers highly comply with food safety practices because the people they share relationships with are important to them (Phillip and Anita, 2010). In line with this notion, when consumers believe that their loved ones think that food safety is integral, they are likely to ensure that only hygienic food is served.

5.3 Perceived behavior control

The PBC is an additional aspect of TPB that distinguishes it from TRA. The PBC refers to one's perception of the ease and difficulty of performing a specific behavior (Ajzen, 1991).

The intention to perform a behavior is high if one finds it easy, convenient, and does not consume much time to practice (Shapiro *et al.*, 2011; Soon and Baines, 2012). If consumers have the means and confidence to perform food safety behaviors, they are bound to have strong intentions to handle food safely.

5.4 Food safety knowledge

Many studies have reported that attitude is affected by food safety knowledge. Consumers with good food safety knowledge had collectively agreed on the significance of complying with food safety measures while preparing food to lower the risk of FBDs, despite they were clueless about cooking temperatures (Talaie *et al.*, 2015; Vadlamani *et al.*, 2015; Baser *et al.*, 2016). Consumers with positive attitude in dealing with FBD are in support of emphasizing food hygiene education inculcated in children as early as at the kindergarten level (Pang *et al.*, 2015). This notion should be encouraged because these children may be involved in food handling in future, either in the industry or at the

domestic home. Consumers with exceptional knowledge level on food safety would not perform risky behaviors, such as eating raw or partially cooked food, but become more willing to enhance their knowledge for better health (Whiley *et al.*, 2017; Luo *et al.*, 2019).

Lim *et al.* (2016) found that food safety knowledge was not positively influenced by attitude. Oxford *et al.* (2013) reported that while the consumer always kept their house clean, the rate of bacterial growth (e.g., *Enterobacteriaceae* and *E. coli*) was still very high, particularly in the kitchen area. Lack of positive attitude pertaining to the importance of kitchen clothes and sponge hygiene appeared to be the main cause for the spread of bacteria despite the consumers were knowledgeable about house hygiene.

Nevin and Baser (2019) asserted that fostering food safety attitude by merely increasing the level of knowledge could be a more appropriate behavioral target. Hence, it is hypothesized that consumers with high food safety knowledge are more likely to have positive attitude towards safe food handling at home.

5.5 Intention

Intention reflects one's willingness, which varies based on attitude, subjective norm, and PBC (Ajzen, 1991; Armitage and Conner, 2001). Intention variance could be accurately explained by attitude, subjective norm, and perceived behavioral control (La Barbera and Ajzen, 2021; Soon *et al.*, 2021).

6. Other survey tools for food safety behavior

Various previous studies on safe food handling used survey instruments that were constructed based on specific behavioral theories. One of the models applied in the studies was the health belief model (HBM). Hanson and Benedict (2002) determined the food handling behavior of older adults' based on two HBM constructs which were: (i) perceived threat of FBD (perceived susceptibility and severity) and, (ii) cues to action (media and educational cues). Meanwhile, in a study by Roseman and Kurzynske (2006), another HBM construct, perceived risk was predicted based on confidence in food supply safety, perception on FBD prevalence and perception on places where FBD occurs frequently. The HBM model was applied for both quantitative and qualitative studies. In a recent study, Vlasin-Martyn *et al.* (2016) developed a script about food safety and FBD for focus group discussion based on HBM constructs to explore respondents' susceptibility, perceptions of severity, barriers, benefits, cues to action and self-efficacy.

Another behavioral-change theory that is frequently applied in predicting safe food handling behavior is the Health Action Process Approach (HAPA). Chow and Mullan (2010) divided the HAPA model into two phases

(motivational and volitional) to predict the food safety behavior of undergraduate students. The motivational phase was assessed by risk awareness, outcome expectancy and action self-efficacy. Meanwhile, the volitional phase was determined by maintenance self-efficacy and recovery self-efficacy with the presence of additional variables such as subjective norm, social support, past-behavior and intention. In another study, Mullan *et al.* (2010) employed the HAPA questionnaire to predict the intention for safe food handling behavior where three different models were constructed. Action self-efficacy, outcome expectancies, relative and absolute risks were the predictors for the intention in the Model 1, while in Model 2, planning, maintenance and recovery self-efficacy were specified as a predictor for behavior. In Model 3, past behavior was the predictor for both intention and behavior. Due to increasing FBD cases caused by *Campylobacter*, Bearth *et al.* (2014a) utilized HAPA constructs such as outcome expectancy, prospective planning, motivational and volitional self-efficacy to predict the self-reported cross-contamination behavior among novice cooks. In a recent study, Freivogel and Visschers (2020) extended the HAPA model by adding subjective norms variables to predict safe food handling practice among consumers in preventing bacterial contamination.

Besides the HBM and HAPA, the Protection Motivation Theory (PMT) is also frequently used in studies related to safe food handling behavior. Mullan *et al.* (2016) applied PMT variables such as severity, vulnerability, response efficacy, self-efficacy and protection motivation. The PMT variables were used by the authors to determine effective intervention in safe food handling for different aspects such as cooking, cross-contamination prevention, temperature control and risk food avoidance. In a different study, Choi *et al.* (2018) employed PMT variables to predict consumer intention in restaurant selection based on food safety evaluation report.

7. Moderating effects of demographic profiles

Consumer characteristics are usually determined based on their demographic profiles that comprise of age, gender, education background, and socioeconomic status. In certain condition, these characteristics may serve as a predictor of consumer's behavior, apart from describing the correlations between independent and dependent variables (Kwok *et al.*, 2016).

7.1 Gender difference in safe food handling

A substantial number of studies have reported that females are more conscious about food safety than their male counterparts. Several studies found that the females were good in food preparation, handling, and storage (Sanlier *et al.*, 2012; Sanlier and Konaklioglu, 2012).

Conventionally, females are frequently involved in food preparation at home, apart from ensuring the hygiene at the kitchen area and its environment for safe food handling (Lazou *et al.*, 2012; Hassan and Dimassi, 2014; Omari *et al.*, 2018). Females become more involved in preparing food at home as they enjoy doing such task and it becomes part of their daily chores (Turnbull-Fortune and Badrie, 2014). Although females tend to perform better than males, they still lack practice in some areas.

Recent studies found that females did not confirm the sufficient time to wash their hands, failed to determine if the cooked food is well done based on prescribed time and temperature, as well as thawing food outside the refrigerator (Alsayeqh, 2015; Farahat *et al.*, 2015). As for hand hygiene, females more frequently touched electronic appliances and their hair using their bare hands than males did (Her *et al.*, 2017). Such habit may increase the risk of food contamination by pathogens.

It has been argued that males are better than females for food safety practices, although females have the advantage in terms of knowledge. Females are more aware of food poisoning outbreak, whereas the males are more concerned about proper handling of food, such as separating food using different containers and identifying recommended temperature of refrigeration to hamper the growth of microorganisms (Al-Shabib *et al.*, 2016; Zeeshan *et al.*, 2017).

7.2 Education level difference in safe food handling

Handling food safely has been linked with one's education level. Past studies reported that those with high education had better KAP level related to food safety (Sharif *et al.*, 2013; Parra *et al.*, 2014; Oladoyinbo *et al.*, 2015; Faremi *et al.*, 2018). Highly educated respondents, such as university or college graduates, displayed better KAP because they are more likely to attend courses related to food safety that would allow them to identify the causes of FBDs (Lu *et al.*, 2012; Vo *et al.*, 2015; Dehghan *et al.*, 2017; Pepple, 2017). Those with higher education also had better awareness regarding pathogens that can cause FBDs, such as *Salmonella* (Sahingoz and Sahin, 2009; Hayajneh *et al.*, 2016).

Those highly educated had more awareness and knowledge on food safety issues, when compared to those with lower education level (Afifi and Abushelaibi, 2012; Liu and Ma, 2016; Iwu *et al.*, 2017). Highly educated individuals were capable of influencing those close to them regarding food safety knowledge. In fact, parents with higher education level appeared to demonstrate better knowledge regarding food safety (Cheng *et al.*, 2017).

Some studies discovered that the level of education is not related to KAP in food safety (Alrabadi *et al.*, 2013). Individuals with higher education do not necessarily have better KAP in food safety. Somewhat surprisingly, this group reported being more often infected by FBDs, when compared to those with lower academic level (Osagbemi *et al.*, 2010; Gurpreet *et al.*, 2011).

Conclusion

This review explores FBDs in Malaysia, with a focus on the microbiological hazards driving outbreaks and the critical impact of consumer behavior on food safety. Major pathogens, including *Vibrio cholerae*, *Salmonella* Typhi, *Bacillus cereus*, and hepatitis A virus, have caused significant public health issues, often stemming from poor sanitation, inadequate food handling, and limited awareness among both consumers and food handlers. While Malaysians generally demonstrate knowledge of hygiene and safe food handling, important gaps persist—particularly with respect to temperature control, proper reheating, cross-contamination prevention, and recognition of foodborne pathogen risks. The recurrent mismatch between knowledge and behavior underscores challenges in education and actual practice.

Behavioral theories provide critical insights into these challenges. The HBM and PMT both highlight self-efficacy, perceived barriers, and risk appraisal as important determinants of food safety intentions and actions. The TPB, specifically, emphasizes that consumer food safety practices are shaped by attitudes towards food safety, subjective norms (social pressure), and perceived behavioral control (the ease or difficulty of performing safe practices). Studies indicate that even when knowledge is present, behavior is most strongly predicted by the intention to act, which is influenced not only by beliefs and knowledge but also by social expectations and the perceived ability to overcome barriers.

Demographic characteristics such as gender and education further moderate food safety practices, with females typically showing more consistent hygienic behaviors. To effectively reduce the burden of FBDs, interventions must target these multi-level determinants—enhancing positive attitudes, self-efficacy, and perceived control, while also addressing subjective norms through family and community influence. Early educational interventions, trusted food safety certification, and strategic public campaigns are recommended to translate knowledge into safer daily practices and ultimately improve public health outcomes in Malaysia.

Conflict of interest

The author declares no conflict of interest.

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