RESEARCH ARTICLE

A food risk assessment model based on HACCP for small scale restaurants

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ABSTRACT

Food safety inspection is a crucial factor in small scale restaurants in Sri Lanka due to limited time as a local public health inspector. This is a minor concerned area in their field of working. A food safety management framework was developed to enhance the existing local food inspection process. Personal interviews with health professionals and a pilot survey for restaurants (30) in Badulla were conducted to understand the existing food inspection programme. Then, food risk assessment model based on HACCP for small scale restaurants was developed. In order to facilitate the end-users to use this developed model, an Android food safety application was developed. This model assures the food safety in small scale restaurants and has potential to improve the food safety practices due to its effectiveness and accessibility. Furthermore, "big data" collection through this mobile application can be used for further data analysis creating multiple research opportunities.

Keywords: Food safety, android food safety application, HACCP, risk assessment model

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INTRODUCTION

Food safety can be defined in both ways as broad and narrow. In the narrow sense, food safety is the opposite of food risk where the probability of not contacting a disease as a consequence of consuming a certain food. In a broad sense, food safety is encompassing nutritional quantities of food and wide-range of the properties of unfamiliar foods (Ritson and WeiMai, 1998). Foodborne illness cases occur daily all over the world but these cases most of the times had not reported the true dimension of the problem (WHO, 2002). Foodborne illnesses are affected by one-third of the population each year in developed countries and the global burden of foodborne illnesses is caused by bacteria, viruses, parasites, toxins, chemicals (WHO, 2016). Foodborne diseases have emerged as important and growing public health issue which creates a huge economic loss in Sri Lanka. As Sri Lanka is a developing country rapid expansion of the food industry, urbanization, rising of the population can be observed. During the last few years, many small food outlets were established with a significant contributor to the burden of foodborne diseases due to the inadequacy in food safety among these food establishments. More often

diarrheal issues in Sri Lanka were caused by *Campylobacter* spp. and Norovirus. In 2012, Sri Lanka had found that prevalence *Bacillus cereus* was 56% in Chinese style fried rice which was available in Colombo city. Those were the organisms responsible for symptoms of diarrhoea and vomiting (Gunasekera *et al.,* 2016).

The national food safety is operated by the Public Health Inspectors (PHIs) who cannot spend adequate time considering the responsibilities as a food inspector as they are with multiple duties were leaving the food safety measures as a subject that is least concerned due to limited time in their field. Annual Bulletin of Health Ministry of Sri Lanka stated that in 2014, 11th leading cause of hospitalization was the intestinal infectious diseases (Ministry of Health, 2015). In 2014, Sri Lanka had reported 1072 cases of typhoid fever among them 27.6% was 5-14 y old age group. Among 4832 cases of dysentery patients, 33.7% were 1-4 y old age group and 27.6% were 5-14 y old age group among 2056 viral hepatitis cases Ministry of Health (2015). The food poisoning cases reported to the medical officers in the Badulla district showed a significant increment in the recent years (2012-2015) by Ministry of Health (2015). The country remains a need of implementing proper food safety management system with a multidisciplinary approach (Gunasekera *et al.,* 2016). It is important to build effective food regulations, proper sanitary inspections and quality assurance to be adopted for small-scale food outlets and small restaurants in order to minimize food-borne infections in Sri Lanka (Munasinghe *et al.,* 2014).

Foodservice operations are complex with their recipes, menus, food varieties (Seward, 2000). But, it must ensure that food is safe for consumption and should give an answer for the question that produced foods are safe for consumption ensuring food safety (Gibson *et al.,* 2002). Food safety management system (FSMS) the preventive approach towards identifying, preventing, reducing food-borne hazards which ensure that the food is safe for the consumption and a well-defined FSMS is with food control measures that comply with food hygiene regulations (Moreb *et al.,* 2017). Prevention of most of the food born infections can be done by hygienic food preparation and training on crucial lines of defense in food preparation and food serving (Gibson *et al.,* 2002). As the causes of foodborne diseases are transferred to food directly or by cross-contamination, a flexible Hazzard Analysis Critical Control Point (HACCP) system introduction will be better for food services operations to reduce most types of contamination (Seward, 2000). For small-scale food outlets and small restaurants, a checklist which is based on the HACCP system may present useful tools like good hygienic practices which can be verifying periodically in order to reduce food hazards. A research conducted in Portuguese to a university canteen had proved that a checklist allows a quantitative evaluation and percentage scores, classification informed about stages and categories that need to improve to accomplish legal requirements (Veiros *et al.,* 2009). "Food risk-based food safety inspection system" gives benefits as such a system can effectively manage personal and monetary

facilities. Such a checklist and instruments can be used to assess food safety due to its reproducibility, cost-effectiveness, and practicality (Cunha *et al.*, 2016).

Information systems provide opportunity for knowledge gathering cumulatively and the capability of providing information on the interpretation of the significance of newly collected data to monitor or investigate natural phenomena (McMeekin *et al.,* 2006). As the expert systems are with the real knowledge in experts' mind and knowledge in the scientific literature, it is useful to analyze quantitative parts with the qualitative knowledge (Linko, 1998). Software packages can be used to establish and modify food safety management practices as they are helping to bring logical sequences of HACCP, risk assessment to practical applications. The international food safety management system is the HACCP system and HACCP based software packages include quantitative modelling techniques, product and organism data and qualitative knowledge combined with a user-friendly user-interface (McMeekin *et al.,* 2006).

HACCP plans and quantitative risk assessments are based on experience and quantitative reasoning. Thus, those can be structured in an expert system. Such systems are with advantages of the transparent and systematic structured procedure, speeds up conditions availability and answers. It helps update new information if available (Wijtzes *et al.,* 1998). A system like "Risk Assessment Tool" gives an analysis of the magnitude of risk and warns the user if a conclusion is potentially dangerous (Ross and McMeekin, 2003). Audits play an important role where it certifies the food safety practices are practicing and also this auditing is crucial in order to maintain food standards and certification where it gives assurance and transparency on standards maintain in the food services (Veiros *et al.,* 2009). With this, a smart food safety management framework may be with the benefits like a transparent systematic procedure speeds up the availability of answers, analysis the food risk, warns the user to improve food safety, records keeping and analysis the data and food standards maintained at an optimum level which ultimately reduces the food risk indirectly.

Accordingly, this type of framework is cost-effective, efficient, and more accurate and a user friendly, simplified reliable source which reduces food safety issues in Sri Lanka. It increases the business value of food services and customer purchasing abilities. Therefore, the objective of this study was to enhance the existing Sri Lankan food inspection process through a developed food safety management framework, which analyses, diagnose and implement main principles of food safety.

MATERIALS AND METHOD

Preliminary studies on the existing food safety inspection system in Sri Lanka

Preliminary studies to identify the current inspection procedures in Sri Lanka were conducted in two phases. As the first phase, personal interviews with the Public Health Inspectors (PHIs) who are responsible with food services food safety. A pilot survey for small restaurants of the selected location, Badulla municipal council area of Sri Lanka, was conducted, as the second phase. In order to identify the current food safety inspection procedure of the food industry, personal interviews and discussions were conducted with PHIs and regional Food and Agriculture Organization (FAO) Instructor of Badulla district, Sri Lanka. This interview was led to identify the problems and issues in the current inspection programme and the problems faced by the PHIs during the food safety inspection of food services. The pilot survey was conducted for selected 30 restaurants in the selected location which were selected through convenience sampling. For the pilot survey, a questionnaire with open-ended questions to evaluate the knowledge of the food handlers and the questionnaire was filled by the researcher herself. Descriptive statistical analysis was used to analyze the results of the pilot survey.

Development of HACCP based food risk assessment model

First identification, ordering, and gathering of information about national legislation related to food services food safety, was done. The production flow of a restaurant was sketched and Critical Control Points (CCPs) were identified in the production flow. To address the identified CCPs, a risk assessment model was developed.

The risk assessment was done as follows:

- High-risk categories   -   Direct contamination measures

- Medium risk categories   -   Indirect contamination measures

- Low risk categories   -   Less concern/Unable to control in small scale level measures

Results of the pilot survey, literature survey and current food services' inspection system were considered as the base in the development of HACCP based risk assessment model. The risk assessment model was prepared by using the general food grading system in Sri Lanka and compilation of data from several studies as indicated by Cunha *et al.* (2016) and Los Angelis reference guide for restaurant inspection.

The developed risk assessment model was a checklist for the inspection of food services. The main food safety measures were categorized into subcategories to

identify the areas that need to be evaluated during the inspection. These subcategories were also with evaluation criteria that need to be considered during the evaluation. If the required criteria are available the scores are given and conditions were given as Good, Adequate, Barely Adequate and Inadequate (Table 1). The evaluation was as follows:

Table 1: Evaluation criteria and the condition for the grading system.

Evaluation criteria score	Score	Condition
4	4	Good
3	3	Adequate
2	2	Barely Adequate
0/1	0	Inadequate

For this evaluation, binary score was assigned to the checklist: one point was assigned for correct measure and zero point was assigned for the not corrected/violated measure. Total score for each main category was allocated as 100. The grading of each section was done as follows and the final grade of the restaurant was determined through the total marks taken by the restaurant for each evaluation section. Table 2 shows scoring System for the final grades of the cafeteria.

Table 2: Scoring System for the final grades of the cafeteria.

Score	Grade
80- 100	A
60 - 79	B
30- 59	C
0 - 29	D

This model was tested for Uva Wellassa University two cafeterias for several times (3 times) and accuracy was checked whether the model was tallying the legal requirements of the current inspection procedure, as well as hygienic and sanitary regulations of Sri Lanka.

Development of food safety management framework for small restaurants

The proposed food safety management framework was developed as a prototype that analyses and diagnoses the main principles of food safety. This was a user-friendly approach of developed risk assessment model. The

inspection was with the risk assessment model, the restaurant inspection checklist. This software analyzes the food risk of the restaurant and gives a notification alert about food risk. It also grades the restaurant each evaluation sections and gives a final grade for the restaurant. Finally, a report generated which includes the entire summary gained by the restaurant inspection and the food risk condition of the restaurant. The application was deployed for the two cafeterias of the university. The accuracy and feasibility of the developed prototyped were tested. Application was tested for 10 medium-scale restaurants available around the Uva Wellassa University premises to check the accuracy and feasibility.

RESULTS AND DISCUSSION

Preliminary studies

For the pilot survey, targeted group was small restaurants in the selected area. 30 small restaurants were selected based on the coverage of category levels ranging from 8 to 39 (SLTDA). Convenience sampling was done to select the restaurants. A questionnaire was prepared to evaluate the knowledge of the food handlers. The evaluation was done based on their Yes/No responses for the closed-ended questions. The questionnaire was filled by the researcher herself.

The responses were evaluated on the categories:

- Knowledge of food safety measures (storage, contaminated substances, sanitation procedure, contaminated substances, packaging materials)

- Knowledge of PHI inspection programme to identify the current food safety inspection procedure of the food industries

- Knowledge on the software applications

Other than the above evaluation criteria, suggestions for the food safety application were taken. Current food inspection system was identified as the grading of food handling establishments (Food factory, Hotel, Bakery, Tea and Snack Bar, Grocery, Super Market, and others). The problems in the current inspection procedure and problems faced by PHIs in the subject food safety were identified. Additionally, suggestions for developing a food safety model were obtained. The inspection system is for all food establishments not specify for specific food services. It was a complex structure of inspection checklist (10 parts with 100 sub-items) and marking, grading is depended according to PHI perception level.

Pilot survey for the food handlers was conducted to verify the knowledge of food safety and sanitation of the food handlers. Suggestions for the food safety management framework were taken from the survey carried out. Accordingly, it was suggested to develop a software package which should be legalized. The

targeted group for the pilot survey was the small-scale restaurant (Minimum 8 covers, maximum 39 covers). Accordingly, most of the food handlers were lack of knowledge on food safety and hygiene (Figure 1). 64% lacked knowledge on contaminated substances among the targeted group food handlers. 63% lacked knowledge on food storage mainly.
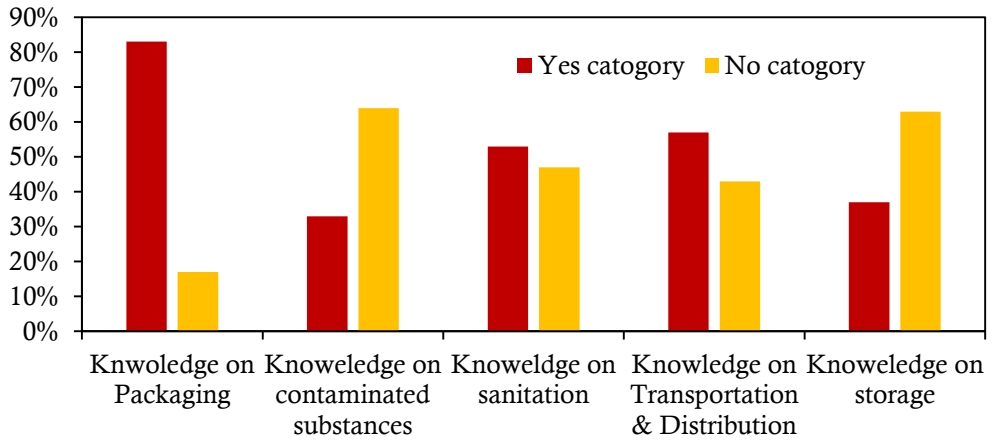
Different criteria on food safety concepts

Figure 1: Percentage knowledge of food safety measures of the selected restaurants.

Based on the analysis, 57% of PHI inspectors were lacking knowledge on food safety inspection procedure (Figure 2). Therefore, these 57% group of people need to improve the knowledge of food handlers and application of food safety management system.
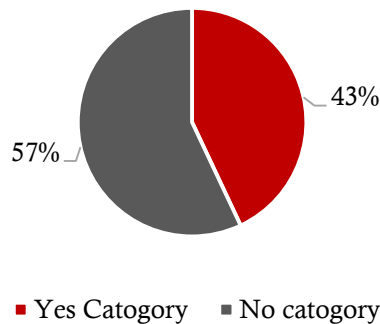
Figure 2: Percentage of knowledge on "PHI checklist".

The management of the restaurants does not observe adequate precautions in most food processing procedures. Therefore, there is a need for presenting

programmes related to HACCP in a practical, realistic and step by step manner. Most of the food waste management was poor; utensils and crockery were fairly clean. Most of the restaurants did not have hot water for day today use of the restaurant. Visually observed sanitation procedure showed that most of the restaurants do not have adequacy in sanitation.

Development of HACCP based food risk assessment model

Production flow of food services and the CCPs were identified. The identified CCPs were food storage, food preparation, food cooking, food cooling, food refrigeration or freezing, and food reheating. These CCPs were identified according to the possible hazardous contaminations for food during processing in food services. Restaurant food handlers should not consider just only cooking time and temperature but also they must teach a method of cooking, the initial temperature of food, size of food, cooking utensil as well as surface area and depth of the utensils during cooking (Griffith and Worsfold, 1994). On the other hand, during food storage, checking the adequacy of temperature in cold holding should be taught for food handlers as most of them shut down the refrigerators and deep freezers at night time. The colour changes in meat or juices, setting or coagulation of proteins in egg, bubbling of liquids for minimum time identification should be taught to them to avoid cross contaminations (Griffith and Worsfold, 1994).

The pilot run of the HACCP based Risk Assessment Model which was done for the cafeteria of the university in a uniformed day got similar results as in the H-800 programme. The final grade for the university cafeteria was C and it got similar marks as existing inspection programme with few deviations. According to this pilot test of inspection, the food preparation section was with the highest number of violations and since they were not practicing any record-keeping they were with the violation in a low-risk item record keeping.

The risk assessment model was developed according to Cunha *et al.* (2016); the food safety policy deployed during the 2014 World Cup in Brazil. It states that food preparation was a section with the greatest number of high-risk items and construction facilities; furniture was low-risk items. The developed risk assessment model has included the risk factors according to direct contamination factors (High Risk), indirect contamination factors (Medium Risk) and the least concern in small scale level was taken as Low Risk factors. The studies indicated that temperature to hold food (hot and cold), general hygiene of food handlers and hygiene were the main cause of foodborne diseases (Cunha *et al.,* 2016). Assigning food services to risk categories supports prioritization of prevention and control FBD and assure food safety (Haog, 2007). This risk assessment model for food services was analyzed and it diagnosed the main principles of food safety. Therefore, it gave output as follows:

- Grade the restaurant according to food safety

- Grade the restaurant's inspection sections individually
- Allocate marks for each inspection sections of the restaurant

To prevent foodborne illnesses among the consumers of retail food inspections are the inherent component of surveillance (Allowood *et al.,* 1999). According to Mortimore and Wallace (1994) HACCP principles often provide a basis for food risk-based inspections. Benefits such as a system can effectively utilize for personnel, management, and monetary funds through the implementation of a risk-based, prevention-oriented inspection programme (Collins, 1995; Wodi and Mill, 1985).

In the checklist, the marks for evaluation were given as binary scores. According to researches, the use of binary scores conceptually not wrong but having limitations; the binary scores may be used to assess what extent the health and food safety legislation is being fulfilled by the foodservice establishment (Cunha *et al.,* 2016). The limitations of the use of binary scores avoided in the developed risk assessment model as the evaluation criteria are with subcategories and evaluation conditions were defined clearly in the checklist. Marks allocation for the evaluation sections and final grading of the restaurants were helped to weigh the restaurant food safety conditions. Cunha *et al.* (2016) stated that to evaluate food safety in restaurants weights and risk categories, inspection scores should be used but with several conditions. A checklist of tools, which continued auditing and verification of a HACCP system, demands the same attention as the initial development of a HACCP plan in food services inspection (Sperber, 1998).

Recently the modern world is running with technology as fast as possible. Therefore, to increase the feasibility and accuracy among evaluators and evaluations, health inspectors must be trained to use new technologies. Audits play an important role where it certifies the food safety practices which are practiced and audited. These food standards and certification, which gives assurance and transparency on standards maintain in the food services, should be maintained (Veiros *et al.,* 2009).

Development of food safety management framework for small restaurants

The smart food safety management framework was built as a user-friendly approach for the developed HACCP based risk assessment model. The prototypical development was achieved by proofing the concept for the feasibility of the developed risk assessment model. HACCP based software packages include quantitative modelling techniques and qualitative knowledge which is combined with a user-friendly user-interface (McMeekin *et al.,* 2006). The accuracy and feasibility of the developed risk assessment model were achieved through this prototypical development, as follows (Figure 3):

- Grade the restaurant according to food safety

- Grade the restaurant's inspection sections individually

- Allocate marks for each inspection sections of the restaurant

- Evaluate each inspection section individually

- Analyze the risk of the restaurant

- Give a message alert on the food risk of restaurant

- Give a report which includes all results obtained by the restaurant
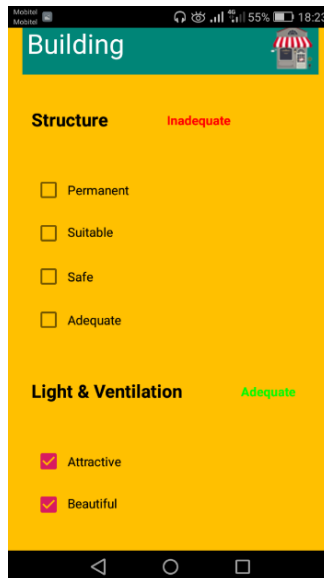
Figure 3: Evaluation criteria interface.

Information systems provide the opportunity for knowledge gathering cumulatively and are with the capability of providing information on the interpretation of the significance of newly collected data to monitor (McMeekin *et al.,* 2006). As the expert systems are with the real knowledge in experts' mind and knowledge in the scientific literature, it is useful to analyze quantitative parts with the qualitative knowledge (Linko, 1998).

This developed software was with the developed risk assessment model, the inspection checklist for food services inspection. The developed software package was an Android Application with Human-Computer Interaction (HCI) concepts. The application was developed according to a theme with different colours, pictures, and a flow pattern (Figure 4). The use of theme was given uniqueness for the application and colours defined variations in the application which gives a user-friendly background for the user.

The developed smart food safety management framework maybe with the benefits like a transparent systematic procedure, speeds up the availability of

answers, analysis the food risk, warn the user to improve food safety, record keeping and analysis the data and food standards maintained at an optimum level which ultimately reduces the food risk indirectly. Accordingly, this type of framework is cost-effective, efficient, and more accurate and a user friendly, simplified reliable source which reduces food safety issues in Sri Lanka. Also, it increases the business value of food services, customer purchasing abilities.

Figure 4: Risk alert interface.

The prototypical development was with a grading system which the grades generated automatically. The grades were given for the inspection sections according to the marks taken by each section and a final grade was obtained. The accent colours were used to highlight the risks of message alerts. The pictures were used to indicate the components that need to be evaluated and it helped avoid language barriers during the practical application. HCI is disciplinary of computer interaction with human which state major surrounding phenomena and concerned implementation with the design and evaluation (Hewett *et al.,* 1992). Carey's HFIS series identified several themes of HCI studies in the early years and stated that HCI as how the computer and user communicate and interface specification tools and design issues for the Computer-user interface (Zhang *et al.,* 2014). The prototypical development was achieved above-mentioned themes.

Evaluation of subsections was done by grading each sub-section. During the evaluation of the inspection sections, the subsections are with evaluation criteria that are to avoid drawbacks in the current inspection procedure; the user can get knowledge on what are the factors that need to be evaluated during the inspection. Therefore, this software package also can be used as a user-friendly approach to educating the food handlers. The software automatically generates a detailed report on the food safety about the restaurant (Figure 5).
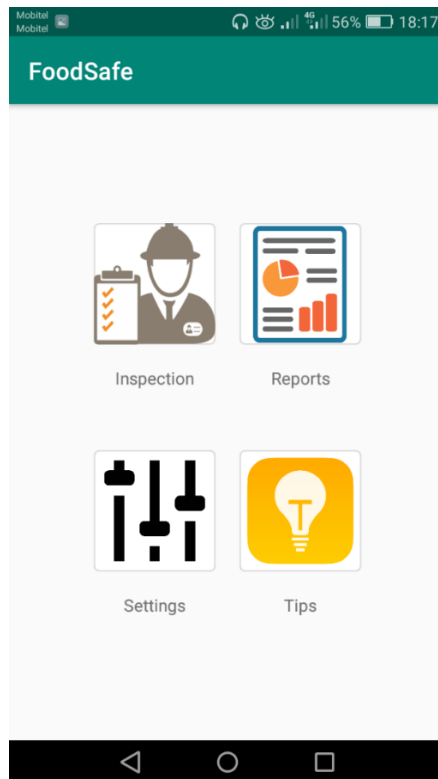
Figure 5: Main interface of the developed programme.

It also includes the total marks taken by each inspection sections and food risk condition of the restaurant. This food safety management system is a trustworthy system to assure food safety as it is with one user still and the real-time database was used to store and retrieving the data. Experts state that a trustworthy system on food risk should be efficient and to accept by the society, it must be based on competence and honesty (Frewer *et al.,* 1996). Though there is no any involvement of the customers for this research so far, the experts were stated that factors of communicator such as knowledge, accuracy and public welfare interest were the factors that trust in food risk communication (Frewer *et al.,* 1996). This was observed during the pilot survey for the food handlers as they also suggested that this introducing system must address their knowledge, accurate without misleading them.

The developed software package was with the "firebase" database which is a real-time database and cloud-hosted. The firebase database was with the user validations thus avoid the fake users of the application. It is with the facilities of high security, support offline and online data storage. The data analysis of the stored data was done by the database itself, receive updates with the newest data and store. JSON file store the data and synchroniz in real-time to the connected client. The real-time database is a database in which transactions have deadlines or timing constraints. They were viewed as time-constrained databases usually as timeliness is not quantified definitely. For some applications, it is milliseconds or it is minutes (Stankovic and Ramamritham, 1988).

Further, this food safety management framework can be deployed through the government as of improving public health to reduce FBD occurred through microorganisms *Bacillus cereus, Escherichia coli, Salmonella* spp. and *Listeria monocytogens* which are the common causes of FBD in Sri Lanka. But, research experts stated that restaurant grading, not co-related with the microbiological quality with the food (Kjeldgaard *et al.,* 2010) and many of influences can be correlated for outbreaks (Scallan *et al.,* 2011). All interviewed groups agreed that the inspection system may increase the credibility of the food services, may influence the quality of food, and suggest that this system should introduce for the consumers too. This may be a good strategy for communicating with consumers and may increase the consumers' confidence in Health Surveillance and also about food safety. The restaurant stakeholders should make their customers tend to feel that they are completely safe about consuming food away from home where most of them believe that regulations may protect theme (Wilcock *et al.,* 2004). Through the food risk alert in this, system can assure the food safety for a certain level as it depends on the risk categorization in the developed HACCP model and the software automatically verify whether the food safety measures of the CCPs are controlling or not in the restaurant. This leads to reduce violations in most important food safety measures in food safety and may improve knowledge about food safety among food handlers.

CONCLUSIONS

The prototypical development was achieved by proofing the concept for the feasibility of the developed risk assessment model. It assures food safety in small scale restaurants and has the potential to improve the food safety practices in food services in the areas covered by the national hygienic and sanitary regulations. This food risk assessment model can bring solutions for most of the practical problems of food safety in small restaurant inspection which avoids food safety violations with the aid to avoid drawbacks in current inspection procedure and enhances food safety knowledge of the public. It also can reduce the foodborne diseases in Sri Lanka. Furthermore, it creates multiple research opportunities in various fields, such as "big data" analyzing, navigation, data

mining, development of active surveillance systems for food safety, Public Health promotion.

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