Microbial risk assessment of ready-to-eat fast foods from different street-vended restaurants

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Abstract

Aim: Microbiological risk analysis of ready-to-eat fast foods for sale on the campus of Bangladesh Agricultural University was undertaken to understand the contribution of such foods to foodborne disease.

Materials and Methods: From each of 10 randomly selected fast food outlets, a total of 120 samples of six food items were collected to assess common microbial load. In parallel, vendors were asked about their food production and selling practices, while consumers (n=200) were asked about their consumption of fast foods and whether they had experienced symptoms of foodborne disease.

Results: Aerobic plate count (APC) varied from 6.92 to 7.24 log colony-forming unit (cfu)/g, *Staphylococcus* spp. 4.67 to 5.15 log cfu/g, *Salmonella* spp. 3.67 to 4.22 log cfu/g, and *Escherichia coli* 4.10 to 4.58 log cfu/g. Microbial risk assessment of *Staphylococcus* spp., *Salmonella* spp., and *E. coli* for daily, weekly, or monthly consumption was estimated by Monte Carlo simulation (10,000 iterations). The consumer survey showed 57% chance of being infected by ready-to-eat fast food samples. The calculated mean annual risks of *Staphylococcu*s spp., *Salmonella* spp., and *E. coli* infection were about 100% in all cases.

Conclusion: Thus, the study revealed high risk of infection associated with the consumption of ready-to-eat fast foods.

Keywords: fast foods, microbial quality, microbial risk, Monte Carlo simulation.

Introduction

It has been estimated that foodborne disease affects around 30 million individuals in Bangladesh every year [1], and it has been postulated that "fast food" (i.e., food that has been prepared for direct human consumption without any need for further processing or handling: [2]) contributes significantly to this total. The consumption of fast food is increasing worldwide, largely because it is generally cheap, readily available, convenient, and fits well into an urbanized lifestyle. Bangladesh has experienced rapid societal changes, including urbanization, increased female employment, longer working hours, education, and other causes of absence from home, whose net effect has been a rapid expansion in the number of fast food premises. This increase in the fast food sector has largely occurred without effective regulation of standards of food safety and hygiene [3], with the result

that, for most people, meals away from home mean various forms of fast food that is prepared and sold at small-scale roadside eateries which are usually unhygienic. Such food is increasingly likely to represent the main meal of the day.

There is a great variety of savory and sweet fast foods available in Bangladesh [4], which are characteristically made from reheated, precooked ingredients, and are served in a packaged form for takeout eating [5]. While most of the ingredients used in manufacturing fast food are nutritious, all have been shown to have the potential to harbor pathogenic organisms, including *Staphylococcus aureus, Salmonella* spp., *Escherichia coli*, *Enterobacter* spp., and *Listeria monocytogenes*, within the Bangladesh fast food chain [6]. These bacteria are responsible for causing foodborne diseases. A wide variety of illnesses is caused by bacterial, viral, parasitic, and chemical contamination that can occur in an unregulated fast food market.

Ready-to-eat fast foods are, therefore, of great significance in the epidemiology of foodborne disease and are probably a major contributor to the increase in foodborne illness that is taking place throughout the world and turns into an alarming concern involving wide scope of infection caused by the harmful

microorganisms [7]. Moreover, there is a growing concern for antimicrobial resistance in common bacterial food contaminants. Ahmed *et al.* [3] have recorded deaths in Bangladesh due to human infection with foodborne bacteria that were resistant to the antibiotics that had been available for the treatment of such infections.

Risk analysis is a useful food safety tool that helps to identify foods or food ingredients that are actually or potentially unsafe, or other hazardous materials and/or practices, to reduce the rate of foodborne disease [8,9]. Risk analysis comprises three components: Risk assessment, risk management, and risk communication. Risk assessment estimates adverse effects on human health using pathophysiological and epidemiological methods that relate to potentially hazardous components [8]. More specifically, quantitative microbial risk assessment (QMRA) evaluates the risks that are related to the utilization of a specific food/ingredient and provides an appraisal of the level of illness that a particular pathogen can cause in a population who are exposed to contaminated food [10].

A preliminary microbial risk assessment of ready-to-eat vegetable salads in Bangladesh Agricultural University (BAU) was undertaken by Younus *et al.* [11], with the key result that ~20% of students who consumed such salads became infected with at least one foodborne species of bacteria. However, that study was undertaken with relatively small numbers of participants, so more generalizable results need to be developed. At present, around 10,000 students are studying in BAU, most of whom are resident on the campus. This densely-populated campus is serviced by many food vendors and restaurants, who, as with most urban fast food providers, are not subject to stringent food safety and hygiene standards. Using the campus as a model of a dense urban population, and with regard to the results of Younus *et al.* [11] of the likelihood of food contamination amongst its fast food premises, the opportunity was taken to determine the contribution of restaurant workers to the microbial contamination of fast foods in different restaurants.

The present research was designed to, for fast food premises on the BAU campus: (1) Determine the presence and total viable bacterial load of common bacterial pathogens (with special emphasis on *Staphylococcus* spp.*, Salmonella* spp., and *E. coli* and (2) undertake microbial risk assessment of fast food items using Monte Carlo simulation, an exponential predictive model.

Materials and Methods

Ethical approval and informed consent

No ethical approval was required; however, during sample collection and survey, verbal permission was taken from restaurant vendors and consumers.

Selection of sampling sites

The study was carried out in and around the campus of BAU, Mymensingh, Bangladesh, between January 2017 and December 2017. There are nearly 50 fast food outlets that are distributed in seven major locations around the BAU campus. Two outlets in each of five of these locations were selected for sampling based on the volume of sales and the density of outlets in the location. The sampling program involved (i) microbiological sampling of food that was for sale at these outlets, (ii) a questionnaire-based study of food handling practices, and (iii) verbal questioning of consumers (purchasers) to evaluate the consumption pattern of fast foods.

Microbiological samples

From each of the 10 selected fast food outlets, at two different time points, six items (i.e., shingara, samosa, piazu, puri, potato chop, and beguni) were acquired as though being purchased and consumed by consumers frequently. Each item (i.e., sample) placed in a labeled sterile polyethylene container and transported on ice to the laboratory. After weighing, the sample was ground in a sterile mortar and pestle. The sample was then mixed with nine volumes of sterile distilled water in a sterile blending machine. Thereafter, serial 10-fold dilutions (10^{-1}-10^{-6}) were made from each sample.

Aliquots (0.1 mL) of each dilution of each sample were inoculated onto microbiological culture media: Nutrient agar, Mannitol salt (MS), Salmonella-Shigella (SS), and eosin methylene blue (EMB) agar. After 24 h of incubation at 37°C, colonies that were golden-yellow, had a black center or metallic sheen color colonies which were observed in MS, SS, and EMB agar were identified as *Staphylococcus* spp., *Salmonella* spp., and *E. coli,* respectively. After that, 30-300 distinct colonies containing plates of each specific media were counted and recorded as colony-forming unit (cfu)/g of fast food samples.

Evaluation of food handling practices

General observations were obtained from various restaurants through observational questions to justify the food handling practices conducted by restaurant workers during sales. On each occasion, when food samples were collected, the following observations were made: (i) Types of fast food served in that restaurant; (ii) the area where fast food is stored or kept for sale; (iii) types of utensil used to serve food; and (iv) practice of the food handlers during serving the fast food. Furthermore, vendors were asked about their food handling practices such as: (i) If they reheat the food before sale; (ii) how they manage the leftover food; and (iii) any training received on hygienic food preparation and handling.

Verbal evaluation of fast food consumption patterns

A total of 200 questionnaires were distributed to consumers comprising 100 males and 100 females from each restaurant randomly, 10 male and 10 female consumers were asked to fill up the questionnaires. They were asked to answer the following questions: (i) How old they were; (ii) how frequently

they consume fast food; (iii) from which source they consume the fast food; (iv) why they eat fast food; (v) if any disease experienced just after having the fast food; and (vi) what type of disease or discomfort they felt. The questionnaires were collected instantly after they wrote the answers by themselves.

Microbial risk assessment

Microbial risk assessment comprises the four steps of hazard identification, hazard characterization, exposure assessment, and risk characterization [12]. The microbial risk associated with fast food handling practices in the present study was conducted as described by Amoah [13], as follows.

Hazard identification

Microbiological risk assessment starts with hazard identification. These hazards were prospectively identified as *Staphylococcus* spp., *Salmonella* spp., and *E. coli* contamination of fast food products. These organisms were selected as the model QMRA organisms as they are commonly present in food samples.

Dose-response assessment (hazard characterization)

Hazard characterization describes the adverse health effects associated consumption of microorganisms using dose-response relationships. An exponential dose-response model [14] was used in this study to predict the probability of *Staphylococcus* spp., *Salmonella* spp., and *E. coli* infection, based on microbial analysis of the selected organism. The equation used for determining the probability of infection is as follows:

$$P(d) = 1 - e^{-rd}$$

Where, $P(d)$ is the probability of infection, d is the dose (cfu) of microorganisms consumed per person per day, and r is dimensionless infectivity constant. The model parameter "r" used was 7.64×10^{-8} for *Staphylococcus* spp. [14], 3.97×10^{-6} for *Salmonella* spp. [15], and 2.18×10^{-4} for *E. coli* [16].

The final dose (d) of microorganisms consumed by per person per serving was as the product of the weight of food consumed and the quantity of organisms present per gram of food (estimated as 50-70 g per serving, based on serving size and consumers' statements of quantities that they consumed). Separate risks were estimated according to each food item. The final doses of *Staphylococcus* spp., *Salmonella* spp., and *E. coli* consumed per serving were inputted into the mathematical model to obtain the probability of infection per day.

Exposure assessment

This step of microbial risk assessment deals with amount of food consumed and the frequency of consumption of food for a specified period of time to evaluate the consumer's exposure to microorganisms associated with particular food with a defined period. Three exposure scenarios were estimated, namely, frequent (daily), average (weekly), or occasional (monthly) consumption of each fast food type, as described by Amoah [13].

Risk characterization

This step integrates the previous three steps and estimates the probability of infection in resulting from exposure to hazards in every scenario. The annual probability of infection for each scenario was calculated from the probability of infection and the number of days of exposure within the year.

$$P_{ann} = 1 - \{1 - P(d)\}^n$$

Where, n is the number of days of exposure within the year.

Statistical analysis

Data were entered into SPSS 25.0 (IBM Corporation, USA) for descriptive analysis. One-way ANOVA was performed to compare difference among the foods and statistical significance of difference between means was tested at 95% confidence level ($p < 0.05$) by Tukey's multiple test [17]. For each of the exposure scenarios, a Monte Carlo simulation was run using Microsoft Excel at risk software version 7.5.0 (Palisade Corporation) sampling 10,000 iterations to determine the annual risk of infection for each exposure scenario.

Results

Basic data

The average microbial load of all fast food items is shown in Table-1. The highest aerobic plate count (APC) was present in piazu samples (7.24 log cfu/g) and the lowest in samosa samples (6.92 log cfu/g). *Staphylococcus* spp. count was highest in puri samples (5.15 log cfu/g) and lowest in beguni samples (4.67 log cfu/g). The highest and lowest *E. coli* counts were present in puri and piazu samples (4.58 log cfu/g vs. 4.10 log cfu/g), respectively. The highest *Salmonella* spp. count (4.22 log cfu/g) was present in samosa samples and the lowest (3.67 log cfu/g) in shingara samples. The average mean difference of APC, *Staphylococcus* spp., *E. coli,* and *Salmonella* spp. among all ready-to-eat fast food items was not statistically significant ($p < 0.05$), but the significant differences were observed in individual food items among the selected restaurants.

All six fast food items were prepared by the majority of the outlets. Handling practices utilized by outlet workers are summarized in Table-2. Key results were that food was stored in an open place in environmental temperature (30-40°C) in 72% of outlets; shared utensils were utilized to serve all of the different types of food; workers did not use gloves for handling food; leftover food was sold on the next day by all outlets, and workers had not received any training on hygienic food preparation and handling. On the other hand, none of the outlets reheated food before the sale.

Table-1: Average microbial load of all ready-to-eat fast food samples.

Item (n=120)	Microbial load (log cfu/g±SD)			
	APC	***Staphylococcus* spp.**	***Salmonella* spp.**	***Escherichia coli***
Shingara (n=20)	7.12±0.42	4.69±0.61	3.67±0.10	4.28±0.56
Samosa (n=20)	6.92±0.45	4.77±0.70	4.22±0.64	4.52±0.39
Piazu (n=20)	7.24±0.09	4.71±0.33	-	4.10±0.54
Puri (n=20)	6.96±0.44	5.15±0.44	3.96±0.47	4.58±0.50
Potato chop (n=20)	7.03±0.59	4.84±0.03	4.07±0.55	4.35±0.54
Beguni (n=20)	6.94±0.50	4.67±0.62	4.04±0.46	4.20±0.40

According to the International Commission for Microbiological Specifications for Foods (ICMSF, 2002), acceptable ranges of APC, *Staphylococcus*, and *Escherichia coli* are 10^6 cfu/g (6 log cfu/g), 10^4 cfu/g (4 log cfu/g), and 10^2 cfu/g (2 log cfu/g), respectively, and detection of any *Salmonella* spp. in a 25 g sample is unacceptable. APC=Aerobic plate count, cfu=Colony-forming unit, SD=Standard deviation

Table-2: Fast food handling practice details.

Parameter	Parameter	Frequency (n=50)	Percentage
Types of fast foods	Shingara	50	100
	Samosa	50	100
	Piazu	44	88
	Puri	50	100
	Potato chop	34	68
	Beguni	40	80
Fast food store or kept for sale	Open place	36	72
	Enclosed area	14	28
Utensil used to serve food	Designated serving utensil	0	0
	Shared utensil	50	100
Fast food served by food handlers	Gloves protected hand	0	0
	Bare hand	50	100
Reheat food before sale	Yes	0	0
	No	50	100
Management of leftover food	Throw it away	0	0
	Eat home	0	0
	Sell it following day	50	100
	Give to beggars	0	0
Any training received on hygienic food preparation and handling	Yes	0	0
	No	50	100

Fast food consumption data are summarized in Table-3. The majority (53.5%) of respondents were between 20 and 25 years of age, and most consumed fast foods from on-campus outlets (51.5%) or university canteens (43.5%). Fast foods were consumed every day by 31% of the respondents, 42% once per week, and 18.5% once per month. A total of 61% of respondents had experienced disease that they associated with eating fast foods. Of these, gastric reflux/abdominal cramp, not associated with vomiting, was reported by 31% of respondents.

Overall, there was 57% chance of being infected by fast food items consumed by total consumers. Among these, males had 49% chance and females had 67% chance of being infected. Frequent consumers (daily) had a higher chance (63%) of becoming infected than other type of consumers. Respondents aged between 25 and 30 years of age had a higher chance (58%) of being infected after consumption of fast food items in relation to the respondents below 20 years of age (Table-4).

Risk analysis
Staphylococcus spp.

The dose-response assessment after Monte Carlo simulation showed that the mean probability of *Staphylococcus* spp. infection was 78% (90% confidence interval [CI]: 4-234%) in puri samples (highest) versus 24% (90% CI: 1-71%) in piazu samples (lowest). The mean annual risk of *Staphylococcus* spp. infection was similar for all three consumption frequencies (daily, weekly, and monthly) at 110%, with minimum and maximum risk ranging from 100% to 213% (Table-5). The result demonstrates that approximately 110 out of 100 consumers had a chance of getting an infection with *Staphylococcus* spp. after consumption of fast food, regardless of the frequency of consumption.

Salmonella spp.

The probability of *Salmonella* spp. infection highest at 99% (90% CI: 5-296%) in samosa and potato samples versus other food items (for example, the probability for shingara samples was 77% [90% CI: 4-234%]). The annual risk of *Salmonella* spp. infection did not differ between exposure frequencies: The annual probability infection of *Salmonella* spp. was 110% in frequent, average, and occasional consumers, in whom the risk of infection varied from 100% to 226% (Table-6).

Table-3: Fast food consumption details.

Parameter	Consumer	Distribution of respondents			Percentage
		Male (n=100)	Female (n=100)	Total (n=200)	
Age	Below 20	27	10	37	18.5
	20-25	40	67	107	53.5
	25-30	33	23	56	28.0
Fast food consumption frequency	Every day	37	25	62	31.0
	Once in week	36	48	84	42.0
	Once in month	17	20	37	18.5
	Unspecified	10	7	17	8.5
Source from which fast food is consumed	Home	3	3	6	3.0
	Restaurants	57	46	103	51.5
	Canteen	37	50	87	43.5
	Others	3	1	4	2.0
Reason for eating fast food	Health benefits	0	1	1	0.5
	Taste	85	71	156	78.0
	Esthetic appeal	9	12	21	10.5
	Social interaction	4	8	12	6.0
	Others	1	9	10	5.0
Disease experienced	Yes	55	67	122	61.0
	No	45	33	78	39.0
Types of diseases	Acidity	24	38	62	31.0
	Vomiting	1	9	10	5.0
	Abdominal discomfort	14	12	26	13.0
	Others	16	8	24	12.0
	None	45	33	78	39.0

Table-4: Risk assessment of consumers according to different parameter.

Parameter	Consumers	Number of consumers (n)	Case findings (d)	Risk (d/n)	Percentage
Sex	Male	57	28	0.49	49
	Female	46	31	0.67	67
Type of consumers	Frequent	32	20	0.63	63
	Average	38	22	0.58	58
	Occasional	26	13	0.50	50
	Unspecified	7	4	0.57	57
Age	<20	25	11	0.44	44
	20-25	53	30	0.57	57
	25-30	25	18	0.72	72

Table-5: Risk assessment of *Staphylococcus* spp. in all ready-to-eat fast food items.

Ready-to-eat fast food items	Mean dose of organisms per serving (cfu)	Mean probability of infection (90% CI)	Mean annual risk of infection (90% CI)		
			Frequent consumer (daily)	Average consumer (weekly)	Occasional consumer (monthly)
Shingara	7.73×10^6	44 (2-131)	110 (100-206)	110 (100-193)	110 (100-200)
Samosa	1.15×10^7	58 (3-174)	110 (100-199)	110 (100-193)	110 (100-197)
Piazu	3.60×10^6	24 (1-71)	110 (100-207)	110 (100-187)	110 (100-200)
Puri	2.0×10^7	78 (4-234)	110 (100-192)	110 (100-211)	110 (100-204)
Potato chop	5.98×10^6	37 (1-110)	110 (100-193)	110 (100-192)	110 (100-206)
Beguni	6.01×10^6	37 (1-110)	110 (100-195)	110 (100-213)	110 (100-187)

cfu=Colony-forming unit, CI=Confidence interval

E. coli

The probability of *E. coli* infection was 100% in all fast food items, although the CI was wide (90% CI: 5-300%). This organism also showed similar results of annual risk of infection to the previous two organisms: Consumers had 110% chance of becoming infected with *E. coli* after consuming fast food items (Table-7).

Discussion

The substantive results of this study are, first, that microbiological contamination of fast food samples was widespread and at a high level. All microbiological parameters (APC: 6.9-7.2 log cfu/g, *Staphylococcus* spp. count: 4.7-5.2 log cfu/g, *Salmonella* spp. count 3.7-4.2 log cfu/g, and *E. coli* count: 4.1-4.6 log cfu/g) from all fast food samples were well above the acceptable limits recognized by the International Commission for Microbiological Specifications for Foods [18]. Parallel studies undertaken in other developing countries have shown similar results. Akusu *et al.* [19], who studied different ready-to-eat fast food samples in Rivers State,

Table-6: Risk assessment of *Salmonella* spp. in all ready-to-eat fast food items.

Ready-to-eat fast food items	Mean dose of consumption per serving (cfu)	Mean probability of infection (90% CI)	Mean annual risk of infection (90% CI)		
			Frequent consumer (daily)	Average consumer (weekly)	Occasional consumer (monthly)
Shingara	3.70×10^5	77 (4-231)	110 (100-206)	110 (100-192)	110 (100-185)
Samosa	1.87×10^6	99 (5-296)	110 (100-194)	110 (100-195)	110 (100-226)
Piazu	Not recovered				
Puri	1.02×10^6	98 (5-294)	110 (100-195)	110 (100-205)	110 (100-202)
Potato chop	1.26×10^6	99 (5-296)	110 (100-200)	110 (100-197)	110 (100-192)
Beguni	9.24×10^5	97 (5-290)	110 (100-216)	110 (100-200)	110 (100-198)

cfu=Colony-forming unit, CI=Confidence interval

Table-7: Risk assessment of *Escherichia coli* in all ready-to-eat fast food items.

Ready-to-eat fast food items	Mean dose of consumption per serving (cfu)	Mean probability of infection (90% CI)	Mean annual risk of infection (90% CI)		
			Frequent consumer (daily)	Average consumer (weekly)	Occasional consumer (monthly)
Shingara	2.37×10^6	100 (5-300)	110 (100-193)	110 (100-197)	110 (100-266)
Samosa	3.0×10^6	100 (5-300)	110 (100-195)	110 (100-200)	110 (100-197)
Piazu	1.22×10^6	100 (5-300)	110 (100-205)	110 (100-195)	110 (100-194)
Puri	5.17×10^6	100 (5-300)	110 (100-192)	110 (100-208)	110 (100-197)
Potato chop	1.97×10^6	100 (5-300)	110 (100-196)	110 (100-195)	110 (100-215)
Beguni	1.25×10^6	100 (5-300)	110 (100-206)	110 (100-197)	110 (100-202)

cfu=Colony-forming unit, CI=Confidence interval

Nigeria, found the mean viable counts of bacteria, coliforms, and SS on meat-based fast food products were 6.6 log cfu/g, 4.2 log cfu/g, and 4.3 log cfu/g, respectively. Adimasu *et al.* [20] also reported coliforms (4.05 log cfu/g), *S. aureus* (4.17 log cfu/g), and *Salmonella* spp. (4.20 log cfu/g) in street-vended fast food samples in Gondar, Ethiopia. Khandoker *et al.* [21] noted total viable count ranged from log 4.5 to 5.4 cfu/g, total staphylococcal count ranged from log 4.4 to 5.2 cfu/g, and total coliform count ranged from log 1.4 to 4.3 cfu/g in spicy puffed rice samples. While there is some variation in actual cfu counts between studies (perhaps, due to types of foods sampled or to handle and personal hygienic practices during fast foods preparation and serving), it is clear that microbiological contamination of such foods is substantial and significant.

In the present study, 72% restaurants kept or stored food in the open place in environmental temperature (30-40°C) favorable for microbial growth, shared utensils were used to serve foods without proper cleaning, restaurant workers did not use any gloves while serving consumers, and none of the restaurant workers had had training on hygienic food preparation and handling practices. These above factors might be caused of increased microbial load in the tested food items. Leftover food was sold in the following day. These trends reflect those of similar investigations. For example, Adimasu *et al.* [20] in Gondar, Ethiopia, reported that only 16 (40%) participants out of 40 had knowledge about the contamination of fast foods. Likewise, Bereda *et al.* [22] (Jigjiga City, Ethiopia) also noted that while 59% of vendors washed food before cooking, 83.3% used filthy surfaces, and 25% utilized reused oil for the preparation of food.

Choudhury *et al.* [23] reported similar findings from Guwahati, Assam, India, where only 37% of vendors were aware of hygienic food handling and preparation, and few of them were aware of biological sources that are responsible for foodborne diseases.

This level of contamination, together with a lack of awareness about the principles of food hygiene, results in a large proportion of the population being at risk of foodborne disease. Most respondents in the present study consumed fast foods (43.5% from canteens and 51.5% from fast food vendors) and most did so often (18.5% at least once a day and 31% once a week). The high level of major or minor, food-related illnesses confirms the level of risk to the population: 61% of respondents experienced some form of disease and, even though the most common complaint was "acidity" (31%), nearly 30% of respondents also reported more serious diseases such as vomiting or abdominal cramps. The preliminary work of Younus *et al.* [11] who reported on ready-to-eat vegetables salads in the BAU campus found that 18/88 respondents developed symptoms of foodborne disease after eating such food.

From this study, it was found that the mean annual risks of *Staphylococcus* spp., *Salmonella* spp., and *E. coli* infection in all three categories of consumers were 110% (90% CI: 100-130%) for frequent, average, and occasional consumers. The annual risk of *Staphylococcus* spp., *Salmonella* spp., and *E. coli* infection for frequent, average, or occasional consumers was approximately 10^1 (i.e., 11, 11, and 11 out of 10 ready-to-eat fast food consumers, respectively). In other words, there is 100% chance of getting infected with these pathogens to all three categories of consumers of fast foods from the tested fast food vendors.

This figure is very substantially above the level of risk that is acceptable to the WHO (10^{-2}-10^{-4} per person per year: [24]).

Women appeared to be at higher risk of developing signs of foodborne disease than men (67% vs. 49%), but biologically-significant result is unclear due to the modest sample size. On the other hand, the higher risk of frequent (daily) than weekly or monthly fast food consumers developing clinical signs (63%, 58%, and 50%, respectively) does appear to be consistent with the microbiological risk analysis. The age distribution of clinical signs is interesting, in as much as a higher proportion of older (25-30 years old) participants developed clinical signs than did those of younger age groups (<20 years: 35%, 20-25 years: 48%, and 25-30 years: 63%).

Taken together, there is an interesting dichotomy between the risk found after determining the dose (cfu/g) of fast foods using Monte Carlo simulation and the reported proportion of participants who developed foodborne illnesses. On the one hand, there was an immense number of potentially pathogenic microorganisms found in the microbiological analysis and there would be about a 100% chance of being infected. However, the self-reported risk of clinical illness determined by the questionnaire demonstrated that consumers have only 57% chance of developing clinical signs associated with eating those fast foods. Presumably, this discrepancy relates to a degree of immunity or resistance to infection in consumers. The findings of our study have to be considered in light of some limitations. First, the sample size was small because of the time limit, and second, we collected samples at a single time point from the fast food outlets. Hence, additional research might be directed toward trying to characterize better the epidemiological associations between food type, level and species of contaminating organisms, and human demographic characteristics in a much larger sample population.

Conclusion

The present study has demonstrated that fast foods sold in and around the BAU campus are contaminated with common indicator bacteria. Furthermore, the majority of restaurant vendors have had no training in managing food safety and foodborne disease such that there were poor personal hygiene, handling practice, prolong storage of foods in ambient temperature, and selling of leftover food after the following day. Hence, it is necessary to ensure education facilities and food safety training program for all the restaurant vendors that might decrease the risk of infection and deliver safe food. At the same time, consumers should also be aware of the unhygienic facts of fast foods and encourage food vendors to follow the food safety rules and regulations. The most important outcome would be for regular monitoring by the health ministry, with strict law implementation, to enhance the hygienic practices of fast food outlets.

Authors' Contributions

AAMS and ZFH carried out the research, analyzed the data, and wrote the initial draft of the manuscript. MIY, AP, and NB helped in data collection. MGH contributed to manuscript writing. SS and MAI designed and supervised research work, revised, and finalized the manuscript. All authors read and approved the manuscript before submission.

Competing Interests

The authors declare that they have no competing interests.

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