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Original Research Article

Outbreak of *Salmonella* food poisoning in a training institute: an epidemiological approach

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ABSTRACT

Background: On 04th April 2020 night report was received from the local hospital that 32 students from the training institute had reported, with complaints of diarrhea; and fever. The investigation team reported to the training institute. Objectives of this investigation were as follows: (a) To identify the incriminating food item(s), (b) To identify the factors leading to food contamination, (c) To identify the agent responsible for the outbreak.
Methods: The study design was a retrospective descriptive epidemiological study. The study population included students dining in the Mess; and staff. Epidemiological investigation was conducted using descriptive epidemiology. Stool samples of cases, samples of prepared meals; and water samples from the Mess were sent for bacteriological examination. Hygiene of the mess, supply chain, personal hygiene of food handlers; and relevant documents were checked.
Results: Total 116 cases reported during the outbreak with two peaks. All cases were dining in the Mess. All cases had diarrhoea; and 75 (64.65%) had abdominal pain. 109 (93.96%) cases were treated as outpatients. Average duration of illness was 2-3 days. Refrigeration of egg storage was defunct. Laboratory reports were positive for coliforms in rajma, milk and chicken curry. Epidemiologically, the incriminated food item was found to be egg bhurji as per attack rate and relative risk. Clinico-epidemiologically, cause of this food poisoning appears to be *Salmonella*.
Conclusions: Detailed epidemiological investigations, laboratory investigations and environmental survey was carried out. Clinico-epidemiologically the causative organism was suspected to be *Salmonella* due to consumption of contaminated egg bhurji.

Keywords: Food poisoning, Outbreak, *Salmonella*

INTRODUCTION

An illness caused by consumption of food or water, which may be contaminated with bacteria and/or bacterial toxins, parasites, viruses or chemicals constitutes the definition of food poisoning. Food poisoning symptoms vary not only in degree but also in combination. These symptoms include abdominal pain, vomiting, diarrhea; and headache. In severe cases, life-threatening neurologic, hepatic, and renal syndromes leading to permanent disability or death may also occur. In some cases, severe disease may necessitate hospitalization, aggressive management of dehydration, besides antibiotic treatment.[1] A food borne disease outbreak is defined by the following 2 criteria: 1) Similar illness, often gastrointestinal, in 2 or more people, 2) Evidence of food as the source. Worldwide, foodborne infections constitute a major cause of morbidity and mortality. Foodborne infections are the cause of death of many children in developing countries. Diarrhoea resulting from food borne infections can have long term on the growth of

children. It may also have a deleterious effect on their physical and cognitive development. Healthcare systems in industrialized countries, are also heavily affected on account of illness caused by foodborne infections.[2] Food borne illnesses may follow ingestion of infectious microorganisms or noninfectious substances. They include botulism, gastroenteritis following ingestion of preformed *Staphylococcus aureus* toxin, which are toxin mediated food poisoning. Food poisoning may also occur on account of bacterial, parasitic, and viral infections, besides ingestion of chemicals in foods.[3]

On 04 Apr 2020 around 2000 h report was received from the local hospital that 32 students from the training institute had reported to the MI room since that morning, with complaints of diarrhea, fever, abdominal pain and vomiting. After discussing the preliminary steps to be taken at that time, the epidemic investigation team reported to the training institute the next morning.

The training institute has around 2000 students residing in 18 blocks (named A to R) on the campus. The students consume all the meals in the Central mess. The mess has a large dining hall in each wing – the West Wing and the East Wing. The students dine from a central mess according to the block to which they belong. This is ensured by the specific seating arrangement in the dining hall of the respective mess.

The fresh ration including non-veg is issued by a contractor thrice a week, whereas eggs are issued once a week. The eggs, meat, chicken, and fish are stored in a walk-in freezer room located near the kitchen and the other fresh ration is stored in a separate room. The dry ration is issued once every fortnight and is stored in dry ration storeroom. There is also a bakery in the mess premises for baked food items.

The outbreak was investigated with the following objectives. (a) To identify the incriminating food item/items, (b) To identify the factors that led to contamination of the food item/s, (c) To identify the biological or chemical agent responsible for the outbreak, (d) To make suitable recommendations based on scientific analysis.

Dimensions of investigation

The outbreak was investigated under the following dimensions to achieve the above objectives: (a) Epidemiological investigation, (b) Environmental investigation, (c) Laboratory investigation.

METHODS

Research design

The study design was a retrospective descriptive epidemiological study.

Study population

The study population included students consuming meals prepared in the West Wing of the Central Mess and the respective staff working there.

Inclusion criteria

Students of the training institute who consumed meals prepared in the West Wing of the Central Mess between 02 to 05 Apr 2020.

Exclusion criteria

Any student who was already suffering from pain abdomen/vomiting/loose stools before 2100 hrs on 03 Apr 2020.

Exposure definition

History of consumption of incriminated food items from 02 to 06 Apr 2020 from the West Wing of the Central Mess by cases.

Case/outcome definition

Any person presenting with diarrhoea and/or any of the two symptoms viz. pain abdomen, vomiting, fever/ headache between 04 Apr and 06 April 2020, who was dining/working in West Wing of the Central Mess of the training institute.

Potential confounder

Exposure history regarding all potential confounders viz. other food items and drinks from any other source from 02 to 06 Apr 2020, which is unlikely since all the other eateries in the training institute were closed on account of the ongoing Covid19 pandemic

Selection of cases

All cases were available and were included in the study.

Data collection

A detailed epidemiological investigation was conducted including, confirmation of existence of outbreak and verification of diagnosis, line listing of cases, defining the population at risk, development of a case definition and the epidemiological case sheet. Subsequently the final line list was prepared and descriptive epidemiology was utilized to describe the outbreak.

Data was collected from cases using interviewer administered pretested semi-structured questionnaire. Relevant epidemiological history was obtained from each and every case. The same was recorded on an epidemiological case sheet. Case sheets and laboratory

reports were thoroughly scrutinized for unusually high incidence of other food and water borne diseases. Search for more cases using the case definition and collection of data using the epidemiological case sheet, was also carried out. The workers liaised with several private practitioners and Government Civil hospital of the city, in order to search for more cases. However, no additional cases were found by medical survey other than those who had already reported sick. Surveillance data obtained from all the above sources was analysed. Detailed environmental survey of the affected area was also carried out.

Hypothesis generation

Based on the common food history possible hypotheses in terms of the likely incriminated food item/s was drawn and an analytical study was planned to test these hypotheses. Since, there were over 2000 students in the campus; it was difficult to carry out a cohort study. Hence, a, simpler and more practical approach of case control study design was planned.

Lab investigations

Stool samples of students admitted were collected on 04 Apr 2020 and were sent for investigation to Pathology laboratory the local hospital. Food samples of prepared meals that were stored in the walk-in freezer room of 2nd and 2nd April 2020 were sent for microbiological examination to the local hospital Water samples from all affected blocks and West Wing of the Central Mess were also sent for bacteriological examination.

Environmental investigations

Overall general hygiene and sanitation of the Central Mess was assessed including the kitchens, storing facilities for raw and prepared food items. Hygiene of the supply chain of the specific food items which were suspected to be involved in food poisoning based on epidemiological study results, were also assessed in detail. Personal hygiene of all food handlers was checked. All relevant documents, registers, including menu record and medical exam of food handlers' register were also thoroughly scrutinized.

Inference

Finally, inference was drawn based on all the above scientific and epidemiological analysis.

RESULTS

Descriptive epidemiology

Age and gender distribution of cases: The age of cases ranged from 18 years to 22 years with median age of 19 years. All cases were males.

Distribution of cases as per time: A total of 116 cases reported from 04 to 08 Apr 2020 during the outbreak. All cases were dining in West Wing of the Central Mess at the training institute. The distribution of cases based on date onset of symptoms; and whether admitted or treated on OPD basis is given in Table 1. Epidemic curve depicting hour wise and day wise occurrence of cases is depicted in Figure 1.

Table 1: Distribution of cases by frequency and date of reporting (n=116).

Date	No. of cases reported (excl those admitted)	No. of cases admitted	Total
03 Apr 2020	04	00	04
04 Apr 2020	53	02	55
05 Apr 2020	04	01	05
06 Apr 2020	48	04	52
07 Apr 2020	00	00	00
Grand total	109	07	116

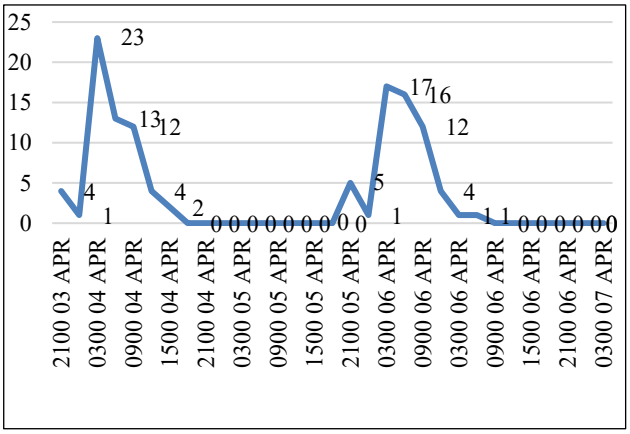

Figure 1: Epidemic curve depicting hour wise and date wise distribution of cases.

The onset of symptoms in the first case was at 2100 hrs on 3rd April 2020, cases peaked at around 0600 hrs on 04 Apr 2020 followed by a gradual decline. The last case reported at 1800 hrs on 06 Apr 2020. The epidemic curve in Figure 1 shows a biphasic pattern with sharp incline and rapid decline in number of cases twice which signifies two exposures, common source outbreak which is consistent with the food poisoning. About 50% of cases of first peak had occurred by 0600 hours on 04 Apr 2020 and similarly 50 % of cases of second peak occurred by 0900 hours on 6th April 2020, which corresponds to the median incubation period from point source exposure.

Distribution of symptoms among cases: Out of total 116 cases, all had diarrhoea, 75 (64.65%) abdominal pain, 52 (44.82%) fever, 17 (14.65%) vomiting and 10 (8.62%) had headache. The frequency of diarrhoea varied from 3-12 per day and was semisolid to watery in consistency. Majority of cases 109 (93.96%) were treated as outpatient with ORS and antibiotics (Norfloxacin and Tinidazole)

and only 07 (06.03%) required admission in the hospital. The illness lasted for an average of 2-3 days.

Distribution of cases by block: The total of 116 cases reported from 11 blocks. Maximum number of cases reported from M, followed by Q block, which were 29 and 18, respectively. However, when cases were described as per the mess they were eating from, it was observed that all the cases had consumed meals from West Wing of the Central Mess. The observed clustering of the cases in the specific blocks was mainly because of the specific mess to which they were affiliated. The distribution of cases by blocks is depicted in Figure 2.

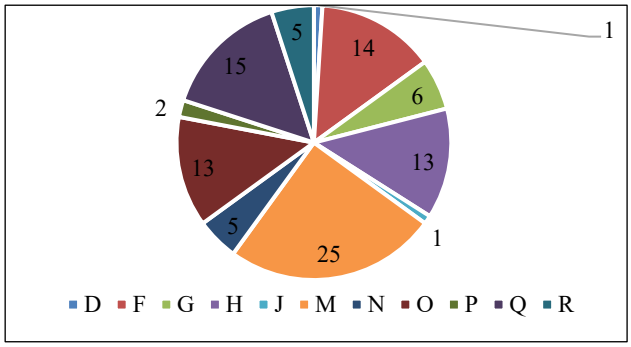

Figure 2: Distribution of cases as per blocks (n=116).

Distribution of food items consumed among cases: There was only one item which was eaten by all the cases, which was bread in breakfast on 3rd Apr 2020 but none among the vegetarian students had fallen sick. Hence, the possibility of bread being the incriminating food was ruled out. Based on the observed median incubation period of approx. 20 hrs from the time of consumption of the incriminated food (breakfast on 3rd Apr 2020), clinical picture of the cases and known incubation period of suspected pathogens, the most likely cause of this food poisoning appears to be *Salmonella* food poisoning, from the food item egg bhurji. The incubation period of *Salmonella* food poisoning varies between 6 and 72 hrs (median incubation period being 18 hrs). The symptoms are predominantly fever, abdominal pain and diarrhoea associated with nausea/vomiting, headache and body ache. The illness usually lasts for 2-7 days without any major complications. This clinico-epidemiological picture resembles closely with present food poisoning. Relative risk and attributable risk of each food item is presented in Table 2.

Chart describing correlation of clinical picture with microbiological cause is presented in Table 3.

Table 2: Relative risk and attributable risk of each food item.

Food item	Consumed the item				Did not consume the item					
	Ill	Not ill	Total	Attack Rate (%)	Ill	Not ill	Total	Attack Rate (%)	Rr	AR (%)
03 Apr_B_Boiled egg	106	870	976	10.86	10	114	124	8.06	1.35	2.80
03 Apr _B_Egg bhurji	114	536	650	17.54	2	448	450	0.44	39.46	17.09
03 Apr _B_Bread	116	984	1100	10.55	0	0	0	0.00	0.00	0.00
03 Apr _B_Veg cutlet	70	730	800	8.75	46	254	300	15.33	0.57	-6.58
03 Apr _L_Fish kofta	100	740	840	11.90	16	244	260	6.15	1.93	5.75
03 Apr _L_ Rajma	102	978	1080	9.44	14	6	20	70.00	0.13	-60.56
03 Apr _L_Rice	100	970	1070	9.35	16	14	30	53.33	0.18	-43.99
03 Apr _L_Cauliflower and potatoes	114	976	1090	10.46	2	8	10	20.00	0.52	-9.54
03 Apr _L_Roti	104	970	1074	9.68	12	14	26	46.15	0.21	-36.47
03 Apr _L_Curd	90	960	1050	8.57	26	24	50	52.00	0.16	-43.43
03 Apr _L_Banana	96	964	1060	9.06	20	20	40	50.00	0.18	-40.94
03 Apr _D_Chicken curry	99	748	847	11.69	17	236	253	6.72	1.74	4.97
03 Apr _D_Rice	95	955	1050	9.05	21	29	50	42.00	0.22	-32.95
03 Apr _D_Malai brinjal	103	972	1075	9.58	13	12	25	52.00	0.18	-42.42
03 Apr _D_Roti	96	972	1068	8.99	20	12	32	62.50	0.14	-53.51
03 Apr _D_Fruit custard	106	924	1030	10.29	10	60	70	14.29	0.72	-3.99
05 Apr_B_Boiled egg	101	873	974	10.37	8	104	112	7.14	1.45	3.23
05 Apr _B_Egg bhurji	95	730	825	11.52	14	247	261	5.36	2.15	6.15
05 Apr _B_Bread	97	850	947	10.24	12	127	139	8.63	1.19	1.61
05 Apr _B_Veg dalia	74	915	989	7.48	35	62	97	36.08	0.21	-28.60
05 Apr _L_Rice	92	780	872	10.55	17	197	214	7.94	1.33	2.61
05 Apr _L_Chana dal	98	950	1048	9.35	11	27	38	28.95	0.32	-19.60
05 Apr _L_Cabbage	99	957	1056	9.38	10	20	30	33.33	0.28	-23.96
05 Apr _L_Roti	95	960	1055	9.00	16	17	33	48.48	0.19	-39.48
05 Apr _L_Boondi raita	104	956	1060	9.81	5	21	26	19.23	0.51	-9.42
05 Apr _L_Apple	97	971	1068	9.08	12	6	18	66.67	0.14	-57.58

Continued.

Food item	Consumed the item				Did not consume the item					
	Ill	Not ill	Total	Attack Rate (%)	Ill	Not ill	Total	Attack Rate (%)	Rr	AR (%)
05 apr _d_Butter chicken	80	817	897	8.92	29	160	189	15.34	0.58	-6.43
05Apr _D_Rice	85	930	1015	8.37	24	47	71	33.80	0.25	-25.43
05 Apr _D_Dum aloo	95	934	1029	9.23	14	43	57	24.56	0.38	-15.33
05 Apr _D_Roti	90	961	1051	8.56	19	12	31	61.29	0.14	-52.73
05 Apr _D_Rice kheer	89	920	1009	9.35	20	60	80	25.00	0.37	-15.65

Legend: B = Breakfast, L = Lunch, D = Dinner, RR = Relative Risk, AR = Attributable Risk

Table 3: Chart giving correlation of clinical picture with microbiological cause.

Microorganism	Clinical features									
	DIARI	VOM	NAU	FEV	AC	BIS	DE	NS	Median incubation period	Remarks
Staphylococcus aureus	±	+++	+++	-	-	-	-	-	½ to 6 hrs	
Bacillus cereus type I	±	+++	+++	-	-	-	-	-	½ to 6 hrs	
Salmonella typhimurium	+++	+	++	+++	+	-	++	-	14 to 30 hrs	
Clostridium perfringens	+++	±	±	±	+++	-	-	-	12 to 18 hrs	
Bacillus cereus type II	+++	±	±	±	+++	-	-	-	12 to 18 hrs	
Shigella	±	+++	+++	+++	+++	-	++	-	4 to 6 hrs	
Clostridium botulinum	±	+++	+++	+++	+++	-	++	+++	4 to 24 hrs	
Present episode	+++	+	+	+	+	-	++	-	13 hrs	Salmonella typhimurium

Legend: Diarr = Diarrhoea, Vom = Vomitting, Nau = Nausea, Fev = Fever, AC = Abdominal Cramps, BIS = Blood in stools, DE= Dehydration, NS = Neurological Symptoms

Environmental investigation: Environmental investigation was also carried out to further ascertain the role of various environmental factors in the present outbreak. All chefs, food handlers and mess waiters were interviewed and medical records checked. Salient observations were as follows:

Tracing back of egg bhurji (incriminated food item): The supply chain of each of the ingredients of the incriminated food item i.e., egg bhurji, was reviewed. Egg bhurji was prepared using eggs, onions, green chilli and condiments. About 60,000 eggs were received from the contractor and were stored in the walk-in freezer room in the ration store.

On 02 Apr 2020, onions and green chillies were stored in the fresh ration store. Spices were kept in containers which were not covered properly. About 50 kgs onions and one kg fresh green chillies were drawn from ration store a night prior, they were chopped manually by mess workers and kept overnight in uncovered utensils on the kitchen work tops. About 2500 eggs were issued the next morning on 3rd Apr 2020 from the ration store. There was no random check to detect rotten eggs. Eggs were cracked manually by the food handlers. Bhurji was prepared in bulk in a large utensil by mixing all the ingredients and frying it in the oil and was ready at around 0600h. It was kept in the food warmer till around 1000h when the last student consumed it.

Hygiene and sanitation of the cook house and mess: The specific findings regarding critical points which could have contaminated the incriminated food item are as under: i) Refrigeration system of walk-in freezer room where eggs were stored, was non-functional. There was no recording of the temperature; and consequently, no record of temp was available, ii) Refrigeration was not adequately functional in the freezer facility for chicken, since the temperature maintained was well above the recommended temperature, iii) Fly nuisance was observed with evidence of unsatisfactory housekeeping in the mess and cook house, iv) There was no system in place to check for rotten eggs, not even randomly, before using them for cooking and v) Thick cobwebs were found at multiple places on the ceiling and walls

Kitchen no. 1 and 2

Drains inside the kitchen were dirty: i) many of the large sized utensils required thorough scrubbing since there was thick layer of grime along their walls and at the corners, ii) food waste, both raw and cooked was collected in waste bins which were open and overflowing, iii) fresh fruit, both good and spoiled, was kept in the same crate, without segregation, iv) The place for dispensing the drinking water was found to be in a very unhygienic condition and v) large cookers used for cooking, each had a pipe next to it for adding water to cook. Although hooks have been provided adjacent to each cooker for hanging the pipes, yet pipes were hanging and touching the floor when not in use, thereby exposing them to contamination.

Dining hall

Table tops as well as the dining chairs were not adequately clean. It was observed that the food handlers neither wash their hands with soap and water, nor do they wear gloves routinely.

General observations

Food samples were stored for the last 36 hrs. Regular med exam of food handlers was being carried out and all the relevant documents were produced for perusal. Fly nuisance was observed in the food storage area, kitchen 1 and 2 and dining hall. Wire mesh on the doors of the ration store was found to be broken.

Laboratory investigation results

Samples of water were collected and samples of food items already stored in the kitchen were forwarded to the pathology laboratory of the local hospital, Laboratory reports were positive for Coliform organism in Rajma, milk and the chicken curry served on 03 Apr 2020. Besides, the sample of bread served in breakfast on 3rd Apr 2020 showed growth of spore bearing organisms. One of the water samples from the West Wing of the mess showed suspicious result. Stool samples did not grow any pathogenic microorganism.

Inference as to possible causative organism: As per laboratory report Coliform organisms were found in Rajma, milk and the chicken curry served on 04 Apr 2020. No organisms were grown in the egg bhurji. However, epidemiologically, the incriminated food item was found to be egg bhurji as per attack rate and relative risk given in Table 2 above. Based on the observed median incubation period of 20 hrs from the time of consumption of the incriminated food item (egg bhurji), clinical picture of the cases and known incubation period of suspected pathogens, the most likely cause of this food poisoning appears to be *Salmonella* food poisoning.

The workers also observed that a significantly large number of cases kept occurring for nearly 4 days after the onset of the first case. Hence, two exposures to the incriminated food item i.e., egg bhurji cannot be ruled out. This seems plausible because the source of eggs was the same as, out of 60000 eggs delivered by the contractor on 02 Apr 2020, only 2500 were consumed on 03 Apr. So the possibility of the lot being contaminated with *Salmonella* and causing a second exposure due to various other factors, such as poor hygiene, manually cracking the eggs etc. Thus, keeping in view the number of cases in the epidemic curve in Figure 1 above, the workers infer that, in all probability, the first exposure would have occurred on 03 Apr 2020 and the second exposure on 05 Apr 2020.

DISCUSSION

Sixteen cases of Vibrio vulnificus were reported in Los Angeles from 1993 to 1996.[4]

Adak et al reported nearly 1,724,315 cases of indigenous foodborne disease per year, leading to 21,997 hospitalizations and 687 deaths. Commonest causative organism in this report was *Campylobacter* infection (160,788 primary care visits and 15,918 hospitalizations), while salmonellosis caused the most deaths (209).[2]

Two clusters of scombroid (histamine) poisoning were reported by Morroy et al. These were related to consumption of tuna fish.[5] Another outbreak of food poisoning was reported by Juru et al in a girls school.[6] From 1961 to 1998 42% outbreaks of food poisoning of known etiology were reported by Jones et al. This subsequently increased to 65%, due to a significant increase in norovirus outbreaks.[7] Genevieve et al reported 3 cases of botulism related food poisoning in New York, following consumption of home canned peas.[8] Julia et al reported an outbreak of 36 cases of food poisoning due to Norovirus following dining in a restaurant.[9] Danielle et al reported increasing incidence of food poisoning due to *Campylobacter*, *Salmonella* and *Cyclospora* infections from 2015 to 2018.[10] Chicken liver was found to be the incriminating food in several outbreaks in the USA by Lanier et al.[11] Sixty percent of outbreaks reported from 1973 to 1997 were of unknown etiology. In 45% of the outbreaks a specific food vehicle of transmission could not be identified.[12] Outbreaks of food poisoning of unknown etiology have also been reported by Singh et al.[13,14]

The limitation of the present study was that only clinical correlation with causative organism could be carried out. Microbiological confirmation though carried out showed a different food item from the food item which was incriminated epidemiologically on the basis of attack rate and relative risk.

CONCLUSION

A massive outbreak of food poisoning occurred in an training institute. Detailed epidemiological investigations, laboratory investigations and environmental survey was carried out by the workers. Clinically the most likely causative organism was suspected to be *Salmonella* which occurred due to consumption of contaminated egg bhurji.

Recommendations

Based on the epidemiological evidence generated by descriptive epidemiological study, environmental investigations and laboratory investigations the workers propose the following salient recommendations: onions and chillies should be cut fresh before preparing egg bhurji or any other item. If at all they need to be stored overnight, they should be stored in a covered utensil under cold storage. Feasibility to procure mechanised onion chopper may be explored. It can be used to chop bulk quantity of onions in short time thereby removing any need to keep the chopped onions overnight; the walk-in freezer storeroom where eggs are stored should be functioning optimally and record of the temperature should be maintained. Facility to have a second walk in freezer room may be explored in case of failure of the first one, as a backup; eggs should be checked randomly to rule out any rotten eggs; procurement of mechanised bulk egg breakers may be explored which will circumvent the present practice of breaking eggs using hands; food thermometers may be procured to verify the cooking temperature of the food items while being cooked; fly, cockroach and rodent control measures should be implemented effectively and health education of the food handlers may be carried out on a monthly basis during the time of their monthly medical examination on WHO recommended five key food safety principles: (i) keep hands clean, ii) separate raw and cooked foods, (iii) monitor the temperature using food thermometer while cooking, (iv) random check for temperature when need to store cooked food items, (v) use safe water, (h) all food handlers ("Farm to fork") must undergo a short hygiene and sanitation training, arranged in such a manner so that can be attended by all at least once in six months, (j) standing operating procedure about functioning and duties of the mess staff must be prepared and displayed.

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Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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