

## Determination of the Critical Control Points of Microbial Contamination in the Production and Distribution of Hospital Food

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### ABSTRACT

**Background and Purpose:** Foodborne infections is one of the health problem that responsible for gastrointestinal and nosocomial infections. Given the importance of food safety and sanitary conditions in hospitals, this study have been conducted with purpose of "investigation of the role of prerequisite programs (PRPs), appropriate methods of production and control of critical control points, in preventing microbial contamination of the hospital food".

**Materials and methods:** The study sample were consisted of employee's hands and nose, cell phone, swabs of frequently used equipment's and kitchen utensils for cooking, dishes and surfaces in contact with food. At each stage, a sample of raw and cooked foods were studied in terms of microbial contamination. Food samples were collected in plastic bags; then the plate count method was used for evaluation of food cultures, and biochemical identification of bacterial isolates was analyzed. Finally, each sample was compared with food safety standards, and according to microbiological data, observations and germ critical control point were determined using the decision tree.

**Results:** The main bacteria isolated from the samples were the *Enterobacteriaceae* family, *Staphylococcus aureus*, and *Bacillus* species; were highly consistent with the bacterial isolates from corresponding foods. In term of *Staphylococcus aureus* contamination of cooked food, there was significant relationship between the employees and kitchen utensils with cooked foods (p value < 0.001). The most important microbial critical control point includes raw material procurement, storage, processing, cooking, keeping warm, and food distribution.

**Conclusion:** These findings indicate the importance of manipulating role of staff, cooking surfaces and utensils in the contamination of food in the studied hospital. Manipulation (preparation) and proper storage of food, availability of desired cooking conditions, with an emphasis on hygiene of food related staff, utensils, surfaces, food preparation and distribution, and implementation of the HACCP system will be effective in preventing food-borne disease.

**KEYWORDS:** food safety, hospital foods, microbial cross-contamination, bacterial infection, HACCP

### INTRODUCTION

Foodborne disease prevalence has not been reduced in the recent years [1, 2] and remained as a common health problem in developing countries [3]. World Health Organization viewed foodborne disease as one of the most important health problems [4]. There's a lot of deaths due to foodborne diseases in various countries, especially in developing and developed countries [5]. In the meantime, hospitals have been identified as areas with high risk of food contamination and foodborne diseases. Patients admitted to these centers are potentially susceptible to foodborne illnesses due to higher vulnerability and a weakened immune system than regular people, thus food contaminated with pathogens can be dangerous for them [6].

Risk analysis and determination of critical control points (HACCP) system has been introduced as food safety management system [7, 8].

This is most economical and efficient system for food safety in most countries of the world [9], and considered as an organized global system and a method for controlling the introduction of high risk biological, chemical and physical substances [8]. The system acts by anticipating and preventing the risk in the final product [10, 11]. Implementation of these principles, especially in hospitals, can reduce the burden of disease and health care costs [8]. The system can provide an early identification of critical control points, and prevention of high risk biological, chemical, physical material from entering the food; and based on a global organized system assist hospitals in controlling the food materials and production process [12, 13].

Considering the clinical condition of hospitalized patients, monitoring the cooking and food production conditions in the hospitals, particularly in terms of microbial contamination are the main concern in this context. Despite the importance of this issue, unfortunately, little studies have been conducted for identification and

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controlling the risks points of these contaminants in the food supply and distribution in the developing countries. The purpose of current study was hazard analysis and determination of critical control points of the microbial foodborne diseases in the process of preparing hospital food at a hospital in Tehran. The results of this study will help in identification of the high risk points of microbial contamination at these points, and derive prevention strategies to remove most of the contaminants in the process of cooking foods at studied hospital.

## MATERIAL AND METHODS

To determine the most important areas of risk of microbial contamination, the process of preparing raw material to distribution of ready to serve foods was represented in the illustration 3-1.

Determine the type and number of samples

To examine bacterial contamination of food, samples were taken from personnel, cooking equipment and utensils, and surfaces in direct contact with food from preparing and cooking to its distribution on the patient's bed. The sampling was done in one of the hospitals affiliated to Shahid Beheshti University of Medical Sciences with permission of the University medical ethics Committee. Then, according to the attained results and statistical analysis, critical control points and sources of both environmental and personal contaminations was identified.

In order to investigate the contamination and the diversity of microbial strains in the food and also the role of cooking equipment and utensils in increasing the rate of contamination, following samples were taken: 13 conventional alimental and eating samples (including four kinds of raw material and nine cooked food); 10 swabs sample from food processing surfaces of main appliance and equipment used in cooking and surfaces in contact with food (including cooking boards, tray A, tray B, knife, skewer A, skewer B, skewer handling, mixer, food and utensils deliveries cart); 78 samples from different staffs involved in preparation and distribution of food (including hands, nose, gloves and cellphone). All the sampling procedures were done in three repeat. Nutrients evaluated in this study included 12 samples of raw foods (tomatoes, shish kebab, fish and chicken barbecue) and 27 samples of cooked (including tomatoes, roast, shish kebab, fish, chicken barbecue, and ground gavage).

### Sampling

The sampling was done on the raw and cooked food ingredients, food related staffs, all the surface in contact with food, cooking utensils and utensils; in order to assessing their bacterial contamination potentials. To determine the repeatability of results, random sampling was performed through three independent replicates, on three different days. Samples has been collected from food, personnel, and utensils in each set of sampling, independently and in a same working day. The type of raw and cooked food's at each stage of sampling was considered in the same cooking process. For this purpose, the most used utensils and surface of 60 cm analyzes, and samples of staffs collected from their hands, nose, and cell phone using swab culture method [14]. Swab soaked in normal saline solution (0.08%) after contact with the predicted sites and the studied surfaces were transferred to an encoded and sterile tube immediately, and with compliance to the conditions of contamination maintenance, transported to the laboratory as soon as possible. Separate sterile swab was used to prepare each sample. On order to assess the gloves and food contamination, samples of raw foods, cooked and prepared food, and cooking gloves were put in a sterile plastic bags, and using a homogeneous mixing system (STOMACHER) with pulsating movements, samples were homogenized in an appropriate volume of sterile saline solution.

Microbial contamination assessment and bacterial strain identification

Swab were inoculated directly on blood agar and Mac Conkey Agar medium, which is used for general isolation and differentiation of gram-negative bacteria. Grown colonies on medium plate that incubated overnight in 37°C were morphologically studied, and the biochemical tests of isolates was interpreted according to Bourji diagnostic standards [15]. The Food ingredients were studied for bacterial contaminations through plate count assay of prepared suspensions and according to FDA approved protocols, similar to tests used for cooking equipment and utensils. The number of colonies growing on the plates were calculated. The severity of bacterial contamination was assessed through colony counts of bacteria growing on the plates, which was calculated as CFU/ml or CFU/gr for food ingredients, CFU/hand or nose in staff assessment, and CFU/60 cm<sup>2</sup> for utensils and also contacted surfaces with food [16, 17].

### Determination of the critical control points

Identification of critical control points was performed based on the findings using inquiries of FAO decision tree [18] and assessment microbial results.

### The statistical data analysis

The significance of relationship between food contamination and contamination of cooking equipment, personnel, and surfaces in contact with them were tested using statistical t-test and Fisher with the help of SPSS Ver. 11.5 software package. Interpretation of the contamination rate in staff, equipment and utensils, and food were done according to the criteria listed in the references [19] and [20].

## RESULTS

Given the importance of humans confounding variables, the accumulation and food storage, preparation and processing condition of these materials, and cooking and distribution of them; the following process flow chart was drawn.

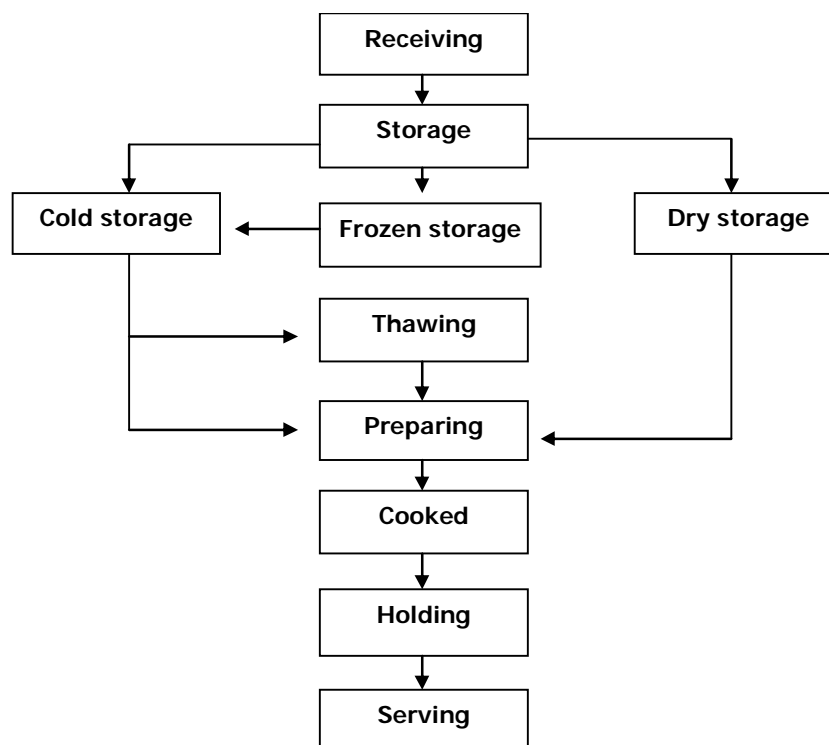


Figure 3-1. Process flow chart

### The results of microbial tests

To identify critical control points of bacterial contamination, bacterial culture of the collected samples were undertaken considering the bacterial forecast process. Among 147 samples collected for study, 39 food samples, 78 samples from employees and 30 samples from cooking instruments and surfaces; the bacterial contamination was observed in 100%, 85.9%, and 96.7% of samples, respectively (Table 1). The most contaminated samples among the food samples, compacted samples of raw and cooked chicken and the gavage showed the highest rate of bacterial contamination. The most contaminated samples among samples of cooking equipment and staff were cooking boards, mixer, and glove.

Table 1. The prevalence of bacteria in the samples under study

Total %	Bacillus species %	S. Aureus %	Escheri chia coli (%)	Coliforms (%)	Enterobacteri aceae (%)	Name and number of samples
100(12)	0	(3)25	(2)16/6	100(12)	(12)100	Raw food (12)
(21)100	(67)52	14(3)	0	(10)47	(10)47	Cooked food (21)
(6)100	(3)50	0	(1)17	(5)83	(5)83	Gavage (6)
(67)86	(24)31	(37)47/4	(7)9	(20)25/6	(20)25/6	Staff(78)
(29)96/7	(18)60	(11)37	(5)17	(17)57	(19)63	utensils(30)

Comparison of the prevalence of *Staphylococcus aureus* in cooking equipment and utensils were shown that frequency of this bacteria in cooking boards (100 %), blender (67 %), knife (33 %), skewer (33 %) and tray (17 %)

compared with other utensils (zero percent). The contamination of raw and cooked food with *Staphylococcus aureus* were observed in 6 cases of shish kebab (33, 17%), 3 cases of tomato (33, 33%) and 6 grounded chicken (33, 17%) and there was not any *staphylococcus aureus* contamination in the fish. The staff contamination were also observed in the 21 hand samples, 20 samples of gloves, 21 samples of nose, and 16 samples of cellphone (57 , 50 , 38 and 44% respectively).

### Determination of the critical control points of microbial contamination based on research findings

According to the FAO model and questions of the HACCP decision tree system, the critical control points of microbial contamination were identified. And the results of biological tests were used for validation of considered points and the evaluation of GMP requirements and prerequisite programs. As it can be seen in Table 3, the most contaminating points of food ingredients were buying raw materials, food storage, preparation, cooking, holding, distribution; also waste disposal, personal hygiene and washing equipment for cooking staff were the most important prerequisite programs.

**Table 2. Decision tree table Critical Control Point**

Processing step	Points under consideration	Q <sub>1</sub> . Do preventive control measures exist?	Q <sub>2</sub> . Is the step specifically designed to eliminate or reduce the likely occurrence of hazard to an acceptable level?	Q <sub>3</sub> . Could contamination with identified hazards(s) occur in excess or could this increase to unacceptable levels?	Q <sub>4</sub> . Will a subsequent step eliminate identified hazards(s) or reduce likely occurrence to acceptable levels?	Is this step a critical control point?
Receiving	-	Y <sup>1</sup>	Y	-	-	CCP <sub>1</sub>
storage	Sub-Zero Refrigerator	Y	Y	Y	N <sup>2</sup>	CCP <sub>2</sub>
	Upper-Zero Refrigerator					
	Dry Storage					
Preparing	Thawing	Y	Y	Y	N	CCP <sub>3</sub>
	Preparation					
cooking	-	Y	Y	Y	N	CCP <sub>4</sub>
Holding	-	Y	Y	Y	N	CCP <sub>5</sub>
Serving	-	Y	Y	Y	N	CCP <sub>6</sub>

Critical Control Point : CCP<sub>1-6</sub> NO:2 yes:1

## DISCUSSION AND CONCLUSION

The preparation and production of safe and proper food in order to provide a safe food supply is depend on identification of critical control points for improvement of prerequisite programs and HACCP [21].

In this study, to determine the critical control points, considering the importance of cooking at the local hospital under study, and in order to meet acceptable standards of FDA, considering all of the critical control points of bacterial contamination were essential. Thus, according to Table 3, the purchase of raw materials, food storage, processing, cooking, keeping warm, and distribution were identified as critical control points (CCP), and proper disposal of waste, workers, tools and surfaces sanitation were among prerequisite programs (PRPs); and they are essential for guaranteeing food safety, and were considered as sources of cross-contamination. The critical control points of cooking and keeping warm are similar to points found in the study of Pederso and colleagues who studied a hospital in Brazil. They have reported the points of supplying raw materials, processing, utensils and surfaces as the risky points; and their microbial test results suggested that the highest contamination were seen on the cooking board ( $2.3 \times 10^3$  CFU/cm<sup>2</sup>) and mixers ( $5.5 \times 10^4$  CFU/cm<sup>2</sup>) [22], which is lower than current study's results.

Richards and et al in their study of a hospitals were identified supply of raw materials, preparation, cooking, food storage as critical control points [23], which is similar to the present study. Yousif and et al found that cooking and warming points were the critical control points which is similar to 2 points considered in the present study. They have considered poor sanitation and hygiene of food related staffs, utensils and surfaces, inappropriate thawin and improper cooking as the most common causes of food contamination [24].

Almeida et al reported that average microbial counts of 58.2% of cooking utensils used in 4 hospitals where they conducted their study, was higher than 20 CFU/cm<sup>2</sup>, which is lower than value obtained in the current study

(81.6 percent). This researchers also considered the preparing, storing in the refrigerator before serving, as keep food ready before serve as the critical control points, and the contamination of personnel and utensils as factors effective in the contamination and the prerequisite programs necessary for the implementation of HACCP systems [25], which is similar to the points considered in this study.

The results of comparing the number and diversity of bacterial species in food samples, indicating increased microbial load equal to 20% in the crushed chicken. In other cases, the ratio of microbial load reduction in the raw than cooked food was variable in the range of 78.2% to 80%. Minimum reduction of microbial load was observed in fish. There was significant increase in bacillus count in all cooked food after the cooking procedures (p value =0.00). There was significant relationship between staff, equipment, tools with cooked food in term of *Staphylococcus aureus* contamination (p value <0.001).

There were 2 cases of *E. coli* contamination in raw food samples under study, which was not observed in any of the cooked food samples, which may have been removed by heating. Also *Bacillus* sp was not observed in any of the raw samples, but found in 66.6% of cooked foods samples, on the other word, 14 samples were contaminated with *Bacillus* species, which confirms the role of the staff, utensils and surfaces in food contamination. Also, it suggests that some bacteria, such as *Bacillus* sp. can survive in a high number during cooking foods such as chicken, kebab or grilled fish, which this number is associated with high risk.

In a study conducted by Ayc\_1c\_eket al [26] in 2002 at the Army hospital in Turkey, from 130 sample of soup, non pathogenic bacteria were detected in the soup samples, and all rice samples were acceptable. And about 98 samples of rice, 232 samples of the conventional main dishes, and 70 samples of salad; the frequency of coliform contamination were 6, 2.2 and 1.4 percent, respectively. There was 47% of coliform contamination in the cooked food in the current study, which is higher than previous study; moreover, all the raw were contaminated with coliforms, which is contributing with higher food contamination and also cross contamination in the kitchen.

Dehnadiet al in 1389 studied enteral feeding solutions for microbial contamination, and found that the contamination of all sampled solution were higher than permissible levels in comparison with FDA standards [27]. They compared gavage samples, raw and cooked food with FDA standards [20] in term of microbial count and concluded that all gavage solutions were 71.4% more contaminated than cooked foods, and also 83.3% more than raw food ingredients; this results emphasis determination of critical control points in reduction of hospital foods.

Microbial analysis of enteral feeding solutions in the Philippines shown that 75-96% of the samples had bacterial counts more than 10 CFU/g[28] , which was fewer than the current study findings.

Cooking boards and mixers were among the most contaminated surfaces that in contact with food in the current study, which is due to the lack of sanitation and regular washing of these surfaces. In this investigations, all the cooking boards were contaminated with *staphylococcus aureus* and coliforms; and 33% of samples (cooking boards, mixer, skewer A, tray A and caldron) was contaminated with *E. coli* bacteria. *Staphylococcus aureus* contamination was not seen in any of the samples of the cart and caldron.

Based on the standards of Europe and America [19] , the results of current study showed that bacterial contamination of cooking surfaces and utensils in term of total bacteria, total *Enterobacteriaceae* organisms, and indicator organisms of hand and fecal contamination (*S. aureus* and *E. coli* ) were 13, 23, 12, and 1%, respectively; which were outside the acceptable threshold.

However, in the study by Rodriguez et al in 2009 in five hospitals in Spain, four surfaces (cooking table, cutting boards, sinks, and tap water faucets) were studied. The hygiene of cooking table was according to microbiological standards, all the surfaces that have contact with staff's hands contaminated with mesophilic aerobic bacteria with indices lower than 1 and 5 CFU/cm<sup>2</sup>, also contamination with *Enterobacteriaceae* bacterial family was confirmed and their contamination was lower than permitted levels, only in one case of cooking boards in the hospital, the cell count of mesophilic aerobic bacteria was higher than allowable range. Similarly, the highest microbial contamination according to specified microbial profiles (mesophilic aerobic bacteria and *Enterobacteriaceae* family) was seen in the cutting boards, in which, two hospitals for mesophilic aerobic bacteria and three hospitals for *Enterobacteriaceae*, exceed the permitted levels. They concluded that foodborne disease in the studied hospitals were due to contaminated cutting boards, which was not washed and cleaned properly or old and decayed [29]. The prevalence of bacterial contamination of food contacted surfaces in these hospitals were lower in comparison with hospital studied in the present study; and suggested that identification and control of these contamination is critical and necessary in medical centers of Iran.

These researcher also examined the hand and apron of the chefs and reported that 40% of staffs hand and 26% of all aprons were contaminated by coliforms, in addition to *E. coli* and *S. aureus*. There was desire to use gloves in the study, but the gloves was not changed regularly; researcher described that using gloves and through hand washing could led to reduction of microbial load of hands and surfaces in contact with food [29]. The prevalence of bacterial contamination of food contacted surfaces in these hospitals were lower in comparison with hospital studied

in the present study; and suggested the importance of identification and controlling these contaminant in the medical centers of Iran.

In the present study, 19 and 60 percent of hands and gloves of food handler associated with food were contaminated with *Enterobacteriaceae* and coliforms, respectively; 4.7 and 20% of their hands and gloves were contaminated with *E. coli*. In comparison with international standards [19], about 83 and 19 percent of samples were higher than standards regarding to total microbial count and *Enterobacteriaceae* count and also 45 and 9% of samples were contaminated with *Staphylococcus aureus* and *Escherichia coli*, which both was higher than set standards and considered unacceptable. These results was similar to Rodriguez et al findings, in which, incorrect hand washing, weak personal hygiene, infrequent glove change were considered as source of these contaminations. Githiri et al report in a hospital in Kenya in 2008 that contamination occur before serving food due to handling cooked food with dirty hands and utensils [30]. The results of microbial tests on staffs in the present study confirms this findings.

Results of current study in term of high frequency of contamination of raw and cooked foods with members of *Enterobacteriaceae* family, coliforms, *S. aureus* suggest that the compliance with sanitation measures during food preparation processes in the hospitals from kitchen to the patient bed, are essential. The higher distribution of contamination in the surfaces contacted with food and cooking utensils than staffs contamination, confirming the role of these factors in improving microbial load of foods that is ready to use. The lowest microbial load reduction was observed in the fish and highest microbial load reduction was seen in tomato. Determination of optimal conditions for cooking, personal hygiene, proper cleaning and disinfection of equipment and surfaces in contact with food are essential for prevention of cross contamination in food preparation and distribution in the studied hospital.

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