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The relationship between hygiene and sanitation to *Escherichia coli* contamination on foods in a campus cafeteria

J Rohmah[1,*], C S Rini[1], S Cholifah[2]

[1]Teknologi Laboratorium Medis, Fakultas Ilmu Kesehatan, Universitas Muhammadiyah Sidoarjo, Kampus 4 Jl Raya Rame No.4 Pilang Wonoayu, East Java.
[2]Kebidanan, Fakultas Ilmu Kesehatan, Universitas Muhammadiyah Sidoarjo, Kampus 4 Jl Raya Rame No.4 Pilang Wonoayu, East Java, Indonesia

[*]E-mail: jamilaturrohmah@umsida.ac.id

Abstract. One of the efforts in improving the degree of health is more optimal with the fulfilment of the need for hygienic food. The objective was to analyse the correlation of the hygiene and sanitation of food handlers to *E.coli* contamination to find the factors which have the strongest correlation with *E.coli* in the foods in three canteens of a university. This study applied the descriptive observational which cross sectional design in canteen food stalls. Observations were carried out at all food stalls and interviews were conducted to 32 respondents consisting of food handlers. Statistical analysis used Chi Square test. The results show that positive *E.coli* contamination on canteen food (canteen campus 1, 2, and 4) was 25 (71.43%). The independent variables that have significant relationship with *E.coli* contamination on food cafeteria are food ingredients OR = 1.203, ingredients food storage OR = 0.000, food storage OR = 0.000, food carrier OR = 0.000, food serving OR = 0.000, building construction OR = 0.000, sanitation facility OR = 0.000, building construction OR = 0.000, sanitation facilities OR = 0.000, and food handler OR = 0.000. While the most influential independent variables on *E.coli* contamination on food in canteen campus is variable food ingredients OR = 1.203 and food processing OR = 3.800.

1. Introduction

Food is a necessary substance and plays an important role for human health. Food that does not meet quality and safety requirements may cause health problems or food borne diseases such as diarrhea, cholera, dysentery, typhoid and other food poisoning. Diseases that occur in humans have a relationship with food about 90% [1]. So the hygiene of food handlers and sanitation practitioners need to be done in order to realize the quality of healthy, safe and halal food. According to Minister of Health Regulation No. 715/Menkes/SK/V/2003, food hygiene sanitation is an effort to control the factors of food, people, places and equipment that can cause illness or health problems.

Increasing people's need for food provided outside the home, the products provided by companies and individuals engaged in the provision of food for the public (food), must be guaranteed of health and safety. As one type of public service place that process and provide food for the community, the seller of food has a potential to cause health problems or food borne diseases. Thus, the quality of food produced, served and sold by food vendors must meet health requirements such as site and building factors, sanitation facilities, equipment, good food processing and food handlers themselves [2].

Based on research according to the type of food processing place, [3] the type of food management place affect the contamination of cooked food, street hawkers have a risk of 4.91 times compared with catering services. While based on the type of food served, street vendors have a risk of 3.50 times, restaurants and cafe 3.25 times compared with catering services.

Cases of food poisoning also occur in elementary students who are in the Bandar Khalipah village, Deli Serdang district, North Sumatra as many as 22 students poisoned by eating meatballs that are sold in the school cafeteria [4]. One of the bacteria that is often used as an indicator of food contamination is *Esherichia coli* or better known as *E.coli*. The presence of *E.coli* in water or food is considered to have a high correlation with the presence of pathogens in food that will lead to the emergence of diseases such as mild to severe diarrhea or poisoning.

The canteen campus has an important role to meet the needs of academician for food on campus. In general, the food sold in the canteen has a very diverse variety, with relatively cheap price and easy to reach by academic community. *E.coli* contamination was positive for food (37.92%), beverage 40 (61,54%), food and drink 49 (75,4%) while in water quality 27 (41,5%) that do not meet the requirements [5]. Fruit juice sold in Margonda Depok street, have *E.coli* contamination at 19 (51,4%) while *E.coli* contamination on food in campus X canteen in Depok equal to 52,8% [6,7].

To assess the presence of hazards arising from food is usually done the final product examination that is taken samples from ready-to-eat foods and tested biological and chemical analysis to assess the presence or absence of biological, chemical hazard, as a guarantee of safety and healthy food [8]. The selection of research sites in the campus canteen of a university in Sidoarjo because the campus is one of the largest campus in Sidoarjo, where the canteen is required to be able to serve all the needs of academic community. At the campus, there is no toxicity caused by the canteen production, but preventive measures are very important considered to prevent risk factors that may arise from food contamination, whether from food, people (food handlers), places and equipment to be safe in consumption and prevent the incidence of foodborne illness or poisoning because all cases of food poisoning cannot be avoided if contamination by harmful substances has occurred.

2. Experimental Method

This research applied the cross sectional design with descriptive observational and interview in all canteens around the campus. The factors being observed were hygiene and sanitation of the canteen food stalls when the research was conducted. The dependent variable was *E. coli* contamination in the preparation of canteen foods. The independent variables are hygiene and sanitation of the canteen food stalls variable was divided into several sub-variables, which consist of food ingredients, ingredients food storage, food processing, food storage, food container, food serving, building construction, sanitation facilities, and food handlers.

Observation was conducted at 16 food stalls throughout the area of Campus 1, 2, and 4, Universitas Muhammadiyah Sidoarjo. Samples were taken from various foods and drinks sold by vendors within the campus area. Interviews of feasibility and sanitation were conducted with all food handlers working at all stalls throughout the university. Samples for laboratory testing are took by total sampling with the main specialty one food and one drink or two foods served at each stall so that there are approximately 35 samples. The types of food and drinks taken are foods that are considered vulnerable and widely sold. 32 respondents were interviewed and 35 food samples were obtained from the corresponding stalls for further testing.

The food samples were obtained using the aseptic technique in which the samples were taken directly from their serving plates or glasses. The foods were mixed thoroughly on their respective plates or glasses used for actual serving, before being moved to the sample containers. If the foods were not served with spoons, they would be mixed using spoons, which had been utilized during the serving process. Fifty five grams of samples were taken from the foods and placed in sterile sample bottles provided by the laboratory staff, Fakultas Ilmu Kesehatan, Universitas Muhammadiyah Sidoarjo. The food samples were measured used Total Plate Count (TPC) method cultured in Methylene Blue Agar (MBA) to identify the presence of *E. coli* bacteria.

To examine the percentage distribution of independent and dependent variables used univariate analysis and to examine the correlation between each of the independent variables and the dependent variable used bivariate analysis. This was achieved by applying the Chi Square test with significance level of 0.05 ($\alpha = 0.05$). Multivariate analysis using the logistic regression test was carried out to determine independent variables which had the strongest correlation with the dependent variable.

3. Results and Discussion

This study found *E.coli* contamination in more than half of canteen food samples under examination by 25 (71.43%). Food ingredients non-qualified of 21 (60.00%), non-qualified ingredients food storage of 24 (68.57%), non-qualified food processing of 23 (65.71%), non-qualified food storage of equal to 26 (74.29%), non-qualified food carrier of 12 (34.29%), non-qualified food serving of 15 (42.86%), non-qualified building construction of 19 (54.29%), sanitation facilities not fulfilling requirement of 26 (74.29%), and non-qualified food handlers of 23 (65.71%) (Table 1).

Table 1. The relationship between food ingredients, ingredients food storage, food processing, food storage, food container, food serving, building construction, sanitation facilities, food handlers and *E.coli* contamination on canteen food in a campus

No.	Variables	*E.coli* Contamination				Amount		P Value	OR
		Positive		Negative					
		f	%	f	%	f	%		
	Food ingredients								
1.	Qualified	10	71.43	4	28.57	14	100	0.000	1.203
	Non-qualified	15	71.43	6	28.57	21	100		
	Ingredients food storage								
2.	Qualified	9	81.82	2	18.18	11	100	0.000	0.000
	Non-qualified	16	66.67	8	33.33	24	100		
	Food processing								
3.	Qualified	9	75.00	3	25.00	12	100	0.000	3.800
	Non-qualified	16	69.57	7	30.43	23	100		
	Food storage								
4.	Qualified	5	55.56	4	44.44	9	100	0.007	0.000
	Non-qualified	20	76.92	6	23.08	26	100		

5.	Food carrier							
	Qualified	8	66.67	4	33.33	12	100	0.001	0.000
	Non-qualified	17	73.91	6	26.09	23	100		
6.	Food serving							
	Qualified	12	80.00	3	20.00	15	100	0.007	0.000
	Non-qualified	13	65.00	7	35.00	20	100		
7.	Building construction							
	Qualified	13	76.47	4	23.53	17	100	0.023	0.000
	Non-qualified	11	61.11	7	38.89	18	100		
8.	Sanitation facilities							
	Qualified	7	77.78	2	22.22	9	100	0.007	0.000
	Non-qualified	18	69.23	8	30.77	26	100		
9.	Food handlers							
	Qualified	10	83.33	2	16.67	12	100	0.001	0.000
	Non-qualified	15	65.22	8	34.78	23	100		

The result of univariate analysis of food ingredients there are some variables that do not fulfil the requirement of physical condition of noodles/vermicelli which are not branded and not registered on Health Department of Indonesia is 12 (34.29%), 14 (40.00%) vegetable wilt, 4 (40.00%) vegetables show signs of decay, 11 (31.43%) fruits are no freshness, 11 (31.43%) fruits withered and 15 (42.86%) showed signs of decay. In addition, 10 (28.57%) unbranded sweetened condensed milk were unregistered in the Ministry of Health, 6 (17.14%) expired sweetened milk, 7 (20.00%) branded tomato sauce and registered in the Ministry of Health, 3 (8.57%) expired tomato sauce, 5 (14.29%) unbranded mayonnaise and unregistered in the Ministry of Health, 2 (5.71%) expired mayonnaise, spices (powdered spices (chilli peppers, etc.)), unbranded peanuts and unregistered in the Ministry of Health of the Republic of Indonesia is 2 (11.76%), and 1 (2.86%) of expired peanut sauce.

Based on table 1 chi square test results between food ingredients and *E.coli* contamination obtained value $p = 0.000$ ($p < 0.05$) and OR = 1.203, it can be concluded there is a significant relationship between the two variables. Non-qualified food ingredients have a risk of 1.203 times can cause *E.coli* contamination in canteen foods, compared to qualified food ingredients. The selection, hygiene and quality of food ingredients to be processed can be a critical point and have certain critical limits as a requirement that the quality of the food ingredients is not within the safe limits to be processed and consumed by consumers. Food should be obtained from registered and registered food providers, must be in good condition, fresh and not rotten. All processed materials in the package must be registered with the Ministry of Health of the Republic of Indonesia, not expired, not defective or undamaged [9]. Factors affecting the existence of *E.coli* are the raw materials treated and the duration of cooking the materials (been/rice) [10].

Food traders in campus canteen should be able to know about the quality of food ingredients, especially regarding the quality and cleanliness of ready-to-cook food. In the preparatory stage, food ingredients need to be washed first to remove dirt also washed after cut or chopped. In the process there is no cross contamination between cooked food and raw food ingredients.

Storage of food ingredients based on statistical test results has a significant relationship (p = 0.000 (p < 0.05) and OR = 0.000) against *E.coli* contamination. The univariate analysis of the percentage of all ingredients food storage variables was non-qualified, namely 8 (22.86%) contained other ingredients other than food ingredients, 17 (48.57) were not available shelves for placement of food ingredients, 15 (42.86%) of food ingredients not meeting insects and rats, 30 (85.71%) do not use FIFO system, 12 (34.29%) where the material is unclean and unattended and in an unclosed state; 9 (25.71%) the temperature and humidity of the storage are not in accordance with the requirements of the food type; 9 (25.71%) no refrigerators available. The canteen storage areas should be free of insects and rats, using a FIFO system, storage area of material that is clean and maintained and in a closed state, provided a refrigerator for storage of ready-to-eat ingredients as well as vegetables and fruit that are not used up in the day. For the storage of noodle or vermicelli materials, it is suggested to be provided a clean and closed place and there is no other material.

While the result of statistical test between food processing and *E.coli* contamination obtained value p = 0.000 (p > 0.05) and OR = 3,800 it can be concluded there is a significant relationship between the two variables. Uncomplicated food processing has a risk of 3,800 times can cause *E.coli* contamination of canteen food, compared with eligible food processing. This can be explained from the univariate analysis of most non-qualified food processing variables ie 18 (51.43%) unavailable work table for the compounding of food ingredients, 20 (57.14%) food insecurity and insects, 33 (94.29%) not using plastic gloves for direct food contact protection, and 7 (20.00%) did not use food clamps for direct contact protection with food. At this stage of food processing, the possibility of food contamination by physical, chemical or biological. Therefore, in this process food handlers must be careful and thorough so that the possibility of contamination can be prevented optimally. Food handlers are forbidden to use fingers to taste food. In the street food vendors, the quality of food is influenced by the cleanliness of food processing, water and personal hygiene at food handlers [14].

The result of statistical test (Table 1) between mature food storage and *E.coli* contamination obtained value p = 0.007 (p < 0.05) and OR = 0.000 then it can be concluded there is a significant relationship between the two variables. While statistical test results between the food container and *E.coli* contamination obtained value p = 0.001 (p < 0.05) and OR = 0.000 then it can be concluded there is a significant relationship between the two variables.

From the univariate analysis of the mature food storage variable in the canteen campus a university in Sidoarjo, the unqualified parameters of mature food storage were not in containers with caps of 20 (57.14%), ice cube storage not in an ice flask equipped with a cap of 4 (11.43 %), mature food storage not in containers with caps of 19 (54.29%), unprotected food storage of dust of 18 (51.43%), unhealthy food storage of hazardous ingredients of 18 (51.43%), and storage ripe food is not protected from insects and rats by 29 (82.86%). To prevent food contamination, among others, by preventing contact with environmental factors, available food storage cabinets, preventing contamination of food scraps or waste, contamination by toxic materials and contamination from insects and mice [11].

The result of statistical test between food serving and *E.coli* contamination obtained p value = 0.007 (p < 0.05) and OR = 0.000 it can be concluded that there is a significant relationship between food serving and *E.coli* contamination. There are 17 (48.57%) ways of serving food in spite of pollution, 3 (8.57%) of equipment used is not clean, 2 (5.71%) finished food is not served in clean containers, 12 (34.29%) intake of food does not use clean

food, 19 (54.29%) finished food served warm not placed on heating facilities, remnant food reprocessed for sale 29 (82.86%), and 19 (54.29%) leftover food reheated for sale. Food serving is the final series of food journeys. The food served is a ready-to-eat food that 30% of cases of poisoning in Indonesia are caused by ready-to-eat food. Good practice in food serving had ratio odds (OR = 0.21) to have *E.coli* contamination on foods [12]. In serving the food must pay attention to the principle of presentation, that is where the presentation of food should be clean and closed, the food should use clean equipment [2].

While the result of statistical test (Table 1) between the food carrier and *E.coli* contamination obtained value p = 0.001 (p < 0.05) and OR = 0.000 then it can be concluded there is a significant relationship between the two variables. The result of univariate analysis of all variables, namely 28 (35.29%) is not available closed-covered food carrier, 18 (51.43%) food storage is not sealed perfectly, made of waterproof material, smooth surface, and easy to clean, 23 (65.71%) the contents of food are too full to prevent condensation, and 19 (54.29%) each food has no container respectively. From the results of observations on the food carrier in the canteen, generally cooked food carried out with simple transportation tools such as carts and bicycles, so the possibility of contamination back is very large. The transport of food by the food processing plant (66.0%) on a sufficient scale so that the method of carried out the food from the food processing to the cafeteria should still be improved in quality [13].

The carrier of ready-to-eat food is more vulnerable to pollution and therefore needs extra caution [2]. Therefore, in the principle of carrier ready-to-eat food, it should be noted that the transport vehicle is specially provided and not used for other transportation, each food has its own container, the food content is not too full because the steam of the melted food is a good medium for bacterial growth so fast food becomes damaged.

While on chi square test result between building construction and *E.coli* contamination, p value = 0.023 (p < 0.05) and OR = 0.000, it can be concluded that there is a significant correlation between building construction variable and *E.coli* contamination. The result of univariate analysis of some variable of non-compliant building construction that is 14 (40.00%) do not escape from dust, 25 (71.43%) do not avoid smoke, 24 (68.57%) do not escape from rats, found 4 (11.43%) food canteen are used as beds, found 8 (22.86%) of the canteen floors are not clean, 4 (11.43%) are not water-resistant, and 14 (40.00%) are slippery. 4 (11.43%) unmade canteens wall, 4 (11.43%) uneven canteen walls, 3 (8.57%) unclean cafeteria walls, 17 (48.57%) unventilated and functioning well, 12 (34.29%) not found 6 (17.14%) of the roof became a nest of mice, 6 (17.14%) there were holes in the ceiling of the canteen, 4 (11.43%) insecure door cafeteria and mice, 6 (17.14%) door closes well but opens inward and 4 (11.43%) doors are not made of strong material and easy to clean.

In this study, canteen campus 1, 2, and 4 in general is good enough for construction. One study reported that 52.5% of the vending sites were open air without any protection from the sun, wind, and dust [14], and 10.2% of food processing sites were in contaminated areas [16]. For canteen construction things to note is to be equipped with a door that qualifies to avoid contamination of food by insects and rats and fix the ceiling of canteen buildings that hollow and leak.

While the result of chi square test between sanitation facility and *E.coli* contamination obtained p value = 0.007 (p < 0.05) and OR = 0.000, it can be concluded there is a significant relationship between the variables of sanitation facilities and *E.coli* contamination. Univariate analysis of variables of sanitation facilities was known 26 (74.29%) of canteen using PAM water and 9 (25.71%) using ground water, 23 (65.71%) were eligible, 7 (20.00%) sewage flow was not fluid, 9 (25.71%) sewerage channel is not waterproof, 9 (25.71%) sewerage is

not closed, 14 (40.00%) toilets are not clean, 14 (40.00%) not enough water available. It was found that had no garbage containers made of waterproof material 23 (65.71%), did not have a covered bin 29 (82.86%), not plastic coated 9 (25.71%), garbage not transported every 24 hours as much as 7 (20.00%), no hand wash with hand wash water sufficient 14 (40.00%), no soap 30 (85.71%), no drying tools 23 (65.71%). A total of 63.1% of street vendors have dump trucks, which are equipped with only 12.4% caps and street hawkers whose sewage disposal flows well 24.8% [14]. One study stated that coliform contamination of clean water at the South Jakarta food processing plant was 56.4% [15]. Contamination of food utensils at food premises in Kuala Pilah Malaysia is 60% of the coliforms were exceeded the acceptable limit compared to *E. coli* on 180 of food utensils (chopping boards: 60, knives: 60 and dish plates: 60) [16]. Therefore, the study [17] also showed the importance of the availability of facilities for personal hygiene (such as showers and toilets near working areas) and the provision of food safety measures focusing on sanitary surveillance, personal hygiene, and periodical medical checkups.

The result of chi square test between food handlers and *E.coli* contamination was obtained $p = 0.023$ ($p < 0.05$) and OR = 0.000, it can be concluded that there is a significant relationship between food handler variable and *E.coli* contamination. There are food handlers in canteen campus a university in Sidoarjo found that do not behave cleanly 16 (45.71%), have a long nail food handler 19 (54.29%), smoke at work 6 (17.14%), do not cover the mouth with a handkerchief when coughing / sneezing 21 (65.71%), did not wash hands with aprons and headgear 33 (94.29%), and did not use suitable and clean tools when taking food 20 (57.14%).

This is consistent with studies that found 83.9% of coliform-treated food handlers [15], 12.5% of food-processing hands contaminated with *E.coli*, wearing aprons and cap 70% [18]. Bacteria can contaminate food through hair, skin, nails, airways, hands, sneezing, spitting, yawning and coughing [2]. The habit of unhygienic food handlers such as smoking at work, not washing hands before and after work and not using clean tools when picking up food can lead to contamination of food. The presence of these bacteria indicates a contamination which is directly or indirectly caused by contact with infected excrement [19,20]. Its principal cause is poor hygiene and low level of sanitation [21]. Besides, two factors having the strongest correlation with the contamination, which were the food handlers' lack of knowledge about food as a medium of disease and low awareness of the importance of washing hands in serving food. Attitude of high risk of washing hands was a protective factor in *E. coli* contamination (OR below 1.00). Poor hand washing techniques practiced among the food handlers increased E. *coli* contamination in food serving [22].

The result of multivariate analysis showed that there were two factors that showed the greatest correlation to *E.coli* contamination on canteen food, namely food ingredients ($p = 0.000$, OR = 1.203) and food processing ($p = 0.000$, OR = 3.800). Food handlers who have low knowledge of food-borne diseases are three times more susceptible to *E.coli* contamination during food processing than good food handlers.

To improve the knowledge of food handlers at canteen campus, Universitas Muhammadiyah Sidoarjo needs to conduct counselling about the behaviour of clean and healthy life to the food handlers so that personal hygiene of food handlers can be improved and the quality of food in canteen can meet the requirements, in addition to regular health checks on the food handlers at least 6 months, especially rectal swab.

4. Conclution

The results showed that positive *E.coli* contamination in canteen of Universitas Muhammadiyah Sidoarjo (canteen campus 1, 2, and 4) was 25 (71.43%). The independent variables that have significant relationship with *E.coli* contamination on canteen are food ingredients OR = 1.203, ingredients food storage OR = 0.000, mature food storage OR = 0.000, food carrier OR = 0.000, food serving OR = 0.000, building construction OR = 0.000, sanitation facility OR = 0.000, building construction OR = 0.000, sanitation facilities OR = 0.000, and food handler OR = 0.000. While the factors that show the greatest correlation effect on *E.coli* contamination on food in canteen consists of food ingredients (p = 0.000, OR = 1.203) and food processing (p = 0.000, OR = 3,800). Food handlers who have low knowledge of food-borne diseases are three times more susceptible to E.coli contamination during food processing than good food handlers.

5. Acknowledgements

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