Bacteriological and Parasitological Assessment of Apparently Healthy Food Handlers at Al-Kharj Province/KSA: A Cross-Sectional Prospective Study

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ABSTRACT

Background: Food handlers are the most important factors participating in food-borne diseases. Our study aimed at determining the frequency of bacterial and parasitic infections among food handlers in different restaurants in Akharj province-Saudi Arabia. **Subject and methods:** Total of 65 stool samples and fingernail swaps were taken from participants between September 2019 and December 2019. Wet mount, Gram stain, culture, and biochemical tests, were performed. Conformiation and antimicrobial sensitivity were performed for some samples (microscan). **Result**: Most of the participants were Indian nationality (26, 40%). About 21 (32%) fingernail and stool samples showed positive culture for different bacterial species, of which, 10% were harboring *Staphylococcus aureus* (19%) in nail swab. *Escherichia coli* 11(17%) was the main bacteria isolated from stool specimens, followed by *Citrobacter* (12%) and *Pseudomonas aeruginosa* (3%). There was a statistically significant difference between the isolation rate of microorganisms and the work experience and nail status of participants (p = 0.00, and 0.01, respectively). About 17% had intestinal parasites of *E. coli* (14%) followed by *B. Hominis* (5%). No parasite was detected in the nails of our study subjects. All *Staphylococcus aureus* and coagulase-negative *Staphylococcus* species isolates were uniformly susceptible to vancomycin, 75% of *S aureus* isolates were resistant to Penicillin. **Conclusion**: The study revealed a high rate of parasitic and bacterial infections among food handlers, a strict preventive measure should be implemented for personal hygiene and hygienic handling practices of food among food handlers.

Key Words: *Food Handler, Intestinal bacteria, and parasites.*

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INTRODUCTION

A food handler is anyone who works in eating and drink establishments and handles food or contacts with any utensils or equipment that are probable to be in contact with food, such as chopping boards, bowls, plates, or cutlery [1, 2]. In addition, the human body surface is always in contact with environmental microorganisms and becomes readily colonized by certain microbial species, Gram-negative and -positive bacterial and parasitic infections in clinical specimens. It can lead to various hospital- or community-acquired infections, including those of the osteomyelitis, empyema, neonatal, meningoencephalitis, bacteremia, burns and wounds, respiratory tract, and urinary tract [3-5]. The hand is the major vehicle of the transmission of numerous microbes, including the enteric species. Various infections are transmitted via hands (fingernails) and even stool. The contamination of hands plays a key role in the fecal-oral transmission of diseases. The unhygienic habits of most people cause several infections via fingernails and hands. About 80% of diseases are associated with poor personal and domestic hygiene. One of the ways of healthy living is hand hygiene [6, 7].

Food-borne disease is a public health problem in developing and developed countries due to poor sanitation

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habits and food handling, inadequate food safety programs, lack of knowledge of food handlers, lack of clean water supply, and poverty [8, 9]. The World Health Organization (WHO) states that most of the populations suffer from foodborne diseases every year in both developed and developing countries [10]. The spread of foodborne diseases through food handlers is a persistent and common global problem [11]. Infected food handlers with poor hygiene practice working in foodservice establishments are potential transmitters and sources of the disease due to pathogenic organisms such as infection with several enteropathogenic bacteria, protozoa, and intestinal helminths [12, 13]. They can transmit both non-enteric and enteric parasitic and bacterial infections through the food that they handled [11]. Microorganisms such as viruses, parasites, and bacteria are common agents for food contamination. In developing countries, *Vibrio cholera, Salmonella typhi, Enterotoxigenic Escherichia coli, Campylobacter jejuni, Polio,* and *Shigella* species are the prevalent food-borne disease-causing organisms [1, 14]. Protozoan and helminthic parasites such as Giardia lamblia, Entamoeba histolytica, Cryptosporidium species, Ascaris lumbricoides, and Enterobius vermicularis are also the main agents of food-borne diseases. These infections in food handlers pose a significant threat to food consumers [1, 14]. Transmission of fingernail bacteria occurs through fingers, nails, water, and food contaminated with feces representing the role of person-to-person oral-fecal transmission [2]. Food handlers who excrete and harbor bacteria may contaminate foods from their feces with their fingers and then to food preparation and servicing and eventually infect healthy individuals [15]. The area under the fingernail can spread pathogens through cross-contamination, cleaning it is challenging compared to other parts of the hand [13]. Food storage systems such as food handlers' skill and knowledge, servicing practices, handling, food preparation, time, and temperature, are some of the factors that directly or indirectly affect the food safety [6]. The formation of biofilm is a key factor in the persistence of microorganisms on the surface. Cells in a biofilm are embedded in an extracellular polymeric matrix constituent, which resists the clearance by the host response and usual therapeutic doses of antimicrobial agents. Biofilm is formed through initial adhesion to the surface and subsequent aggregation into multicellular structures. Thus, biofilm development requires adhesive forces to colonize surfaces and cell interaction. Specifically, *S. epidermidis* is the major biofilm-producing bacterium, acts by attaching to various surfaces [7]. Intestinal parasitic infections are of the prevalent diseases worldwide, especially in developing countries with poor living and low socio-economic conditions [8, 10-12]. From the estimated one-third of the world population with intestinal parasitic infections, the majority live in tropical and sub-tropical parts of the world [13, 14]. These infections are endemic in some countries of Africa, Southeast Asia, South America, and Eastern Europe [1, 10, 12]. So we aimed to determine the frequency of parasitic, bacterial, and intestinal infections among food handlers at Alkharj area, Saudi Arabia.

MATERIALS AND METHODS:

Study Design: An Analytical cross-sectional prospective study was carried out. Participants were enrolled based on the following inclusion criteria: both sexes, different ages, different Nationalities. Each participant who had a recent history of using antibiotics was excluded from the study.

Study area and study participants: Study participants recruited in the study were residents in different areas of AlKharj province. All laboratory works were conducted at the Microbiology laboratory, Faculty of Applied Medical Sciences, Department of Medical Laboratory Sciences, Prince Sattam University from September 2019 to December 2019.

Sampling and Sample Size: Non-probability samples namely convenience sampling method was followed. A total of (65) stool and nail swab samples were collected from each participants.

Methods:

Samples Collection: The stool sample was collected from each participant into a sterile, dry, air-tight, leak-proof plastic stool container and transferred to the laboratory at the end of each working day. Swab samples were collected under the fingernails of both hands from each subject using sterile-moistened cotton-tipped swabs and placed in a sterile test tube. Until inoculated on to respective cultured media, the samples were kept in a test tube containing normal saline for less than 5min [16]. Fresh stool samples were separated into two parts as follow; One part for bacterial culture techniques and also for the detection of parasites by wet preparation and iodine stain and; other reminder samples were preserved in 10% Formal saline fixative; from this sample, smears were made for permanent staining and the remainder was used for Formalin/ether concentration technique [16].

For microbiological examination, a fresh stool sample and nail swab samples were cultured as soon as possible on suitable culture media. Quality control was done in each step starting from constructing the questionnaire, data, and sample collection (an intensive training was given to (Students) data collectors); we instructed participants to be sure the stool doesn't touch the inside of the toilet and

not mixed with urine or water. All reagent and cultured media were well prepared and checked thoroughly.

Culture and identification

The full microbiological examination was done to all samples including culture on Xylose Lysine Deoxy-cholate agar plates and re-incubation at 37°C for 2 hours. The examination of the plates was done for significant colonies of Shigella and Salmonella species. Other MacConkey agar plates were inoculated to detect the Gram-negative bacteria in the samples. The Gram-negative bacilli were detected using the automated system (microsn) that determined the organism and minimum inhibitory concentration for antibiotics.

Culture and Identification

Processing of Fingernail Swabs and stool Identification of *Parasites and Bacteria.*

Each stool sample and fingernail swab obtained from each food handler was immediately cultured on Mannitol Salt Agar (MSA) to isolate Coagulase-Negative *Staphylococci* and also *S. aureus*. Fingernail swabs were cultured on Blood agar (Oxoid) and MacConkey agar (Difco), and then incubated at 37°C for 24h to isolate Gram-negative bacteria. The bacterial colonies grown on the agar media were presumptively identified by colonial gram staining and morphology and a battery of biochemical tests like reaction on catalase, oxidase, simmon citrate, indole production, urease, motility, KIA, and gas and hydrogen sulfide (H2S) production [17]

Direct Wet Smear Examination (Cheesbrough M):

Wet films are particularly appropriate for the immediate detection of trophic forms of protozoa. A small portion of feces (approximately 2 mg of the fecal specimen) was thoroughly mixed and emulsified on a glass slide in one drop of physiological saline and then covered with cover glass, a similar preparation was made on another slide using Lugol's iodine. These preparations were evaluated under both low power (10x) & high dry power (40x) objectives [18]

Formal Ether Concentration (Ritchie):

About 1 ml of stool emulsified in sodium acetate-acetic acid-formalin was made up to about 7 ml with 10 formalin and mixed well. Then about 3 ml of ether was added and shaken vigorously for 30-40 seconds, and poured through a surgical gauze sieve into a 15 ml glass conical centrifuge tube, which then centrifuged at 450 g for 5 min. The three upper layers were carefully discarded and a deposit was used to prepare smears for staining. The preparations were examined under both low power (10X) & high dry power (40X) objectives for ova and cysts of parasites [19].

RESULT

In our study, a total of 65 food handlers were examined; by collecting stool samples and nail swabs from each of them during a period between September 2019 and December 2019. Their age group ranged between 25-55 years old, mean age of 33.7 ± 8.2 SD, 19 (82.2 %) were in the age group of 25-35 years old, of whom 49 (75%) were male. The majority of participants were of Indian Nationality (26, 40%) followed by Bangladeshi, Philippines, Pakistan, and Saudi, with a percentage of 23%, 17%, 14%, and 6%, respectively. A total of 35 (54%) food handlers had work experience of fewer than 5 years, and 21(23%) between 5-10 years, while only 9 (14%) their work experience ≥10 years. Regarding self-hygiene as hand washing, all food handlers (65, 100%) were washing their hand after the toilet and before starting the work. Regarding regular medical checkups, only 12 (18%) underwent medical checkups. All data have been summarized in table 1.

Table 1 also provides the frequency of the total number of isolated bacteria and parasites from nail and stool and their correlation to all study parameters, there was no statistically significant difference between the age groups, gender, and isolated bacteria and parasites. Indian nationality was significantly (p-value 0.03) higher infected with intestinal bacteria 10/28 (36%), while Bangladesh was the common nationality infected with intestinal parasites and nail bacteria ((7/17, 41%) and (8/19, 42%), respectively). Regarding the hygienic practices of food handlers working at food service, only 15 (23%) finger samples were non-trimmed as the majority of infected participants' nail status was non trimmed (P-value 0.01), and all of the participants (100%) were washing their hand before and after work.

As shown in Table 2, the frequency of the total bacteria and parasites isolated from stool and nail swab was 21(32%), where *Entamoeba coli* was more prevalent 9 (14%) followed by *Blastocystis hominis* 3 (5%); more than one enteric parasite and bacteria were observed in the same subject under study. 28(44%) food handlers carried intestinal bacteria, where *E. coli* was the predominant bacteria. Coagulase-negative Staph was the more prevalent species 10/19(15%) isolated from nail swabs. There was no parasite detected in the nail of our study subjects. There was a significant relationship between the nail status (long fingernails) and the isolation rate of bacteria parasites, as well as hand hygiene, which shows a high frequency of bacteria and parasites.

The antimicrobial resistance pattern of gram-positive and gram-negative bacteria isolated from fingernail and stool cultures of food handlers working at food service showed that some isolated strains were resistant for some antibiotics. All *Staphylococcus aureus* and coagulase-

negative *Staphylococcus* species isolates were susceptible to the majority of tested antibiotics such as vancomycin, Clindamycin, and Gentamycin. Relatively, *Staphylococcus aureus* showed low resistance to Trimeth/sulfa (25%), Erythromycin (25%), and penicillin (75%). High resistance was detected in coagulase-negative *Staphylococcus* with Amox/k clav (10%), Ciprofloxacin (30%), and Erythromycin (40%), and Trimeth/sulfa (10%), penicillin (30%), and ampicillin **BLAC** activity (10%). On the other hand, all Enterobacteriaceae were sensitive for the tested antibiotics. *Klebsiella* species had BLAC activity to Amox/K Calv (20%). All results are summarized in **Tables 3 and 4**.

Table 1: Sociodemographic characteristics among food handlers compared with isolated bacteria and parasites from stool and nail swab

Variable	Frequency n=65 (%)	Intestinal parasites isolated n=17 (%)	Intestinal bacteria isolated n=28 (%)	Nail bacteria isolated n=19 (%)	P-value
		Positive (%)			
Age					
(25-35) years	26 (40%)	5 (29%)	11 (39.3%)	8 (42%)	0.33
(36-45) years	33(51%)	9 (53%)	13 (46.4%)	8 (42%	
(46-55) years	6 (9%)	3 (18%)	4 (14.3%)	3 (16%)	
Gender					
Female	16 (25%)	4 (24%)	10 (36%)	7 (37%)	0.41
Male	49 (75%)	13 (76%)	18 (64%)	12 (63%)	
Nationality					
Saudi	4 (6%)	1 (6%)	-	1 (5%)	0.03
Pakistan	9 (14%)	2 (12%)	5 (18%)	4(21%)	
Indian	26 (40%)	6 (35%)	10 (36%)	3 (16%)	
Philippines	11 (17%)	1 (6%)	7 (25%)	3 (16%)	
Bangladesh	15 (23%)	7 (41%)	6 (21%)	8 (42%)	
Hygienic practices of food handlers					
Finger nail trimmed	15 (23%)	11 (73%)	13 (87%)	14 (93%)	0.01
Washing hand after toilet	65 (100)	17 (100%	28 (100%)	19 (100%)	0.05
Washing hand before start work	65 (100%)	17 (100%)	28 (100%)	19 (100%)	0.00
Regular Medical checkup certificate	12 (18%)	10 (59%)	11(39%)	7 (37%)	0.24
Work experience					
≤ 5 years	35 (54%)	11 (65%)	13 (46.4%)	9 (47%)	0.00
6 -10 years	21 (32%)	4 (24%)	9 (32.2%)	6 (32%)	
≥10 years	9 (14%)	2 (12%)	6 (21.4%)	4 (21%)	

Table 2: Frequency of isolated bacteria and parasites from stool and nail from apparently healthy food handler

Parameter	Isolated organisms	Frequency n=65 (%)
Intestinal Parasites in stool sample	*E.coli* *	9 (14%)
	H. nana	2 (3%)
	Isospora belli	1 (2%)
	*B. hominis**	3 (5%)
	E. histolytica/dispar	1 (2%)
	Cryptosporidium parvum	1 (2%)
	Total	17 (28%)
Intestinal Bacteria in stool samples	*E.coli* *	11 (17%)
	Enterobacter spp	1 (2%)
	Citroacter spp	8 (12%)
	Klebsiella pneumoniae *	5 (8%)
	Pseudomonas aeruginosa	3 (5%)
	Total	28 (44%)

Bacteria from isolated from nail	*Staph aureus**	4 (6%)
	*Coagulase negative staph**	10 (15%)
	Streptococcus faecalis	1 (2%)
	Staph hominis subsp hominis	1 (2%)
	Bacillus spp	3 (5%)
	Total	19 (30%)
Total participants infected		21(32%)

*Samples contain more than one species

Table 3: Antimicrobial resistance pattern of *S. aureus* and CNS isolated from fingernail cultures of apparently health food handlers working at foodservice

Antimicrobial tested	MIC	Interpretation	Staph aureus n= (4)	Coagulase-negative staph n=(10)
Amox/k clav	≤ 4	S	4 (100%)	9(90%)
		R	0	**1(10%)**
Ampicillin	≤ 0.25	S	4 (100%)	9(90%)
		R	0	**BLAC(10%)**
Azithromycin	≤ 2	S	4 (100%)	10 (100%)
		R	0	0
Cefoxitin Screen	≤ 4	NEG	4(100%)	10(100%)
		S	0	0
Ciprofloxacin	≤ 1	S	4(100%)	7(70%)
		R	0	**3(30%)**
Clindamycin	≤ 0.25	S	4(100%)	10(100%)
		R	0	0
Erythromycin	≤ 32	S	3(75%)	6(60%)
		R	**1(25%)**	**4(40%)**
Fusidic acid	≤ 2	S	4(100%)	10(100%)
		R	0	0
Gentamycin	≤ 32	S	4(100%)	10(100%)
		R	0	0
Imipenem	≤ 4	S	4(100%)	10(100%)
		R	0	0
Moxifloxacin	≤ 0.5	S	4(100%)	10(100%)
		R	0	0
Mupirocin	≤ 4	S	4(100%)	10(100%)
		R	0	0
Oxacillin	≤ 0.25	S	4(100%)	10(100%)
		R	0	0
Penicillin	≤ 0.12	S	1(25%)	7(70%)
		R	**3(75%)**	**3(30%)**
Rifampicin	≤ 1	S	4(100%)	10(100%)
		R	0	0
Tetracycline	≤ 4	S	4(100%)	7(70%)
		R	0	3(30%)
Trimeth/sulfa	≤ 2	S	3(75%)	9(90%)
		R	**1(25%**	**1 (10%)**
Vancomycin	≤ 1	S	4(100%)	10(100%)
		R	0	0

S=sensitive, R= resistant, NEG=Negative, Blac= Beta-lactamase positive, CNS=Coagulase Negative Staphylococci

Table 4: Antimicrobial resistance pattern of *gram-negative bacteria* isolated from stool cultures of apparently health food handlers working at food service

Antimicrobial tested	MIC	Interpretation	*E. coli* n= (11)	*Klebsiella spp* n=(5)	*Citrobacter spp* n=(8)	*Pseudomonas aeruginosa n=(3)*	*Enterobacter spp n=(1)*
Amikacin	≤ 16	S	11 (100%)	5(100%)	8(100%)	3(100%)	1(100%)

		R	0	0	0	0	0
Amox/K Calv	≤ 8	S	11(100%)	4(80%)	8(100%)	3(100%)	1(100%)
		R	0	BLAC(20%)	0	0	0
Amp/Subactam	≤ 8	S	11(100%)	5(100%)	8(100%)	3(100%)	1(100%)
		R	0	0	0	0	0
Ampicillin	≤ 16	NEG	10(91%)	5(100%)	6(75%)	2(67%)	1(100%)
		S	1(9%)	0	2(25%)	1(33%)	0
Azteronam	≤ 4	S	11(100%)	5(100%)	8(100%)	3(100%)	1(100%)
		R	0	0	0	0	0
Cefepime	≤ 8	S	11(100%)	5(100%)	8(100%)	3(100%)	1(100%)
		R	0	0	0	0	0
Ciprofloxacin	≤ 1	S	11(100%)	5(100%)	8(100%)	3(100%)	1(100%)
		R	0	0	0	0	0
Colistin	≤ 2	S	11(100%)	5(100%)	8(100%)	3(100%)	1(100%)
		R	0	0	0	0	0
Gentamycin	≤ 4	S	8(73%)	5(100%)	8(100%)	3(100%)	0
		R	3(27%)	0	0	0	1(100%)
Norfloxacin	≤ 4	S	11(100%)	5(100%)	8(100%)	3(100%)	1(100%)
		R	0	0	0	0	0
Tigecycline	≤ 1	S	11(100%)	5(100%)	8(100%)	3(100%)	1(100%)
		R	0	0	0	0	0
Tobramycin	≤ 4	S	11(100%)	5(100%)	8(100%)	3(100%)	11(100%)
		R	0	0	0	0	0
Trimeth/sulfa	≤ 2	S	11(100%)	5(100%)	8(100%)	3(100%)	11(100%)
		R	0	0	0	0	0

DISCUSSION

Food handlers play an essential role in micro-organisms transmission, and improper handling practices can lead to the contamination of food and ultimately foodborne diseases, posing a potential risk to public health [20, 21]. Therefore, the current study was conducted to evaluate the contamination of hands with intestinal bacteria and parasites and antibiotic susceptibility profile of the isolated bacteria among apparently health food handlers from different restaurants at Alkharj province.

About 21(32%) of our study subjects were carriers of enteric and skin bacteria; including coagulase-negative *Staphylococcus* 10(15%), *Staphylococcus aureus 4*(6%), *Escherichia coli* (17%), *Klebsiella* species (8%), in their fingernail and stool. Regarding parasites, about (17/65) 48% of the study subjects were a carrier for intestinal parasites (protozoa and helminths) such as *Entameaba coli* 9(14%), *Blastocyitis hominis* 3(5%), *Hymenolypis nana* 2(3%), and 1(2%) for each of *E. histolytica/dispar, Cryptosporidium parvum* and *Isospora*. These findings are very interesting as all isolated parasites can be transmitted orofecally and then may be transmitted through infected food handlers to customers causing serious diseases. Similar types of were identified among food handlers in different parts of Saudi Arabia Al-Goblan et al. [22] and Zaglool in 2011 [23]. Our results are also similar to different studies carried out in other countries like Iran [24], Ethiopia [25], and Brazil [26].

In the present study, approximately 10 (15%) of cultures of fingernail contents were found to be positive for coagulase-negative *Staphylococci* followed by *Staphylococcus aureus* 4(6%). These findings are similar to the results of Zaglool et al. [23] who reported these bacteria as the most prevalent pathogens isolated from food handlers. Coagulase-negative Staphylococci are the normal flora of the skin, and this justifies their high prevalence in this study. But the isolation of *S. aureus* is crucial as it is the true pathogenic bacteria included in the resident microflora of the nose and skin and food handlers may contaminate food with *S. aureus* (common cause of food poising) if they don't properly wash their hands after using a toilet, after making contact with their nose, and before touching food. Tambekar et al. [27] reported a reduction in the number of pathogens after washing hands.

Different species of Enterobacteriaceae were isolated from stool samples in 28(44%) of food handlers in the present study. *Escherichia coli* (17%), *Citrobacter species* (12%), *and Klebsiella* (8%) were predominates, for sure, these bacteria are normal flora and the presence of these bacteria gives a clue of the current fecal contamination with enteric pathogens [28]. Foods that do not need further heat treatment are contaminated with such pathogens and could cause food-borne diseases due to inadequate handwashing by food handlers, which are a cause of serious diseases for the public [29]. Especially, some of our study participants had non-trimmed nails.

However, our result is higher than another study by Assefa *et al*. who revealed that 22% as the frequency of intestinal bacteria among their study subjects. Differences between our results and the other studies may be attributed to the sample size, sampling techniques, as well as different methods used for detection. [25]. No intestinal parasite was detected in the fingernails of food handlers, which is in agreement with the results of the study conducted earlier in Ethiopia, Gondar town, and Makkah, Saudi Arabia [22, 25].

In this study, about 17 % of the food handlers were carriers of one or more of the intestinal parasites. This is comparable with the finding of 15.5 % done in Iran [30], although it was lower than the prevalence of 38.1% done in Nigeria [31], and 41.1% in Bahir dar, Northwest Ethiopia [32]. Moreover, it is higher than the study of 1.3 to 7% in India [33], 6.9% in Omdurman, Sudan [34], and 8.8% in Turkey [35]. Differences in the reported prevalence in different investigations may be due to community and personal hygiene, poverty, climatic conditions, and socioeconomic status.

S. aureus and coagulase-negative *Staphylococcus* isolated from fingernails were resistant to multiple antibiotics in the present study. *S. aureus* isolated from the fingernail contents was resistant to Penicillin, erythromycin, and Gentamycin, as well as coagulase-negative Staphylococcus. If it is transmitted to patients, it may cause epidemics in patients. The findings of this study are consistent with different reports [36] suggesting that food handlers who are not exposed to living animals or carcasses likely do not have an increased risk to carry LA-MRSA. Similarly, they are only at low risk of carrying MRSA as long as they are not exposed to respective risk factors described earlier in this study. However, during the last decades, food workers have been implicated in the occurrence of staphylococcal foodborne diseases in various settings worldwide mostly by contaminating food with methicillin-sensitive, enterotoxin producing isolates originating from the handlers' nose or hands [36], these findings come in line with our results. Regarding Enterobactereacea drug resistance observed in our result is the same as finding revealed by Mengist *et al*. [37].

There was a significant relationship between bacterial and parasitic isolation rate and service years (P= 0.00) as the majority of isolated bacteria and parasites from either stool and nail swab samples were detected from food handlers whose work experience was less than 5 years. This finding disagrees with the result obtained from a study conducted in Addis Ababa and Arba Minch University, South Ethiopia [37] where no statistically significant association was seen between bacterial isolation and service. However, this was contrary to the findings in Debre Markos Ethiopia [38]. These results revealed that food handlers with more work experience have less risk of bacterial fingernail isolation, as well as enteric pathogens, meaning that food handlers with more work experience have better personal hygienic practices than inexperienced food handlers [38]

Regarding hygienic practices of food handlers, a significant association was found for fingernail status and handwashing habit and isolation rate of bacteria and parasites (p=0.01 and 0.05, respectively). This is the same result obtained in the study conducted in Jimma, which revealed a significant association between bacterial hand contamination rates with age [37]. Likewise, findings in Sari, northern Iran, determined a statistically significant relationship between bacterial infestation and educational level and handwashing practice after using a toilet [30].

CONCLUSION:

Since educational, epidemiological, and legal programs to enhance food safety are active in Saudi Arabia, this study revealed a high rate of bacterial and parasitic infection among food handlers. Hence, a strict preventive measure should be implemented to personal hygiene and hygienic handling practices of food among food handlers, which is an effective way of preventing the pathogens' transmission from food handlers to their consumers through food. Periodic medical checkups, care of hand and personal hygiene, and eating raw meat were major risk factors, which is significantly associated with the transmission of pathogenic microorganisms. Therefore, continuous epidemiological surveillance, enhancement of personal hygiene, and drinking pasteurized milk and eating cooked meat are recommended to control pathogens' infection in food handlers.

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Authors' contribution:

- SE, (sample collection, and laboratory work, purchasing reagents)
- LA (sample collection, laboratory works, preparation Study protocol and SOPs (Standard Operating Procedures)
- HAW (Statistical analysis of Data, and proof

reading and review)

- LBE (Scientific writing of manuscript, proof reading and review).

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