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Prevalence of *Salmonella* Typhi, *Staphylococcus aureus* and intestinal parasites among male food handlers in Laghouat Province, Algeria

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Abstract:

Background: Food-borne diseases are a global public health problem, most especially in developing countries. Food handlers with a low level of personal hygiene may be colonized or infected by a wide range of enteric pathogenic micro-organisms including intestinal parasites and bacteria. The aim of this study is to determine the prevalence of *Salmonella* Typhi, *Staphylococcus aureus* and intestinal parasites among male food handlers in Laghouat province, southern Algeria.
Methodology: In this cross-sectional study, stool samples and fingernail samples of both hands were collected from 155 randomly selected male food handlers. Stool specimens were examined by direct wet mount, formalin-ether concentration, xenic *invitro* culture and staining methods for parasitological identification. For bacterial isolation, standard culture media including Hektoen agar, *Salmonella-Shigella* (SS), Mannitol salt, and Blood agar plates were used. Conventional biochemical tests were used for identification of *S.* Typhi and *S. aureus*. Antimicrobial susceptibility test (AST) was performed for bacterial isolates by the Kirby-Bauer disk diffusion method. Data analysis was done using Minitab version 19 software, and Pearson's Chi-square test was used to determine association between categorical variables. P value < 0.05 was considered statistically significant.
Results: The overall prevalence rate of intestinal parasites among the study subjects was 40% (62/155). *Blastocystis* spp was the most frequent parasite isolated (16.8%), followed by *Giardia intestinalis* (8.4%), *Entamoeba histolytica/dispar* (7.7%), *Entamoeba coli* (3.2%), *Trichomonas intestinalis* (2.6%) and *Endolimax nana* (1.3%). Stool cultures revealed 4 (2.6%) positive samples for *S.* Typhi, and *S. aureus* was isolated from fingernail contents of 23 (14.8%) subjects. All *S.* Typhi isolates were sensitive to imipenem and ciprofloxacin while *S. aureus* isolates show high sensitivity to pristinamycin. Hand washing with soap, finger nail status and clinical manifestations were significantly associated with intestinal parasitic infections, while clinical manifestation was the only factor associated with *S. aureus* infection.
Conclusion: The present study indicates a high prevalence of pathogenic micro-organisms among male food handlers which highlight the important role of food handlers in the spread and transmission of foodborne infections, and thus requires more attention.

Keywords: Intestinal parasites, *Salmonella*, *Staphylococcus*, food handlers, Laghouat, Algeria

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Prévalence de *Salmonella* Typhi, *Staphylococcus aureus* et les parasites intestinaux chez les hommes manipulateurs d'aliments dans la province de Laghouat, Algérie

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Résumé:

Contexte: Les maladies d'origine alimentaire sont un problème de santé publique mondial, plus particulièrement dans les pays en développement. Les manipulateurs d'aliments avec un faible niveau d'hygiène personnelle peuvent être colonisé ou infectés par un large éventail de micro-organismes entéropathogènes, notamment des parasites intestinaux et des bactéries. L'objectif de cette étude est de déterminer la prévalence de *Salmonella* Typhi, *Staphylococcus aureus* et les parasites intestinaux chez les manipulateurs d'aliments dans la province de Laghouat, sud de l'Algérie.
Méthodologie: Dans cette étude transversale, des échantillons de selles et écouvillonnage des ongles des deux mains ont été prélevés auprès de 155 manipulateurs d'aliments de sexe masculins sélectionnés au hasard. Chaque échantillon de selles a fait l'objet d'un examen microscopique direct, d'un enrichissement, d'une coloration et d'une culture xénique in vitro pour l'identification parasitologique. Pour l'isolement bactérien, des milieux de culture standard comprenant, gélose Hektoen, gélose *Salmonella-Shigella* (SS), sel de mannitol et gélose au sang ont été utilisés. Des tests biochimiques conventionnels ont été utilisés pour l'identification de *S. Typhi* et *S. aureus*. Un test de sensibilité aux antibiotiques (AST) a été réalisé pour les isolats bactériens par la méthode de diffusion sur disque de Kirby-Bauer. L'analyse des données a été effectuée à l'aide du logiciel Minitab version 19 et le test du chi carré de Pearson a été utilisé pour déterminer l'association entre les variables catégorielles. La valeur $p < 0,05$ a été considérée comme statistiquement significative.
Résultats: Le taux de prévalence global des parasites intestinaux parmi les sujets de l'étude était de 40% (62/155). *Blastocystis* spp était le parasite le plus fréquemment isolé (16,8%), suivi de *Giardia intestinalis* (8,4%), *Entamoeba histolytica/dispar* (7,7%), *Entamoeba coli* (3,2%), *Trichomonas intestinalis* (2,6%) et *Endolimax nana* (1,3%). Les cultures de selles ont révélés 4 (2,6%) échantillons positifs pour *S. Typhi*, et *S. aureus* a été isolé du contenu des ongles dans 23 (14,8%) sujets. Tous les isolats de *S. Typhi* étaient sensibles à l'imipénem et à la ciprofloxacine tandis que les isolats de *S. aureus* montrent une sensibilité élevée à la pristinamycine. Lavage des mains au savon, l'état des ongles et les manifestations cliniques étaient significativement associés aux infections parasitaires intestinales, tandis que la manifestation clinique était le seul facteur associé à l'infection à *S. aureus*.
Conclusion: La présente étude indique une prévalence élevée de micro-organismes pathogènes chez les manipulateurs d'aliments, qui soulignent le rôle important des manipulateurs d'aliments dans la propagation et la transmission des infections d'origine alimentaire et nécessite donc plus d'attention.

Mots clés: Parasites intestinaux, *Salmonella, Staphylococcus*, Manipulateurs d'aliments, Laghouat, Algérie.

Introduction:

Foodborne diseases are a public health problem in developed and developing countries, mostly caused by eating food contaminated with bacteria, viruses, parasites or chemical substances such as heavy metals (1). According to the World health organization (WHO), up to 30% of the population suffer from foodborne diseases each year in developed countries, whereas in developing countries up to 2 million deaths are estimated per year (2).

Numerous outbreaks of gastroenteritis have been associated with ingestion and consumption of raw foods or foods obtained from unsafe sources (3,4). Transmission of intestinal parasites and enteropathogenic bacteria is affected directly or indirectly through objects contaminated with faeces, these include food, water, nails, and fingers, indicating the importance of faecal-oral human-to-human transmission (5). Food handlers with a low level of personal hygiene could be potential sources of parasitic worms, protozoa, as well as intestinal pathogenic bacteria, and may contaminate foods from their faeces via their fingers, then to food processing, and finally to healthy individuals (6).

Bacterial food poisoning has been reported to be a result of infection with *Staphylococcus aureus, Salmonella*, *Campylobacter*, *Listeria*, pathogenic *Escherichia coli*, *Yersinia*, *Shigella*, *Enterobacter* and *Citrobacter* (1). These organisms may exist on food handler's hands, and become intoxication agents if these foods are then kept for several hours without refrigeration or stored in containers (3). Although many outbreaks of gastroenteritis caused by protozoan pathogens have occurred, recognized as waterborne parasites, *Giardia intestinalis*, *Cryptosporidium* spp, *Entamoeba histolytica*, *Blastocystis* spp and *Cyclospora* spp have now been associated with several foodborne outbreaks (7-9). In Algeria, food handlers are screened annually for parasitic and bacteriological infections, therefore this study was aimed to determine the prevalence of intestinal parasites and pathogenic bacteria among food handlers in Laghouat Province, southern Algeria.

Materials and method:

Study area

This cross-sectional study was carried out in the province of Laghouat situated in the center of the country at 400 km to the south of the capital Algiers, between latitude 33° 48' north and longitude 02° 53' east. This province is characterized by an agro-pastoral activity and covers about 25,052 km^2 for a population estimated to be 520,188 inhabitants.

Study design and ethical approval

A cross sectional study was conducted from December 2017 to April 2019 to determine the prevalence of bacterial and parasite

infections among 155 randomly selected male food handlers including kitchen workers (n= 61), bakers (n=58) and butchers (n=36). In general, copro-parasitological assessment was requested by the managing physicians after presenting with digestive disorders or following an annual check-up to obtain medical certificate. Written informed consent was obtained from each participant and ethical approval for the study was granted by the Faculty of Science, Nature and Life, Djelfa University, Algeria (Ref: AT04/E.V.E.S/ 2017).

Data and sample collection

A structured questionnaire administered by face-to-face interview was used to collect data on socio-demographic characteristics, age, place of living (rural or urban), personal hygiene practices, risk factors and clinical symptoms. Stool samples were collected from each participant into clean stool cup for bacteriological and copro-parasitological examinations, and the fingernail samples were collected from both hands of each subject using sterile moistened swab.

Intestinal parasite identification

Stool samples were examined microscopically using saline and iodine-stained wet-mount preparations. In addition, specimens were concentrated by formol-ether concentration technique and faecal smears were fixed with methanol and stained by modified Ziehl-Neelsen (ZN) technique. Approximately 50 mg of stool samples were inoculated in 5 ml of Boeck and Drbohlav's Locke-egg-serum medium supplemented with 10% horse serum (10). The cultures were checked for the presence of *Blastocystis* after 48-72 hours of incubation by direct microscopy. The fingernail contents were also examined microscopically by direct wet mount preparations in normal saline and iodine solution for intestinal parasites identification.

Bacterial culture isolation and identification

For bacteriological examination, stool samples were cultured onto Hektoen enteric (HE) agar and enriched in Selenite F broth for 24 hours at 37°C. Inoculum from Selenite F broth was sub-cultured on Hektoen enteric (HE) and *Salmonella-Shigella* (SS) agar plates. After 24 hours incubation at 37°C, the growth of *Salmonella* and *Shigella* was differentiated by their colony characteristic appearance on HE agar (*Salmonella* appear as clear colonies with black center while *Shigella* appear as clear/green colonies) and on SS agar (*Salmonella* as colorless colonies with black center while *Shigella* as colorless colonies without black center). Bacterial species were identified with the API 20E System (bio-Mérieux, France) (11).

Fingernail samples were also cultured onto Mannitol salt agar (MSA) and Blood agar plate (BAP) and incubated for 24 hours at 37°C. *Staphylococcus aureus* colonies were identified by growth characteristics on BAP and MSA, Gram stain reaction and biochemical tests such as catalase and coagulase.

Antimicrobial susceptibility testing

Antimicrobial susceptibility test (AST) was performed for each *S.* Typh*i* and *S. aureus* isolate by Kirby-Bauer disc diffusion method on Mueller Hinton (MH) agar. The antimicrobial agents tested for *S.* Typhi were ampicillin (10µg), amoxicillin/clavulanic acid (20µg/10 µg), imipenem (10µg), cefoxitin (30µg), ciprofloxacin (5µg), cefotaxime (30µg) and gentamicin (10µg). Antimicrobial agents tested for *S. aureus* strain were erythromycin (15µg), ciprofloxacin (10µg), fosfomycine (50µg), pristinamycin (30µg), ofloxacin (5µg), and gentamicin (10µg). The resistance and sensitivity were interpreted according to the Clinical and Laboratory Standards Institute (CLSI) guidelines (12).

Statistical analysis

Statistical analysis was done using Minitab version 19 software. Pearson's Chi-square test was applied to determine association between variable. Values were considered significant at $p < 0.05$.

Results:

Socio-demographic characteristics and risk factors of food handlers

A total of 155 male food handlers were included in the study. Majority of the study participants were between the age group 18-38 years (68.4%) with a mean age of 33.14± 10.04 years and age range of 19-57 years. Regarding hand washing practice, 58% of food handlers had the habit of washing hands with soap before starting their work and 41.3% of participants did not trim their finger nails. Concerning region of residence, 53.5% of food handlers live in urban area while 46.5% live in rural area. Majority (63.2%) of the participants were not in contact with or rearing animals and 33% reported that they have clinical symptoms. The principal characteristics of the study population of the food handlers are summarized in Table 1.

Table 1: Prevalence of *Staphylococcus aureus* and intestinal parasite infections with socio-demographic characteristics and risk factor of food handlers in Laghouat Province, Algeria

Characteristics	N° examined N (%)	No positive for intestinal parasite N (%)	X^2 (p-value)	No positive for *S. aureus* N (%)	X^2 (p-value)
Food handlers					
Kitchen workers	61 (39.4)	23 (37.7)	1.020 (0.601)	6 (9.8)	2.077 (0.354)
Bakers	58 (37.4)	22 (37.9)		10 (17.2)	
Butchers	36 (23.2)	17 (47.2)		7 (19.4)	
Age group (years)					
18-28	64 (41.3)	26 (40.6)	0.6333 (0.888)	9 (14.0)	0.17038 (0.9822)
29-38	42 (27.1)	18 (42.9)		7 (16.7)	
39-48	36 (23.2)	14 (38.9)		5 (13.9)	
> 49	13 (8.4)	4 (30.8)		2 (15.4)	
Living area					
Urban	83 (53.5)	35 (42.2)	1.03226 (0.310)	12 (14.5)	0.04347 (0.835)
Rural	72 (46.5)	27 (37.5)		11 (15.3)	
Hand washing with soap					
Yes	90 (58.0)	23 (25.6)	4.12903 (0.042*)	15 (16.7)	2.13043 (0.144)
No	65 (42.0)	39 (60.0)		8 (12.3)	
Rearing animals					
Yes	57 (36.8)	25 (43.9)	2.32258 (0.128)	9 (15.8)	1.08696 (0.297)
No	98 (63.2)	37 (37.8)		14 (14.3)	
Finger nail status					
Trimmed	91 (58.7)	20 (21.9)	7.80645 (0.005*)	11 (12.1)	0.04347 (0.835)
Not Trimmed	64 (41.3)	42 (65.6)		12 (18.8)	
Clinical manifestation					
Asymptomatic	104 (67.0)	33 (31.7)	148 (0.0001*)	9 (8.6)	40.0435 (0.0001*)
Symptomatic	51 (33.0)	29 (56.9)		14 (27.5)	
Abdominal pain	27 (17.4)	15 (55.6)		7 (25.9)	
Diarrhea	9 (5.8)	5 (55.6)		3 (33.3)	
Fever	3 (1.9)	1 (33.3)		3 (100)	
Nausea	3 (1.9)	1 (33.3)		0	
Diarrhea+ Abdominal pain	7 (4.5)	5 (71.4)		1 (14.3)	
Diarrhea+ Abdominal pain+ Fever	2 (1.3)	2 (100)		0	

*= significant association; X^2=Chi square

Prevalence of intestinal parasites

The overall prevalence of intestinal parasitic infection among the food handlers was 40% (62/155) with six different parasite species. *Blastocystis* spp was the most frequent parasite identified (16.8%), followed by *Giardia intestinalis* (8.4%), *Entamoeba histolytica/dispar* (7.7%), *Entamoeba coli* (3.2%), *Trichomonas intestinalis* (2.6%) and *Endolimax nana* (1.3%). There was no mixed parasite infections in the study population, and no intestinal parasite was identified in fingernail contents (Table 2).

Prevalence of bacterial pathogens

Of the 155 participants, stool cultures were positive for *S.* Typhi in 4 (2.6%) (Table 2). All 4 participants had co-infecting pathogens; 3 with intestinal parasites (*Blastocystis* spp., *G. intestinalis* and *E. histolytica/dispar*) and 1 with *S. aureus* (Table 3). No *Shigella* species or other enteropathogenic bacteria were isolated from the stool samples.

For the fingernails culture result, *S. aureus* was isolated in 23 (14.8%) of the 155 samples (Table 2). Other bacterial species recovered from the fingernail cultures include coagulase negative staphylococci (37.4%), *Escherichia coli* (1.9%) and *Klebsiella* spp (0.7%), while no bacteria was isolated from 45.2% of the fingernail contents. However, co-infection was observed in 11 participants positive for *S. aureus*; 1 (7.1%) with *S.* Typhi and 10 (21.4%) with intestinal parasites, which include *Blastocystis* spp 3 (21.4%), *G. intestinalis* 2 (14.3%), *E. histolytica/dispa* 2 (14.3 %), *E. coli* 2 (14.3%) and *T. intestinalis* 1 (7.1%) (Table 3).

Table 2: Prevalence of pathogenic bacterial and intestinal parasites among 155 male food handlers

Pathogens	Frequency (%)
Pathogenic bacteria	
Salmonella Typhi	4 (2.6)
Staphylococcus aureus	23 (14.8)
Parasites species	
Blastocystis spp	26 (16.8)
Giardia intestinalis	13 (8.4)
Entamoeba histolytica/dispar	12 (7.7)
Entamoeba coli	5 (3.2)
Trichomonas intestinalis	4 (2.6)
Endolimax nana	2 (1.3)
Total	**89 (57.4)**

Table 3: Co-infections of bacterial and intestinal pathogens

Pathogens	Frequency (%)
Blastocystis spp + *Staphylococcus aureus*	3 (21.4)
Giardia intestinalis + *Staphylococcus aureus*	2 (14.3)
Entamoeba coli + *Staphylococcus aureus*	2 (14.3)
Entamoeba histolytica/dispar + *Staphylococcus aureus*	2 (14.3)
Trichomonas intestinalis + *Staphylococcus aureus*	1 (7.1)
Blastocystis spp + *Salmonella* Typhi	1 (7.1)
Giardia intestinalis + *Salmonella* Typhi	1 (7.1)
Entamoeba coli + *Salmonella* Typhi	1 (7.1)
Staphylococcus aureus + *Salmonella* Typhi	1 (7.1)
Total	**14 (100)**

Antimicrobial susceptibility test (AST) results

Concerning the AST result, all *S.* Typhi isolates were sensitive to imipenem and ciprofloxacin, while all were resistant to ampicillin and cefotaxime, 75% to amoxicillin/clavulanic acid, 50% to cefoxitin, and 25% to gentamicin (Table 4). AST result of *S. aureus* isolates showed that they were highly resistant to fosfomycine (82.6%), 11 (47.8%) were resistant to erythromycin, 10 (43.5%) to ofloxacin and 9 (39.1%) to ciprofloxacin and gentamicin each, while the *S. aureus* isolates showed high sensitivity to pristinamycin (Table 4).

Risk factors associated with bacterial and intestinal parasites infection

Significant associations were observed between prevalence of intestinal parasites and socio-demographic characteristics and risk factors among the food handlers (Table 1). Of the food handlers positive for intestinal parasites, the highest prevalence was seen in 29-38 years age group (42.9%) which decreased gradually with advancing age of participants, but this was not significant (p=0.888) (Fig.1).

Twenty five percent of the participants with intestinal parasites had the habit of washing hand with soap before starting their work while 60% do not usually wash their hands with soap before starting their work, and this difference was statistically significant (p=0.042).

Table 4. Antimicrobial resistance patterns of *Salmonella* Typhi and *Staphylococcus aureus* isolates from male food handlers in Laghouat Province, Algeria

Antimicrobial agents	**No of resistant *S.* Typhi strain (%)**	**Antimicrobial agents**	**No of resistant *S. aureus* strain (%)**
Ampicillin (10µg)	4 (100)	Erythromycin (15µg)	11 (47.8)
Amoxicillin/Clavulanic acid (20µg/10µg)	3 (75)	Fosfomycine (50µg)	19 (82.6)
Imipenem (10µg)	0 (00)	Pristinamycin (30µg)	3 (13)
Cefoxitin (30µg)	2 (50)	Ciprofloxacin (10µg)	9 (39.1)
Ciprofloxacin (5µg)	0 (00)	Ofloxacin (5µg)	10 (43.5)
Cefotaxime (30µg)	4(100)	Gentamicin (10µg)	9 (39.1)
Gentamicin (10µg)	1 (25)	/	/

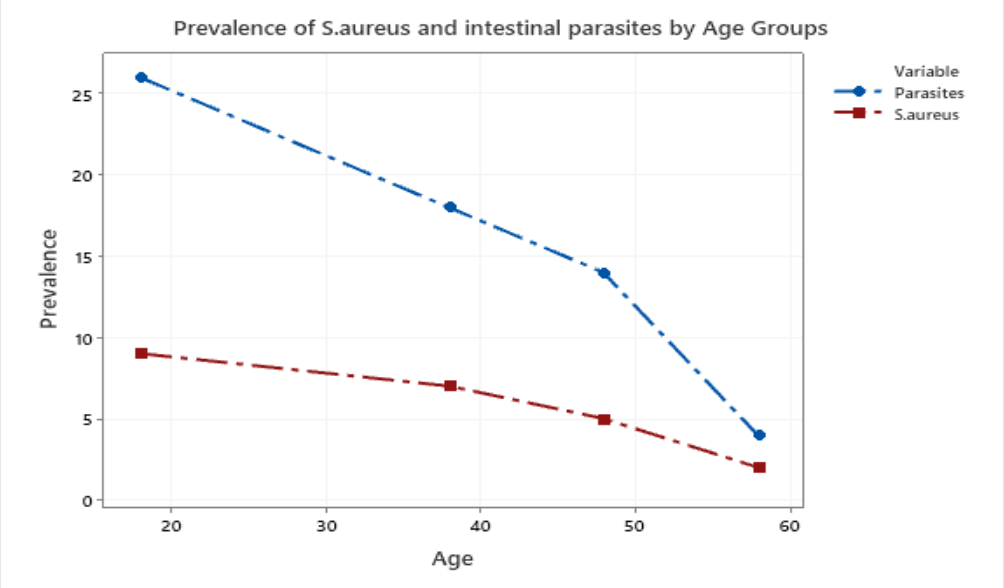

Fig 1. Prevalence of *Staphylococcus aureus* and intestinal parasites by age groups of male food handlers

Univariate analysis of the risk factors for intestinal parasite infection in the study showed significant association between fingernail status and prevalence of intestinal parasites, with prevalence of 65.6% among food handlers who do not trim their fingernails, compared to 21.9% in those who trimmed their fingernails (X^2=7.8064, p=0.005). Additionally, the prevalence of intestinal parasites was significantly higher in the symptomatic participants compared to asymptomatic ones (56.9% vs 31.7%; X^2=148; p=0.0001). With respect to clinical features observed among the food handlers with intestinal parasites (as summarized in Table 1), there was no significant association between prevalence of intestinal parasitic infections and categories of food handlers, living area of participants and rearing of animals by the participants (p>0.05)

The prevalence of *S. aureus* was high in the age group 29-38 years (16.7%) but this was not significantly different from the prevalence in other age groups (p=0.9822) (Fig 1). Also, prevalence of *S. aureus* was higher in the participants who did not trim their nails (18.8%), but there was no significant association with respect to nail trimming (p=0.835). However, there was significant association between prevalence of *S. aureus* and clinical manifestations, with 27.5% of symptomatic participants having *S. aureus* isolated from them compared to 8.6% of asymptomatic participants (p=0.0001). The most frequent clinical features were fever (100%), diarrhea (33.3%) and abdominal pain (25.9%) (Table 1), but there was no significant association between prevalence of *S. aureus* and socio-demographic and risk factors among the food handlers.

Also, there was no significant association between socio-demographic and risk factors among the food handlers and carriage of *S.* Typhi (p=0.276), but all 4 food handlers infected with *S.* Typhi were symptomatic, 2 had diarrhea, abdominal pain and fever, 1 had abdominal pain, and 1 had fever.

Table 5: Distribution of different pathogenic species among male food handlers

Food handlers	Pathogenic species (%)					Total
	S. aureus	***S.* Typhi**	***Blastocystis* spp**	***G. intestinalis***	***E. histolytica/dispar***	
Kitchen workers	6 (26.1)	4 (100)	12 (46.2)	4 (30.8)	3 (25)	29 (37.2)
Bakers	10 (43.5)	0	9 (34.6)	4 (30.8)	5 (41.7)	28 (35.9)
Butchers	7 (30.4)	0	5 (19.2)	5 (38.4)	4 (33.3)	21 (26.9)
Total	**23 (100)**	**4 (100)**	**26 (100)**	**13 (100)**	**12 (100)**	**78 (100)**

S. aureus = *Staphylococcus aureus*; *S.* Typhi = *Salmonella* Typhi; *B.* spp = *Blastocystis* spp; *G. intestinalis* = *Giardia intestinalis*; *E. histolytica/dispar* = *Entamoeba histolytica/dispar*

The distribution of different pathogenic species according to the types of food handlers showed that *S. aureus* was most frequently isolated in bakers (43.5%) followed by butchers (30.4%) and kitchen workers (26.1%), while *S.* Typhi was isolated only in kitchen workers. *Blastocystis* spp was more frequently identified among kitchen workers (46.2%) than in bakers (34.6%) and butchers (19.2%), *G. intestinalis* was more frequently identified in butchers (38.4%) followed by kitchen workers (30.8%) and bakers (30.8%), while *E. histolytica/dispar* was more frequently identified in bakers (41.7%) than in butchers (33.3%) and kitchen workers (25%) (Table 5).

Discussion:

This study was undertaken to determine the prevalence of bacterial and intestinal parasites among food handlers and antibiotic susceptibility profile of the isolated bacteria in Laghouat Province of southern Algeria. The study reported 40% (62/155) prevalence rate of intestinal parasitosis among food handlers, which were mainly protozoan parasites with no helminthes. Our findings are consistent with studies conducted in Qatar (13), Nigeria (14), Yebu, southwest Ethiopia (15) and Bahir Dar, Ethiopia (16), with comparative prevalence of 33.9%, 41.2%, 44.1% and 41.1% respectively, but relatively higher than the rates reported in studies from Tunisia 13.5% (17), Libya 8.26% (18) and Sudan 6.9% (3). Our rate is however much lower than the rates of 97% from Nigeria (19), 50.15% from Jeddah, Saudi Arabia (20), and 52.2% from southeastern Anatolia, Turkey (21). The differences in prevalence rates of intestinal parasitosis in various studies may be related to differences in socioeconomic status, geographical location, personal hygienic practice, lack of supply of safe water and environmental sanitation.

In the current study, *Blastocystis* spp (16.8%) was the predominant parasite identified followed by *G. intestinalis* (8.4%) and *E. histolytica/dispar* (7.7%). Similar results have been reported in previous studies conducted in Jeddah-Saudi Arabia (20) and Sirte-Libya (22) which identified *Blastocystis* spp as the predominant parasite with prevalence of 23.9% and 35.5% respectively. Also, previous studies conducted in other countries revealed that the leading parasites were *G. intestinalis*, *Blastocystis* spp and *E. histolytica/dispar* among food handlers (23-25).

It should be noted that these parasites are recognized as water-food borne pathogens (7-9). However, the prevalence of intestinal parasitosis was higher in the age groups 29-38 years (42.9%) and 18-28 years (40.6%). The higher prevalence in these younger age groups (though the difference was not statistically significant, X^2=0.633, p=0.888), is consistent with the result of the study conducted in Bahir Dar, Ethiopia (16), with the highest infection rate (18.5%) reported in age group 20-40 years, and in Addis Ababa, Ethiopia with 56.4% in the age group 17-34 years (26), but with no significant associations. Furthermore, the finding of our study showed that the prevalence of parasitic infection was significantly higher among food handlers who did not trim their fingernails (65.6%, p= 0.005)) and those who did not wash their hands with soap before starting work (60%, p=0.042). This indicates that most of the intestinal parasites in the present study must have been transmitted through improper hand washing, as a result of ignorance of the food handlers about the importance of personal and hand hygiene.

In the present study, *S.* Typhi was isolated from stool samples of 4 (2.6%) food handlers, which is similar to the low prevalence (2.3%) of *Salmonella* among food handlers reported in Kumasi, Ghana (27), 3.5% in Addis Ababa, Ethiopia (26), 3.8% in Omdurman, Sudan (3) and 1.6% in Bahir Dar, Ethiopia (16). However, these *S.* Typhi were exclusively isolated from the kitchen workers, which is an alarming finding that requires taking into consideration the importance of bacteriological analysis as a routine checkup of food handlers. There was no statistical significance with respect to *S.* Typhi infection and socio-demographic and risk factors among the food handlers. Also, the *S.* Typhi isolates were highly resistant to ampicillin (100%), cefotaxime (100%) and amoxicillin/clavulanic acid (75%), whereas they were 100% sensitive to imipenem and ciprofloxacin, which is compar-

able to the results of the studies conducted in Addis Ababa, Ethiopia where *S.* Typhi also showed 100% resistance to ampicillin, and 100% sensitivity to ciprofloxacin (26), and in Bahir Dar, Ethiopia where *S.* Typhi showed 100% resistance to ampicillin and 33.3% resistance to gentamicin (16), indicating that antimicrobial resistance of *S.* Typhi is an increasing concern. The high resistance to antimicrobial agents in the current study may be due to the easy access to antimicrobial drugs in Algeria.

Several species of bacteria were isolated from the fingernail contents of the food handlers including *S. aureus* (14.8%), coagulase negative staphylococci (37.4%), *Escherichia coli* (1.9%) and *Klebsiella* spp (0.7%). This is similar to bacterial isolates from fingernails of food handlers in other countries like Saudi Arabia (23), Nigeria (28), Ethiopia (29-31) and Iran (32). Coagulase-negative staphylococci are normal flora of the skin, which explains why they are the predominant bacteria isolate from finger nails in the present study. The presence of Gram-negative bacterial species in fingernails indicates faecal contamination due to inadequate hand washing of the food handlers, supporting the notion of poor personnel hygiene.

The prevalence of *S. aureus* reported in the present study (14.8%) is lower than the rates in studies conducted in Gondar, Ethiopia with 16-16.5% (29,30), Saudi Arabia with 17.5% (23) and Iran with 46% (32), but is higher than the rates reported from studies from Nigeria with 7.1% (28) and northwest Ethiopia with 5% (31). Many studies have reported high prevalence of *S. aureus* from nasal and throat swabs including 21.6% in Sudan (3), 20.5% in Gondar, Ethiopia (33), 31% in Egypt (34) and 23.1% in Anatolia, Turkey (21). The detection of *S. aureus* in fingernails of food handlers may pose significant risk for the consumers and public health because certain strains of *S. aureus* may produce enterotoxin on contaminated food substances, which can cause outbreak of staphylococcal food poisoning.

The *S. aureus* isolates showed multiple resistance to antibiotics and were resistant to fosfomycine (82.6%), erythromycin (47.8%), ofloxacin (43.5%), ciprofloxacin (43.5%), and gentamicin (39.1%), but highly sensitive to pristinamycin (87%). Although, we did not test for methicillin resistance among the *S. aureus* isolates in our study, other studies had reported high resistance of *S. aureus* to methicillin and emphasized the importance of the emergence and dissemination of methicillin-resistant *Staphylococcus aureus* (MRSA), which has complicated the therapeutic management of staphylococcal infections (30,31,33).

In the present study, no intestinal parasites or *Salmonella-Shigella* species were detected from fingernails content, which is consistent with the results obtained from studies done in Ethiopia (29-31) and Saudi Arabia (23). However, a study done in Jimma, Ethiopia showed the presence of ova, larvae, and cysts of intestinal parasites under fingernails of the study participants (35), another study done in India showed the presence of *Salmonella* in 65.7% from fingernails and 79% from nail cuts among hotel workers (36).

Conclusion:

The present study reported a high prevalence of intestinal parasitosis, *S.* Typhi and *S. aureus* among stool and fingernails contents of symptomatic and asymptomatic male food handlers in Laghouat Province, Algeria, with high antibiotic resistance among the bacterial isolates. This finding indicate that food handlers may be potential source of food borne disease, for which local health authorities in Algeria should implement strict medical checkup, training on food safety and good-hygiene practices for food handlers.

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References:

1. Centers for Disease Control. Food borne illness report-United States, January 10, 2005. Annual report 2005, 1–13. http://www.cdc.gov/ncidod/dbmd/diseaseinfo/files/foodborne_illness_faq.pdf.
2. World Health Organization. Food Safety – Food borne Diseases and value chain management for food safety. "Forging links between Agriculture and Health" CGIAR on Agriculture and Health Meeting in WHO/HQ, 25 June 2007.
3. Humodi, A. S., and Hatim, H. H. Bacteriological and parasitological assessment of food handlers in the Omdurman area of Sudan. J Microbiol Immunol Infect. 2010; 43 (1):70–73.
4. Diriba, K., Awulachew, E., and Ashuro, Z. Prevalence and Antimicrobial Resistance Pattern of *Salmonella*, *Shigella,* and Intestinal Parasites and Associated Factor among Food Handlers in Dilla University Student Cafeteria, Dilla, Ethiopia. Int J Microbiol 2020; doi: 10.1155/2020/3150539.
5. Centers for Disease Control. Foodborne hepatitis A- Alaska, Florida, North Carolina, Washington. MMWR. 1990; 32:659.
6. Käferstein, F., and Abdussalam, M. Bulletin of the World Health Organization. Int J Publ Hlth. 1999; 77 (4): 347-351.
7. Slifko, T. R., Smith, H. V., and Rose, J. B. Emerging parasite zoonoses associated with water and food. Int J Parasitol. 2020; 30: 1379-1393.
8. Dawson D. Foodborne protozoan parasites. Int J Food Microbiol. 2005; 103: 207– 227.
9. Anuar, T. S., Abdul Ghani, M. K., Azreen, S. N., Salleh, F. M., and Moktar, N. *Blastocystis* infection in Malaysia: Evidence of waterborne and

human-to-human transmissions among the Proto-Malay, Negrito and Senoi tribes of Orang Asli. Parasites Vectors. 2013; 6(40); 1-12.
10. Saksirisampant, W., Nuchprayoon, S., Pradniwat, P., and Lamchuan, D. Boeck and Drbohlav Locke egg serum medium for detection of *Blastocystis hominis*. Chula Med. J. 2010; 54 (6): 527-536.
11. World Health Organization. Manual for the laboratory identification and antimicrobial susceptibility testing of bacterial pathogens of public health importance in the developing world. Geneva: WHO, 2003.
12. Clinical and Laboratory Standards Institute. Performance Standards for Antimicrobial Susceptibility Testing. 27th ed. CLSI supplement M100. Wayne, PA: Clinical and Laboratory Standards Institute; 2017
13. Abu-Madi, M. A., Behnke, J. M., and Ismail, A. Patterns of infection with intestinal parasites in Qatar among food handlers and housemaids from different geographical regions of origin. Acta Tropica. 2008; 106: 213-220.
14. Egbuobi, R. C., Nwagbaraocha, M. A., Dike-Ndudim, J. N., et al. Incidence of Intestinal Parasites among Food Handlers (Hawkers) around the University of Nigeria Teaching Hospital Enugu, Enugu State, Nigeria. Open J Med Microbiol. 2014; 4: 23-28. http://dx.doi.org/10.4236/ojmm.2014.41004.
15. Tefara, T., and Mebrie, G. Prevalence and Predictors of Intestinal Parasites among Food Handlers in Yebu Town, Southwest Ethiopia. PLoS One. 2014; 10: e110621.
16. Abera, B., Biadegelgen, F., and Bezabih, B. Prevalence of *Salmonella* Typhi and intestinal parasites among food handlers in Bahir Dar Town, Northwest Ethiopia. Ethiop J Heal Dev. 2010; 24 (1): 46–50.
17. Siala, E., Guidara, R., Ben Abdellah, R., et al. Les parasites intestinaux chez manipulateurs de denrées alimenatires de la region de Tunis : étude de 8502 prélèvement de selles (1998-2008). Archs Inst Pasteur Tunis. 2011; 88: 1-4.
18. Kubti, Y., Muftah, A. Y., Khan, A. H., and Daw, A. Prevalence of Intestinal Parasitosis among Food Handlers in Benghazi, Libya. Sebha Med J. 2011; 10 (2): 22-24.
19. Idowu, O. A., and Rowland, S. A. Oral fecal parasites and personal hygiene of food handlers in Abeokuta, Nigeria. Afri Hlth Sci. 2006; 6 (3): 160–164.
20. Wakid, M. H. Distribution of intestinal parasites among food handlers in Jeddah, Saudi Arabia. J Parasitol Dis. 2006; 30 (2): 146–152.
21. Simsek, Z., Koruk, I., Copur, A. C., and Gurses, G. Prevalence of *Staphylococcus aureus* and intestinal parasites among food handlers in Sanliurfa, Southeastern Anatolia. J Publ Hlth Manag Pract. 2009; 15 (6): 518-523. doi: 10.1097/PHH.0b013e3181aa2814.
22. Fathy, F. M. A study on Blastocystis hominis in food-handlers: diagnosis and potential pathogenicity. J Egypt Soc Parasitol. 2011; 41 (2):433-453.
23. Zaglool, D., Khodari, Y., Othman, R., and Farooq, M. Prevalence of intestinal parasites and bacteria among food handlers in a tertiary care hospital. Nig Med J. 2011; 52 (4): 266.
24. Kheirandish, F., Tarahi, M. J., and Ezatpour, B. Prevalence of intestinal parasites among food handlers in western Iran. Rev Inst Med Trop Sao Paulo. 2014; 56 (2): 111-114. doi: 10.1590/S0036-46652014000200004.
25. Sharif, M., Daryani, A., Kia, E., Rezaei, F., Nasiri, M., and Nasrolahei, M. Prevalence of intestinal parasites among food handlers of Sari, northern Iran. Rev Inst Med Trop Sao Paulo. 2015; 57 (2): 139-144. http://dx.doi.org/10.1590/S0036-46652015000200007.
26. Aklilu, A., Kahase, D., Dessalegn, M., et al. Prevalence of intestinal parasites, salmonella and Shigella among apparently health food handlers of Addis Ababa University student's cafeteria, Addis Ababa, Ethiopia. BMC Res Notes. 2015; 8: 17. doi: 10.1186/s13104-014-0967-x.
27. Feglo, P. K., Frimpong, E. H., and Essel-Ahun, M. Salmonellae carrier status of food vendors in Kumasi, Ghana. East Afr Med J. 2004; 81 (7): 358–361.
28. Ifeadike, C. O., Ironkwe, O. C., Adogu, P. O. U., Nnebue, C. C., Emelumadu, O. F., and Nwabueze, S. A. Prevalence and pattern of bacteria and intestinal parasites among food handlers in the Federal Capital Territory of Nigeria. Nig Med J. 2012; 53 (2): 166-171. doi: 10.4103/0300-1652.104389.
29. Andargie, G., Kassu, A., Moges, F., Tiruneh, M., and Huruy, K. Prevalence of bacteria and intestinal parasites among food handlers in Gondar town, northwest Ethiopia. J Hlth Popul Nutr. 2008; 26 (4): 451-455.
30. Dagnew, M., Tiruneh, M., Moges, F., and Gizachew, M. Bacterial profile and antimicrobial susceptibility pattern among food handlers at Gondar University Cafeteria, Northwest Ethiopia. J Infect Dis Ther. 2013; 1 (2): 1-6.
31. Mengist, A., Aschale, Y., and Reta, A. Bacterial and Parasitic Assessment from Fingernails in Debre Markos, Northwest Ethiopia. Can J Infect Dis Med Microbiol. 2018. https://doi.org/10.1155/2018/6532014.
32. Nasrolahei, M., Mirshafiee, S., Kholdi, S., Salehian, M., and Nasrolahei, M. Bacterial assessment of food handlers in sari City, Mazandaran Province, north of Iran. J Infect Publ Hlth. 2017; 10 (2): 171-176.
33. Dagnew, M., Tiruneh, M., Moges, F., and Tekeste, Z. Survey of nasal carriage of *Staphylococcus aureus* and intestinal parasites among food handlers working at Gondar University, Northwest Ethiopia. BMC Publ Hlth. 2012; 12: 837.
34. El-Shenawy, E., El-Hosseiny, L., Tawfeek, M., et al. Nasal Carriage of Enterotoxigenic *Staphylococcus aureus* and Risk Factors among Food Handlers-Egypt. Food Publ Hlth. 2013; 3 (6): 284-288. doi: 10.5923/j.fph.20130306.04.
35. Sahlemariam, Z., and Mekete, G. Examination of fingernail contents and stool for ova, cyst and larva of intestinal parasites from food handlers working in student cafeterias in three Higher Institutions in Jimma. Ethiop J Hlth Sci. 2001; 11: 131-37.
36. Francis, S. P., Nagarajan, P., and Upgade, A. Prevalence of Salmonella in finger swabs and nail cuts of hotel workers. J Microbiol Infect Dis. 2012; 2 (1): 1–4.