Burden of intestinal pathogens and associated factors among asymptomatic food handlers in South Ethiopia: emphasis on salmonellosis

Fithamlak Bisetegen Solomon1*, Fiseha Wadilo Wada1, Antehun Alemayehu Anjulo1, Hailu Chare Koyra2 and Efrata Girma Tufa3

Abstract

Objective: The study aims to assess the burden of intestinal parasites and Salmonellosis among asymptomatic food handlers at meal serving facilities in Sodo town. Antibiotic resistance was also common and increasing among Salmonella isolates with multidrug resistance as current concern.

Result: Community based cross-sectional study was carried out from 387 food handlers working in meal serving facilities. Food handlers, 159(41%) had one or more intestinal parasites. A. lumbricoides was the most prevalent parasite 30(7.8%), followed by Taenia species 26(6.7%) and Hook worm 23(5.9%). A total number of 35 Salmonella isolates were found of which Sero-group D was the most frequent, 17(48.5%) followed by Sero-group C, 12(34.3%), and B 6(17.1%). Ten (2.5%) isolates were Salmonella typhi. Raw meat eating, hand washing after toilet and after touching dirty materials showed significant association with intestinal pathogens. Salmonella isolates were highly resistant to ampicillin (85.7%), amoxicillin and tetracycline 74.3% each. Multidrug resistance prevalence of 81.8% was identified. Periodic screening of food handlers is important in order to prevent the transmission of intestinal parasites and Salmonellosis. Treatment needs to be based on accurate laboratory detection to mitigate the spread of drug resistant Salmonella strains.

Keywords: Intestinal parasites, Salmonella, Sero-group, S. typhi, Antibiotic, Multi-drug resistance, Food handlers

Introduction

Food-borne infections are common public health problems, which become a significant public health issue all over the world [1]. Food handlers serve as vehicle to transmit food borne illness, during the course of gastrointestinal illness or during and after convalescence depending on the health status of the food handlers, personal hygiene, knowledge and practice of food hygiene [2–4].

About 3.5 billion people are affected by intestinal parasites (IPs), with an estimated 200,000 deaths annually [5].

The most common intestinal helminthes include Taenia a, Hymenolepis, Ascaris, Strongyloides, Trichuris, Enterobius vermicularis and Hook worm [6], and are usually transmitted from contaminated food, water or environment [7]. Potential carriers, food handlers, lead to difficulties in the eradication and control of IPs since they become asymptomatic [8].

Salmonella typhi is one of the major causes of food and water borne gastroenteritis in human and causes typhoid fever. It is highly prevalent in countries with poor sanitation during food preparation and poor sewage disposal and handling system [9]. Multi drug resistant (MDR) S. typhi has also been increased from time to time and got primary attention in the last few years [10].
Raw beef consumption habit is a potential cause for food borne illnesses in Ethiopia, especially in the study area besides the common factors such as overcrowding, poverty, inadequate sanitary conditions and poor general hygiene [11].

In Ethiopia, provision of safe food has been the primary focus in order to mitigate the spread of food borne outbreaks [3]. Therefore, the main objective of the current study was to determine the prevalence of IPs, with emphasis on Salmonella spp. (S. typhi) among asymptomatic food handlers.

**Main text**

**Methods**

**Study design**

A community based cross-sectional study was carried out among food handlers in randomly selected meal serving facilities in Wolaita Sodo town from September 2016 to April 2017. The town is structured in three sub-cities and 11 administrative kebeles. There were 59 meal serving facilities (MSF), restaurants and cafeterias, in the town during the study period. A total number of 5520 food handlers were registered in the town municipality. The sample size was determined by using a single population proportion formula [10] considering the following assumptions: $Z_{α/2} = 1.96$ for the standard scale of 95% level of confidence, level of precision = 5%, $P = 0.5$

$$n = \left(\frac{Z_{α/2}}{\pi}\right)^2 P \left(1 - P\right)/d^2 = 384.$$

The total sample size was 422 with 10% non response rate. Since the source population is less than 10,000, correction formula is used to determine the sample size. So the final sample size was 394.

**Data collection and analysis**

Socio-demographic variables were assessed using an interview with pre-structured questionnaire.

**Ova/parasite identification**

Freshly passed stool samples collected aseptically and examined microscopically following direct wet mount preparations in normal saline, iodine solution and formol-ether concentration sedimentation techniques as per the standards. The parasites identified in any one of the three techniques from a single specimen will be reported as positive.

**Stool culture**

Fecal specimen was homogenized in buffered peptone water (Oxoid, England) and incubated for 24 h at 37 °C. Then, 1 ml aliquot of the enrichment broths was transferred aseptically into 10 ml saline F broth and incubated at 37 °C for 24 h. After incubation, loop full of colonies were incubated in Xylose lysine desoxycholate agar (XLD) and brilliant green agar (BGA) plates. Salmonella presumptive colonies on agar media were subjected onto Triple Sugar Iron agar, Lysine Iron agar, Methyl Red broth, Voges Proskauer broth, Urea broth, Indole test, and Citrate utilization tests and incubated for 24–48 h at 37 °C.

**Sero-grouping**

Sero-grouping of Salmonella spp. was done by slide agglutination technique using poly O (A1) and monovalent (O2, O3, O4, O5, O7, O9, O15 and Vi) antigens for identification of Salmonella sero-groups, A–E (Difco, Detroit, USA) [11].

**Agglutination technique**

Qualitative slide agglutination A drop of S. typhi O and H antigens are added on a drop of serum and rotated at 100RPM and reported as reactive or non reactive by observing agglutination.

Semi-quantitative tube agglutination (titration) Reactive and weakly reactive serum samples were serially diluted by using fresh 0.95% saline preparation from 1:20 to 1:640 for anti O and anti H separately. Then O antigens and H antigens were added in the test tubes and an antibody titer of 1:80 and higher for anti O and 1:160 and higher for anti H antibodies were taken as a cut of value to indicate recent infection of typhoid fever [12].

**Antimicrobial susceptibility**

Antimicrobial susceptibility tests were performed on Muller Hinton Agar (Oxoid, Hampshire, UK) by disc diffusion method. The following antimicrobial agents all from Oxoid were used: ampicillin (10 µg), amoxicillin (10 µg), trimethoprim/sulphamethoxazole (1.25/23.75 µg), amikacin (30 µg), kanamycin (25 µg), chloramphenicol (30 µg), ciprofloxacin (5 µg), ceftriaxone (30 µg), nalidixic acid (30 µg), gentamicin (10 µg) and tetracycline (30 µg). The resistance and sensitivity results were interpreted according to the clinical and laboratory standards institute [13].

MDR was defined as acquired non-susceptibility to at least one agent in three or more antimicrobial categories.

Pan resistance-Resistance for all antibiotics tested.

**Data analysis procedures**

The data was analyzed using statistical package for social science version 21. Bivariate analysis was conducted and variables found to have association with the dependent variable at P value of 0.25 was entered into multiple logistic regression model. The variables P-value less than 0.05
in the multivariate logistic regression were independent factors.

Results
Out of a total 394 food handling personnel, 387 food handlers participated in the study, giving response rate of 98.2%. Mean age of the study subjects was 25 years (±SD2.8). The median age of the food handlers and their mean work experience was 22 years (± SD4.9) and 3 years (±SD2.1) respectively. Nearly a third (236; 61%) respondents were female and a significant proportion (56.3%) were completed secondary education (Additional file 1: Table S1).

Prevalence of intestinal parasites
The study aim to assess common intestinal parasites among food handlers, 159(41%) had one or more IPs and 34(8.8%) food handlers have been diagnosed with mixed IPs. *A. lumbricoides* was the most prevalent parasite 30(7.8%), followed by *Taenia* spp. 26(6.7%) (Additional file 1: Figure S1).

Prevalence of salmonellosis
Microbiological culture was done to isolate *Salmonella* species and a total number of 35 *Salmonella* spp. were found of which Sero-group D was the most frequently isolated 17(48.6%) followed by C, 12(34.3%), and B 6(17.1%). According to widal test, 10(2.5%) of the total isolates were *S. typhi* isolates.

Factors associated with intestinal microorganisms
Multivariable logistic regression results showed that raw meat eating habit, hand washing after toilet and hand washing after touching dirty materials have shown significant association (P < 0.05) (Table 1).

| Associated factors                      | Positivity COR | AOR (95% CI) | P value |
|----------------------------------------|---------------|--------------|---------|
| Age                                    |               |              |         |
| ≤ 20                                   | 92(23.1%)     | 3.42(2.51–5.67) | 0.0     |
| > 20                                   | 306(76.9%)    | 1            |         |
| Work experience (years)                |               |              |         |
| ≤ 2                                    | 135(33.9%)    | 1.52(1.04–3.7) | 0.8712  |
| > 2                                    | 263(76.1%)    | 1            |         |
| Raw meat eating habit                  |               |              |         |
| Yes                                    | 369(92.8%)    | 3.3(2.4–4.6)  | 0.001   |
| No                                     | 29(7.2%)      | 1            |         |
| Hand wash after toilet                 |               |              |         |
| No                                     | 93(23.4%)     | 2.31(1.34–3.84) | 0.0046  |
| Yes                                    | 305(76.6%)    | 1            |         |
| Hand wash after touching dirty materials|             |              |         |
| Yes                                    | 225(56.5%)    | 2.4(1.7–3.5)  | 0.0025  |
| No                                     | 173(43.5%)    | 1            |         |
| Trimmered finger nail                  |               |              |         |
| Yes                                    | 95(23.9%)     | 1.78(1.24–2.88) | 0.094  |
| No                                     | 303(72.1%)    | 1            |         |
| Food hygiene training                  |               |              |         |
| Yes                                    | 80(20.1%)     | 2.14(1.55–4.91) | 0.1206  |
| No                                     | 318(79.9%)    | 1            |         |

Discussion
The overall prevalence of IPs in the current study, 41% was in harmony with studies conducted at South Ethiopia [14], North East Ethiopia 41.1% [15], Nigeria 38.1% [16], Jimma 44.1% [2] Addis Ababa, 45.3% [17]. On the other hand, lower findings were also reported in the country and elsewhere 14.5% [18], 24.3% [19], 29.1% [4], and 30.5% [8]. Higher prevalence of IPs were reported, in Southeastern Anatolia (52.2%) [20], Abeokuta, Nigeria (97%) [21] and Ethiopia, 63% [18] and 49.4% [1] as compared with the present study. A wide difference in magnitude of IPs across surveys could be due to variation among personal hygiene practices, environmental sanitation and ignorance of health-promotion practices.

*A. lumbricoides* was the leading parasite isolated alone or in combination with other parasites from food handlers in the current study. Similar findings have been reported in previous studies in Ethiopia [2, 4, 14, 15, 17, 22, 23]. Soil transmitted Helminthes, *A. lumbricoides*, *Taenia* spp., *H. worm* and *S. stercoralis* reported in this study may indicate low personal hygiene in food handlers and the habit of open field defecation of the community.

Even though the magnitude of protozoan's *G. lamblia* 21(5.4%) and *E. histolytica/dispar* 19(4.9%) is not much higher as compared with intestinal helminthes like *A. lumbricoides* and others, infected food handlers can directly transmit them to consumers if ingested via contaminated food and water. Thus, food handlers should be in a good health and those suffering from diarrhea and
dysentery must be excluded from work until they have been completely free of symptoms and must get rest.

Salmonella spp. prevalence in this study, 8.8% was in harmony with 6.9% prevalence reported in Arbaminch [24] but higher than study of 5.5% in Abeokuta [21], 5% in Haromaya [6], 3.5% in Addis Ababa [17], 3.1% in Gondar [6], 1.6% in Bahir-Dar town, North West Ethiopia [15], and 1% in Mekele [1]. In the contrary to this, higher findings, 13.56% were also reported in Ethiopia [26] and Nigeria, 31.5% [16] and 42.3% [27].

Pooled Salmonella prevalence recorded 11.72% of in raw meat in our country [28] could support our finding, even worse the actual data could be higher since our specific setting is one of the region where raw meat consumption is the highest.

The five major sero-groups A, B, C, D, E were reported according to different studies in Ethiopia but the three serotypes B, C and D were the leading groups interchangeably [29–35]. Sero-group D and C were the most frequent sero-groups in the present study of which higher indexes of invasion were also recorded.

Salmonella sero-group distribution in this study was in agreement with a systematic review of Salmonellosis in Ethiopia from 1974 to 2012 [30] where sero-group D was the most frequent strain [29]. On the other hand, sero-group C occurred more frequently than sero-groups C and B in Central and North Ethiopia. This could be because of large number of Salmonella isolates were from children where sero-group C is most common [35], whilst sero-group C ranked first in children, sero-group D was dominant in samples predominantly taken from adults [30].

Salmonella typhi as a common aetologic agent to typhoid fever is a public health concern as it was evidenced in north Ethiopia where the episode is the predominant illness among food handlers and street food vendors [36]. In this study, 2.6% S. typhi prevalence is comparable with 2.7% reported in Bahirdar University cafeteria [15], but lower than 1.3% in Gondar University cafeteria [3]. The higher percentage of S. typhi as compared with previous study could be due to difference in cultural habit of eating raw meat. Comparatively higher, 3.8% in India [37], and much higher findings 8.1% in

| Bacterial isolates | Pattern | Antibiotics | No (%) |
|--------------------|---------|-------------|--------|
| Salmonella spp. n=35 | R₀ | None | 3(8.6) |
| R₁ | AMX | 1(2.9) |
| R₂ | TTC, TMP–SXT | 2(5.7) |
| R₃ | AMP, TTC, TMP–SXT | 3(8.6) |
| R₄ | AMP, AMX, NA | 3(8.6) |
| R₅ | AMP, TTC, AMX, TMP–SXT, NA | 3(8.6) |
| R₆ | AMP, TTC, AMX, TMP–SXT, K, CN | 3(8.6) |
| R₇ | AMP, TTC, AMX, TMP–SXT, K, CIP | 2(5.7) |
| R₈ | AMP, TTC, AMX, TMP–SXT, K, NA, CN, AMK, CRO, CIP | 2(5.7) |

R*: MDR (resistance to more than two class of antibiotic)
Hawassa University [38] and 17.4% in Jordan were also documented [39]. Difference in prevalence of S. typhi could be attributed to difference in diagnostic technique, different in study settings and recent or previously treated infection. Although a systematic survey on the risk factors is not available, the lower living standard and poor hygienic matters of the general population is suggestive evidence that enteric fever is a threat in present day Ethiopia.

The resistance rates for the isolated Salmonella species in this study were high (>70%) for ampicillin, amoxicillin, and tetracycline. This study was comparable with previous study conducted in Gondar [17] and Central Ethiopia [1]. Our finding was also in line with the pooled proportion of ampicillin (86.1%), and Co-trimoxazole (68%) in Ethiopia [40]. Ceftriaxone resistant Salmonella isolates were not revealed in previous studies in Ethiopia [41, 42] in contrary to our study. This may indicate emerging of Ceftriaxone resistance isolates over time. The Magnitude of MDR Salmonella spp. in this study corroborated with previous finding in Ethiopia (78.9%) but lower than 100% resistance in Addis Ababa University [17]. The high MDR rate of Salmonella isolates and resistance for most of the antibiotics currently used like Ciprofloxacin and Amikacin could limit our antibiotic option for empirical therapy.

Food handling certification, medical checkup, hand washing practice after touching dirty materials and before food preparation have no any significant association with intestinal parasite prevalence which is in line with other studies conducted in the country, north Ethiopia, Bahirdar [15] and South Ethiopia [38] but hand washing practice after toilet have significant association with IPs prevalence which is in harmony with studies conducted in South West [2] and South Ethiopia [24].

Limitation
Sero-typing of Salmonella isolates were not done in this study and observation with inspection team among meal serving facilities wasn’t carried out.

Conclusion
Significant proportion of the population have affected with intestinal parasites and Salmonella infection. Considerable number of Salmonella isolates showed MDR. Salmonella isolates were highly resistant to ampicillin, amoxicillin and tetracycline. Food handlers should be aware of the burden of having IP and salmonellosis through training. Studies on antibiotic resistance should give concern for food handlers. Health education and promotion programs should be sought through extensive training on food hygiene, which would potentially decrease the prevalence of various infections.

Additional file

Additional file 1: Table S1. Socio demographic and Personal hygiene practice of food handlers (n = 387) Wolaita Sodo town, Southern Ethiopia, 2017. Figure S1. Prevalence of intestinal parasites isolated from food handlers (n = 387) in Wolaita Sodo meal serving facilities, 2017.

Abbreviations
BGA: brilliant green agar; BPW: buffered peptone water; CLSI: clinical and laboratory standards institute; MDR: multi-drug resistant; MSF: meal serving facilities; SNNPR: South nation nationalities and people representative; SD: standard deviation; SPSS: statistical package for social science; XLD: Xylose lysine desoxycholate agar.

Authors’ contributions
FW, FS: Conceived the study; FS, FW, AA, and EG. Participated in the design of the study and performed the statistical analysis, FS. Interpreted the data: FW. Obtained ethical clearance and permission for study: FS, EG, FW, HC. Supervised data collectors: FW, FS, AA, HC, EG. Drafting the article or revisiting it critically for important intellectual content. All authors read and approved the final manuscript.

Author details
1 Department of Medical Laboratory, School of Medicine, Wolaita Sodo University, PO.Box: 138, Wolaita Sodo, Ethiopia. 2 Department of Pharmacy, Wolaita Sodo University, Wolaita Sodo, Ethiopia. 3 School of Public Health, Wolaita Sodo University, Wolaita Sodo, Ethiopia.

Acknowledgements
We would like to acknowledge Wolaita Sodo University for funding the budget and Wolaita sodo city administration, owner of food handling establishments and food handlers. We would also like to extend our thanks to WSUTRH laboratory workers, nurses and data collectors.

Competing interests
The authors declare that they have no competing interests.

Availability of data and materials
The data that support the findings of this study are available. Anyone interested can get upon reasonable online request by writing to fitha2007@yahoo.com.

Consent for publication
Not applicable.

Ethics approval and consent to participate
The study proposal got ethical approval (152/2016) from Wolaita Sodo University ethical review committee. Written consent was obtained from study participants.

Funding
The funding for this study was granted by Wolaita Sodo University. The funding body had no influence on study design, data collection, analysis and interpretation of data, writing of the manuscript and in the decision to submit the manuscript for publication.

Publisher’s Note
Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.
References

1. Negusse D, Kumie A. Food hygiene practices and prevalence of intestinal parasites among food handlers working in Mekele university students cafeteria Mekelle. G.ARJSS. 2012;4(4):65–71.

2. Tefera T, Mebrie G. Prevalence and predictors of intestinal parasites among food handlers in Yebu town, southwest Ethiopia. PLoS One. 2014;9(10):e109621.

3. Dagnew M, Tiruneh M, Moges F, et al. Bacterial profile and antimicrobial susceptibility pattern among food handlers at Gondar University Cafeteria, Northwest Ethiopia. J Infect Dis Ther. 2013;1:105.

4. Andargie G, Kassu A, Moges F, et al. Prevalence of bacteria and intestinal parasites among food-handlers in Gondar town, northwest Ethiopia. J Health Popul Nutr. 2008;26:451–5.

5. Mudey BA, Keshavan N, Mudey AG, Goyal RC, Davale AK. Health status and personal hygiene among food handlers working at food establishment around a rural teaching hospital in Wardha District of Maharashtra, India. Glob J Health. 2010;2(2):198.

6. Gareedew KL, Wondafrash N, Feleke A. Identification of drug-resistant Salmonella from food handlers at the University of Gondar, Ethiopia. BMC Res Notes. 2014;7:545.

7. Khan KH, Ganjewala D, Bhaskara KV. Recent advancement in typhoid research—a review. Adv Biotech. 2008;4:35–41.

8. Siddiqi FJ, Rabbi F, Hasen R, Nizami SQ, Bhutta ZA. Typhoid fever in children: some epidemiological considerations from Karachi, Pakistan. Int J Infect Dis. 2006;10:215–22.

9. Maritha M, Nelene C, Demetre L. Small and micro enterprises aspects of knowledge, attitudes and practices of managers’ and food handlers’ knowledge of food safety in the proximity of Tygerberg Academic Hospital, Western Cape. SAJCN. 2007;20(2):50–61.

10. Thrusfield M. Veterinary epidemiology. 3rd ed, Diagnostic testing.Cambridge: Black Well Science Ltd. 2005. p. 228–46.

11. CLSI. Performance standards for antimicrobial susceptibility testing; Twenty-Second Informational Supplements. CLSI Document M100-S24. Wayne: Clinical and Laboratory Standards Institute; 2014.

12. Ogah JO, Adekunle OC, Adegoke AA. Prevalence of salmonellosis among food handlers and the health implications on the food consumers in Lagos State, Nigeria. J Med Microb Diagn. 2015;4:180.

13. CLSI. Performance standards for antimicrobial susceptibility testing. Twenty-Second Informational Supplements. CLSI Document M100-S24. Wayne: Clinical and Laboratory Standards Institute; 2014.

14. Mama M, Alemu G. Prevalence and factors associated with intestinal parasitic infections among food handlers of Southern Ethiopia: cross sectional study. BMC Public Health. 2016;16:105.

15. Albera B, Biadegelgen F, Bezabih B. Prevalence of Salmonella typhi and intestinal parasites among food handlers in Bahir Dar Town, Northwest Ethiopia. Ethiop J Health Dev. 2010;24(1):46–50.

16. Heffadie C, Ironkwe O, Adogu P, et al. Prevalence and pattern of bacteria and intestinal parasites among food handlers in the Federal Capital Terri- tory of Nigeria. Niger Med J. 2012;53(3):166.

17. Aklilu A, Kahase D, Dessalegn M, et al. Prevalence of intestinal parasites, Salmonella and Shigellosis among apparently healthy food handlers of Addis Ababa University student’s cafeteria, Addis Ababa, Ethiopia. BMC Res Notes. 2015;8:17.

18. Gezehegn D, Abay M, Tetemke D, Zelalem H, Teklay H, Baraki Z, Medhin G. Prevalence and factors associated with intestinal parasites among food handlers of food and drinking establishments in Aksum Town, Northern Ethiopia. BMC Public Health. 2017;17:819.

19. Ashour N, Hassa’n I. Occurrence of intestinal parasites and hygiene character- onts among food handlers in Gaza Strip, Palestine. Ann Alquds Med. 2012;2(2):–13.

20. Simsek Z, Konuk I, Copur AC, Gurses G. Prevalence of Staphylococcus aureus and intestinal parasites among food handlers in Sanliurfa, South- ern Anatolia. J Public Health Manag Pract. 2009;15:S18–23.

21. Mobolaji OA, Olubunmi OF. Assessment of the hygienic practices and the incidence of enteric bacteria in food handlers in small businesses in an urban area in Abeokuta. Int J Microbiol Res. 2014;3(3):41–9.

22. Teklemariam S, Ruma B, Sona S, Worku S, Erose L. Assessment of sanitary and hygienic status of catering establishments of Awassa town. Ethiop J Health Dev. 2000;14(1):91–8.

23. Sahletemariam Z, Mekeste G. Examination of finger nail 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 Health Sci. 2001;1(1):131–7.

24. Mama M, Getaneh G. Prevalence, antimicrobial susceptibility patterns and associated risk factors of Shigella and Salmonella among food handlers in Arba Minch University, South Ethiopia. BMC Infect Dis. 2016;16:686.

25. Marami D, Hailu K, Tolea M. Prevalence and antimicrobial susceptibility pattern of Salmonella and Shigella species among asymptomatic food handlers working in Haramaya University cafeterias, Eastern Ethiopia. BMC Res Notes. 2018;11(1):74.

26. Addis Z, Kebede K, Sisay Z, Alemayehu H, Yirsaw A, Kassa T. Prevalence and antimicrobial resistance of Salmonella isolated from lactating cows and in contact humans in dairy farms of Addis Ababa: a cross sectional study. BMC Infect Dis. 2011;11:1–7.

27. David OM, Oluyege AO. Antimicrobial resistance and plasmid carriage among Salmonella typhi isolated from food and hands of food handlers in a Nigerian University. Int J Curr Microbiol App Sci. 2015;4(3):906–14.

28. Tadesse G, Gebremedhin EZ. Prevalence of Salmonella in raw animal products in Ethiopia: a meta-analysis. BMC Res Notes. 2015;8:163.

29. Asrat D, David OM, Oluyege AO. Shigella and Salmonella serogroups and their antibiotic susceptibility patterns in Ethiopia. East Mediterr Health J. 2008;14:760–7.

30. Tadesse G. Prevalence of human Salmonellosis in Ethiopia: a systematic review and meta-analysis. BMC Infect Dis. 2014;14:88.

31. Gebre-Yohannes A. Salmonella from Ethiopia: prevalent species and their susceptibility to drugs. Ethiop Med J. 1985;23:97–102.

32. Gedebo M, Tasew A. Antimicrobial resistance and risk factor of Salmonella isolates from Addis Ababa. Ethiop Med J. 1981;19:77–85.

33. Mache A. Salmonella serogroup and their antibiotic resistance patterns isolated from diarrhoeal stools of pediatric out patients in Jimma Hospital and Jimma Health Center, South West Ethiopia. Ethiop J Health Sci. 2002;12:37–45.

34. Mache A, Mengistu Y, Cowley S. Salmonella serogroups identified from adult diarrhoeal out-patients in Addis Ababa, Ethiopia: antibiotic resist- ance and plasmid profile analysis. East Afr Med J. 1997;74:183–6.

35. Beyene G. Phenotypic and molecular characterizations of Salmonella species in Ethiopia. AUA electronic library. PhD thesis. 2008.

36. Adane M, Tekla B, Gismu Y, Halefom G, Ademe M. Food hygiene and safety measures among food handlers in street food shops and food establishments of Dessie town, Ethiopia: a community-based cross-sectional study. PLoS ONE. 2018;13(5):e0196919.

37. Senthilkumar B, Prabakaran G. Multidrug resistant Salmonella typhi in asymptomatic typhoid carriers among food handlers in Namakkal district, Tamil Nadu. Indian J Med Microbiol. 2005;23:92–4.

38. Desta M, Asrat D, Weldeamanuel Y. Health sciences College of Hawassa University, Hawassa, Ethiopia. Ethiop J Health Dev. 2014;28(1):29–34.

39. Al-Lahham AB, Abu-Saud M, Shehabi AA. Prevalence of Salmonella, Shigella and intestinal parasites in food handlers in Irbid, Jordan. J Diarrheal Dis Res. 1990;16:160–2.

40. Tadesse G. A meta-analysis of the proportion of antimicrobial resistant human Salmonella isolates in Ethiopia. BMC Pharmacol Toxicol. 2014;15:51.

41. Mengistu G, Mulugeta G, Lema T, et al. Prevalence and antimicrobial sus- ceptibility patterns of Salmonella serovars and Shigella species. J Microb Biochem Technol. 2014;2:6.

42. Mamuye Y, Metaferia G, Birhanu A, et al. Isolation and antibiotic suscepti- bility patterns of Shigella and Salmonella among under 5 children with acute diarrhoea: a cross-sectional study at selected public health facilities in Addis Ababa, Ethiopia. Clin Micorbiol. 2015;4:186.