Diarrheagenic Escherichia coli O157 from Libya: recent perspectives and challenges

Mohamed O. Ahmed, Nariman F. Almshawt, Hiam R. Elnaghe
Department of Microbiology and Parasitology, Faculty of Veterinary Medicine, University of Tripoli, Libya

Diarrheal pathogens persist as a primary cause of high morbidity and mortality, especially among young children and are a major cause of diarrheal illnesses, and a seasonal infection transmitted by the fecal-oral route. The increased incidence of rotavirus infection among human populations has been attributed to its wide-range presence in animals and ability to exchange genetic determinants between strains affecting animal and human hosts. Bacteria pathogens are also a leading cause of diarrheal illness, especially among children. Researchers in Libya have begun reporting on the isolation of E. coli O157 from a range of animals and animal products. Herein, we summarize the recent peer-reviewed articles on this topic and provide commentary to promote interest in this important public health concern and highlight the research opportunities (Table 1).

In Libya, 24-33% of pediatric diarrheal cases are caused by rotavirus rotavirus. In addition, a recent study uncovered an alarming trend in increasing incidence, with these cases estimated to represent up to 57%. Bacterial pathogens are also reported to be a major cause of diarrheal illness in children and are responsible for an approximate 27% of the clinical samples examined. Several genogroups of E. coli have been characterized (i.e., EPEC, ETEC, EHEC, EIHC, EAEC) and found to express multidrug-resistant phenotypes. However, the epidemiology, phylogenetic relation and zoonotic features of the reported strains isolated from pediatric human cases, and at population level, are largely unknown.

In Libya, the recently reported E. coli O157 isolates from food-producing animals and most recently from animal products underscore the serious health concern facing this region (Table 1). Garbage et al. for instance, have reported the isolation of E. coli O157 from raw milk and dairy products collected from different animals, with cow origin being predominant (7/11 of total isolates). This particular study has reported high isolation rate for E. coli O157 from raw milk and dairy products collected from different animals, with cow origin being predominant (7/11 of total isolates). This study has reported high isolation rate for E. coli O157 from fresh white cheese samples (35.6% of tested samples) collected from local factories around Tripoli; however, the animal origin of the samples was not clear.

The consumption of raw or undercooked meat of bovine origin has been frequently reported to be the most common source of E. coli O157 contamination and infection. A study of raw sausage specimens (locally known as almergaz) that had been collected from local markets in Tripoli isolated E. coli O157 from 48%, with 60% genopositivity for stx genes among the isolated strains; however, the animal source of meat samples was not stated. Previously, studies have reported the isolation of this pathogen from burger meat specimens of beef and chicken origins. Considering the collective findings from these studies, the rates of isolation/contamination was found to range between 4-5% in cooked meat and from 20-27% in uncooked meat specimens of burgers (Table 1). Unfortunately, most of the previous studies have not determined the possible sources of these contaminant bacteria or the epidemiologic and phylogenetic relation among these strains and/or towards humans (either humans-in-contact or the consumers).

Prevalence of E. coli O157 in healthy dairy cows has been studied as well. In suburban areas of Tripoli, the reported rates range from 6-9%. Shedding of E. coli O157 from healthy cattle was reported to be significantly associated with signs of diarrhea and source of water-intake (identifying these parameters as risk factors of shedding). Surprisingly, age which is frequently associated with shedding of E. coli O157, was not found to be a significant risk factor. Ultimately, healthy dairy cows have been posited as a natural reservoir of E. coli O157 in Libya. A regional study from Egypt identified E. coli O157 isolates from marine life (seafood and animals from coastal water; 48% of tested samples). Thus, there is a
serious public health threat among important food resources of this region. Interestingly, recent reports have documented the possible association of outbreaks and infections with the new emergent *E. coli* serotype O104:H4 in Europe and travel history to North Africa. Environmental contaminants and waste materials of urban and suburban sources can harbor pathogenic and infectious agents and therefore pose a significant public health threat. The non-developed sanitary and health systems of underdeveloped regions can play a major role in the dissemination and emergence of infectious pathogens, such as *E. coli* O157.

The collective peer-reviewed literature on this topic highlights the likely role of food-producing animals as a potential source and carrier of public health-threatening pathogens. However, the carriage status of *E. coli* O157 in different food-producing animals and the related epidemiological information still require investigation. Also, information is absent on the most significant diarrheagenic *E. coli* that are frequently reported and associated with global human outbreaks. Documentation of *E. coli* O157 isolates from animal products is necessary, so that appropriate prevention measures can be developed and applied to control risk in the food chain as well as in the environment. Thus, systematic epidemiological studies are required to determine an accurate estimation of the burden of *E. coli* O157 and other diarrheagenic strains, particularly in food-producing animals. This will require interactive collaboration between human and veterinary medicine professionals at the clinical, public health and research level.

### References

1. Kosek M, Bern C, Guerrant RL. The global burden of diarrheal disease, as estimated from studies published between 1992 and 2000. Bull WHO 2003;81:197204.
2. Fletcher SM, Stark D, Ellis J. Prevalence of gastrointestinal pathogens in Sub-Saharan Africa: systematic review and meta-analysis. J Public Health Afr 2011;5:e30.
3. Khoury H, Ogilvie I, El Khoury AC, et al. Burden of rotavirus gastroenteritis in the pediatric population. BMC Infect Dis 2011;7:9.
4. Rahouma A, Klena JD, Krema Z, et al. Enteric pathogens associated with childhood diarrhea in Tripoli-Libya. Am J Trop Med Hyg 2011;84:886-1.
5. Ali MM, Mohamed ZK, Klena JD, et al. Molecular characterization of diarrheagenic Escherichia coli from Libya. Am J Trop Med Hyg 2012;86:866-6.
6. Shaban R, Abdulsalam B. Prevalence of Escherichia coli O157:H7 causing childhood diarrhea in Sirte, Libya. IDWeek Advance Science, Improving Care. 2013. p. 1293. Available from:

https://idsa.confex.com/idsa/2013/webprogram/Paper41774.html [cited 5 October 2013]
7. Ghenghesh KS, Ben-Taher S, Aibeid S, Tawil A. Escherichia coli O157:H7 in children diarrhoea in Libya. Clin Microbiol Infect 1997;3:221.
8. Ghenghesh KS, Bara F, Bukris B, et al. Characterization of virulence factors of Aeromonas isolated from children with and without diarrhea in Tripoli, Libya. J Diarrhoeal Dis Res 1999;17:75-80.
9. Ghenghesh KS, Aibeid SS, Bara F, Bukris B. Etiology of childhood diarrhoea in Tripoli-Libya. Jamahiriya Med J 2001;1:23-9
10. Ghanim MA, Taher IAA, Ahmadi AI, Tobgi RS. Etiology of childhood diarrhoea in Benghazi, Libya. Garyounis Med J 2003;20:22-4.
11. Dow MA, Toth I, Malik A, et al. Phenotypic and genetic characterization of enteropathogenic Escherichia coli (EPEC) and entero-aggregative E. coli (EAEC) from diarrheal and non-diarrheal children in Libya. Comp Immunol Microbiol Infect Dis 2006;29:100-3.
12. Islam MZ, Musekiwa A, Islam K, et al. Regional Variation in the prevalence of E. coli O157 in cattle: a meta-analysis and meta-regression. PLoS One 2014;9:e93299.
13. De RK, Vincen S, Garabedian L, et al. Enteroaggregative Shiga toxin-producing Escherichia coli of serotype

### Table 1. Summary of the prevalence and isolation frequencies of diarrheagenic *Escherichia coli* from humans, animals and animal products in Libya.

| Sample origin | Origin and source | N. tested samples | Total positivity, % | Identified E. coli group and/or strains | Identification method | Ref. |
|---------------|-------------------|-------------------|---------------------|----------------------------------------|-----------------------|------|
| Human Stool (Children) | Diarrheic | 239 | 11.2% | EAEC, EPEC, EHEC, EIEC | PCR | 4 |
| | Diarrheic | 124 | 8.7% | O157:H7 | Sera | 6 |
| | Diarrheic | 157 | 7.0% | O157:H7 | Sera | 7 |
| | Control | 157 | 4.4% | EPEC, ETEC, EAEC | EPEC | 5 |
| | Diarrheic | 243 | 8.6% | | PCR | 5 |
| | Diarrheic | 157 | 0.11 | | Sera | 9 |
| | Control | 157 | 0.07 | EPEC | Sera | 10 |
| | Diarrheic | 356 | 0.04 | O157, EAEC | O157 | 11.8 |
| | Control | 100 | 0 | O157, EAEC | O157 | 11.8 |
| | Diarrheic | 157 | 8.9% | PCR | O157 | 11.8 |
| | Control | 157 | 2.5% | PCR | O157 | 11.8 |
| Cattle | Feaces | 97 | 6.2 | O157 | Sera | 14 |
| | Feaces | 200 | 9 | O157 | Sera | 23 |
| | Raw milk | 28 | 3.5 | O157 | 16srDNA-PCR | 18 |
| | Dairy products* | 49 | 9.5/21.4 | O157 | 16srDNA-PCR | 18 |
| | Burger° | 15° | 5.4/27.1° | O157:H7 | Sera | 21 |
| Camel | Raw milk | 97 | 0 | O157 | 16sr DNA-PCR | 18 |
| Goat | Raw milk | 9 | 0 | O157 | 16sr DNA-PCR | 18 |
| Chicken | Burger° | 120° | 4.7/20.3° | O157:H7 | Sera | 22 |
| Unknown | Raw sausages | 100 | 48 | O157:H7 | Sera and PCR | 20 |
| | Cheese | 87 | 35.6 | O157:H7 | Unspecified | 19 |

ID, identification. *Dairy products [Include cheese (n=21; 9.5%) and fermented milk (n=28; 21.4%)]; °Burgers (sample size is presented in total and positive rates are in respect to cooked/raw products).
O104:H4 in Belgium and Luxembourg. New Microbes New Infect 2014;2:138-3.
14. Ahmed MO, Abouzeed YM. Enterohaemorrhagic Escherichia coli O157: a survey of dairy cattle in Tripoli, Libya. Libyan J Med 2014;9:24409.
15. Abugalia M, Cuevas L, Kirby A, et al. Clinical features and molecular epidemiology of rotavirus and norovirus infections in Libyan children. J Med Virol 2011;83:1849-6.
16. Kalaf RN, Elahmer OR, Zorgani AA, Ghenghesh KS. Rotavirus in children with diarrhea in Tripoli, Libya. Libyan J Med 2011;18:6.
17. Alkoshi S, Ernst K, Maimaiti N, Dahlui M. Rota viral infection: a significant disease burden to Libya. Iran J Public Health 2014;43:1356-3.
18. Garbaj AM, Awad EM, Azwai SM, et al. Enterohemorrhagic Escherichia coli O157 in milk and dairy products from Libya: isolation and molecular identification by partial sequencing of 16S rDNA. Vet World 2016;9:1184-9.
19. Abujnah YS, El Magdoli LS, Gnan SO, et al. Bacteriological quality and incidence of some pathogenic bacteria in fresh white cheese sold in Tripoli, Libya. J Microb Biochem Technol 2016;8:307-1
20. Ben Hamza IM. Detection of stx gene of E.coli 0157:H7 in sausages by using polymerase chain reaction (PCR) in Tripoli. The Libyan Academy of Graduate Studies 2012. Ref no. 4556.
21. Elshrek YM, Madi NS, El-Bakoush E, El-Tawil A. Microbiological studies of spiced beef burgers in Tripoli city, Libyan Arab Jamahiriya. East Mediterr Health J 2008;14:172-8.
22. El Shrek YM, Ali MR. Microbiological study of spiced chicken burgers in Tripoli City, Libya. East Mediterr Health J 2012;18:653-2.
23. Helmi HA. The prevalence of verocytotoxin-producing Escherichia coli 0157 (VTEC) in dairy cattle in Tripoli area. Thesis dissertation. Faculty of veterinary medicine 2013.
24. El-shenawy MA, EL-shenawy M. Enterohaemorrhagic Escherichia coli O157 in coastal environment of Alexandria, Egypt. Microb Ecol Health Dis 2005;17:103-6.