DETECTION OF DIARRHEAGENIC ESCHERICHIA COLI IN HUMAN DIARRHEIC STOOL AND DRINKING WATER SAMPLES IN OUAGADOUGOU, BURKINA FASO.

Isidore Juste Ouindgueta Bonkoungou1*, Namwin Siourimé Somda1, Oumar Traoré2,3, Barthelemy Sibiri Zoma4,5, Zakaria Garba1,6, Koine Maxime Drabo1, Nicolas Barro1.

1Département de Biochimie-Microbiologie. UFR- Sciences de la vie et de la terre. Université Joseph Ki-Zerbo, 03 BP 7021 Ouagadougou 03, Burkina Faso. 2 Département Technologie Alimentaire (DTA) / IRSAT / CNRST, Burkina Faso, 03 BP 7047 Ouagadougou 03. 3 Unité de Formation et de Recherche en Sciences Appliquées à la Technologie (UFR/SAT). Université de Dédougou, BP 176 Dédougou. 4Laboratoire National de Santé Publique (LNSP), 09 BP 24 Ouagadougou 09, Burkina Faso. 5Polyon Bio Services SARL. 09 BP 969 Ouagadougou 09, Ouagadougou, Burkina Faso 969. 6Unité de Recherche Clinique de NANORO, IRSS-CNRST, BP: 218 Ouaga 11 Burkina Faso, 7Institut de Recherche en Sciences de la santé, CNRST, 03 B.P. 7192 Ouagadougou 03 Burkina Faso.

*Corresponding author E-mail: ouindgueta@gmail.com

Abstract

Background: The presence of diarrheagenic Escherichia coli (DEC) in drinking water, is a grave public health problem. This study was aimed at characterization of diarrheagenic Escherichia coli isolated from drinking water and faecal samples from diarrheic patients in Ouagadougou, Burkina Faso.

Materials and Methods: A total of 242 water samples consisting of 182 potable sachets and 60 from boreholes were collected in the period between October 2018 and April 2019 in the city of Ouagadougou. Faecal samples were also collected from 201 diarrheic patients visiting National Public Health Laboratory for a biological diagnosis by coproculture. The presence of virulence genes associated with DEC was determined by 16-plex polymerase chain reaction from bacteria culture.

Results: From drinking water, we found 17% (42/242) Escherichia coli isolates in which 1% (2/242) DEC were detected. Among analyzed samples (182 sachet water versus 60 borehole water), the two DEC (01 ETEC and 01 EPEC) were detected in sachet water. DEC were detected in 20% (40/201) of patients. Enterogaegregative Escherichia coli (EAEC) were mostly detected in 10% followed by Enteropathogenic Escherichia coli (EPEC) in 4%, Enteroinvasive Escherichia coli (EIEC) in 2%, and Shiga toxin-producing Escherichia coli (STEC) 0.5%. However, Enterotoxigenic Escherichia coli (ETEC) was not detected alone, but in co-infections with EAEC.

Conclusion: The present study documented the prevalence of Escherichia coli pathovars associated in patients with diarrhea, and shows that drinking water might be a source of DEC transmission in human.

Keywords: 16-plex PCR; drinking water; diarrheagenic Escherichia coli; Burkina Faso.

List of Abbreviations: DEC = Diarrheagenic Escherichia coli., LNSP = National Public Health Laboratory
BF = Burkina Faso., BICC = Cervel Heart Infusion Broth, EAEC = Enterogaegregative Escherichia coli, EPEC = Enteropathogenic Escherichia coli, ETEC = Enterotoxigenic Escherichia coli, STEC = Shiga toxin-producing Escherichia coli, EIEC = Enteroinvasive Escherichia coli, PCR = polymerase chain reaction

Introduction

Diarrheal diseases are among the main causes of morbidity and mortality in Africa and mainly affect children under 5 years old (Adjuik et al., 2006). They are usually caused by at least one bacterial, viral or parasitic agent. These infections are often linked to non-compliance with the conditions of good hygiene practices during foods processing and especially poor quality of drinking water. According to World Health Organization (WHO), better access to drinking water is a key factor in the reduction of diarrheal diseases. However, access to water is poor the cities of sub-Saharan Africa where only 20% of the population is supplied by an unimproved source of water (Aubry and Gauzère,
Water sources can be investigated for detection of fecal contamination; high fecal levels can mean that water contains pathogens by testing for the presence of *Escherichia coli* (Cowan, 2018). *Escherichia coli* is a member of the faecal coliform group that is mostly considered as a specific indicator of faecal pollution. They are normally found in the feces of humans or other warm-blooded animals. Most strains of *Escherichia coli* are harmless, and their presence in the water only suggests that faecal contamination may have occurred and that disease-causing organisms may be present (Aubry and Gaüzère, 2012). According to their virulence properties, symptoms of the disease that they cause, species and age group where they are found, *Escherichia coli* is classified into: enteropathogenic *E. coli* (EPEC), enterotoxigenic *E. coli* (ETEC), Shiga toxin-producing *E. coli* (STEC), enteroinvasive *E. coli* (EIEC) and enteroaggregative *E. coli* (EAEC) being the most important (Kaper et al., 2004). Presence of DEC in drinking water has been mentioned by previous studies (Hunter, 2003) and all are known to be endemic in essentially all developing countries (Jafari et al., 2012). Its presence is therefore important to assess the prevalence of diarrheal diseases and identify the associated risk factors, in particular, those linked to the consumption of water and sanitation. Over the past decade, researchers have focused studies on *Escherichia coli* pathovars of clinical and environmental origin, which are responsible for diarrhea in children under 5 years old and adults in Burkina Faso (Bonkoungou et al., 2011; Kagambéga et al., 2013; Somda et al., 2017). However, up to date, no study to our knowledge has characterized the *Escherichia coli* pathovars in drinking water, in order to establish the role of drinking water in development of diarrhea diseases in Burkina Faso.

In this study, virulence genes of DEC were detected in drinking water for the first time in Burkina Faso through potable sachets and boreholes water. Also, DEC prevalence were investigated in stools samples from diarrheic patients in the same city (Ouagadougou), Burkina Faso.

**Materials and Methods**

**Sample collection**

In this study, sampling considered the fact that potable sachets and boreholes water have emerged as an alternative source of drinking water in the capital city, Ouagadougou in Burkina Faso. We included stool samples in order to update DEC prevalence in the area and during the period of drinking water sampling.

The study was conducted at the National Public Health Laboratory (LNSP) in the capital city of Ouagadougou, Burkina Faso. LNSP is a multidisciplinary institute with the following departments: Environment, Food, Drugs and Medical Biology departments.

This study was part of LNSP routine activities in which diarrheic stool samples were collected from patients visiting the Medical Biology department for a biological diagnosis by coproculture prescribed by a health worker as described in our previous study (Somda et al., 2017). Stool samples were collected from October 2018 to April 2019 from 201 patients visiting a health worker due to gastroenteritis. All samples used in this study had been anonymized and made untraceable before storage. The study received permission from the LNSP authorities of Burkina Faso and verbal informed consent was acquired from patients or parents/legal guardian prior to enrollment.

For drinking water, a total of 242 samples from LNSP’s Environment Control Department collected during routine analysis (from October 2018 to April 2019) of drilling water and sachet water were included. Samples of sachet water were taken randomly in their original packaging on the storage site according to LNSP water routine activities sampling plan and sent to the laboratory for analysis. The sampling of drilling (borehole) water was exhaustive, involving all the companies which were the subject of a quality control request. The samples were taken directly at the source in an aseptic manner in sterile bottles, placed in coolers, and sent immediately to the laboratory for analysis.

**Microbiological analysis**

**Drinking water samples:** The membrane filtration method was used: 100 ml of drilling water and 250 ml of sachet water were homogenized and filtered through a cellulose nitrate filtration membrane with a porosity of 0.45 μm and then placed on an Extra Selective Chromocult Agar and incubated at 37°C for 24 hours. After incubation, suspected colonies (dark blue to purple) were scraped with sterile Pasteur pipette and put in sterile cryotubes containing brain-heart infusion broth added 15% glycerol and conserved at -20°C for molecular analysis.

**Clinical samples:** All collected stool samples were cultured on MacConkey Sorbitol agar (HIMEDIA, M2981-500G, India) and incubated at 37°C for 24 hours. After incubation, bacterial mass was scraped using sterilized Pasteur pipette and put in sterile cryotubes containing Cervel Heart Infusion Broth (BICC) added 15% glycerol and conserved at -20°C for *E. coli* pathovars detection.

**16-plex PCR assay**

DEC pathovars Shiga toxin-producing *Escherichia coli*, Enteropathogenic *Escherichia coli*, Enterotoxigenic *Escherichia coli*, Enteroinvasive *Escherichia coli*, and Enteroaggregative *Escherichia coli* (STEC, EPEC, ETEC, EIEC, and EAEC) were detected by using 16-plex PCR technique as described by (Antikainen et al., 2009). Principal genes detected were uidA, pic, bfp, invE, elt, ent, escV, aggR, stx1, stx2, estla, estfb, and ast (Müller et al., 2007), hlyA...
et water of EIEC ° for 00 (45 light hours. each a and from f EMC 02 followed were 5 as (1%)
PCR from old, staining 1 E. between above E. (Solis and old, 3% water no water). were 5 by
DEC 2017 previous 30 after (1%) diarrheal 201 7% children of water drilling (13%)
children of 2017 81 diarrheal children were 16 and 18 in 2011 26 Out 6 40 (aged
a years, added 18 years. However, EPEC detected (Table 1). 4% (8/201), EIEC 2% (05/201) and STEC 1% (01/201). However, ETEC were not detected alone, but in co-infections with others pathovars. More than one DEC was detected in 5 samples (2%). (Table 1).

Prevalence of diarrheal Escherichia coli according age and sex

Out of 40 DEC detected, 17% (18/105) were from males and 23% (22/96) were from females. Of the 40 DEC detected 26 (29%) were from children under 5 years old, 9 (30%) in patients aged between 6 and 18 years old, and 5 (6%) from patients over age 19 years old. Among the 26 cases detected in children under 5 years, the composition was as follows: EAEC, 14%; EPEC, 7%; EIEC, 3%; STEC, 1%; and 3 co-infections EAEC + ETEC, EAEC+ STEC, EAEC+EPEC at 1% in each of the cases (Table 1). In patients aged between 6 and 18 years old, EAEC were found in 17% followed by EPEC in 7%, EIEC in 3%, and 3% of 1 co-infection of EAEC+EIEC. Among patients aged over 19 years old, EAEC were detected in 4% followed by EIEC in 1% and 1% of co-infection of EAEC+STEC.

Table 1: Distribution of the different DEC detected according to age

| Pathovars/ages (years) | [0 - 5] n=90 (%) | [6 - 18] n=30 (%) | > 19 years n=81 (%) | Total n=201 (%) |
|------------------------|------------------|-------------------|-------------------|---------------|
| EAEC                   | 13 (14)          | 05 (17)           | 03 (4)            | 21 (10)       |
| EPEC                   | 06 (7)           | 02 (7)            | 00                | 08 (4)        |
| EIEC                   | 03 (3)           | 01 (3)            | 01 (1)            | 05 (2)        |
| STEC                   | 01 (1)           | 00                | 00                | 01 (1)        |
| EAEC + EIEC            | 00               | 01 (3)            | 00                | 01 (1)        |
| EAEC + ETEC            | 01 (1)           | 00                | 00                | 01 (1)        |
| EAEC + STEC            | 01 (1)           | 00                | 01 (1)            | 02 (1)        |
| Total                  | 26 (29)          | 09 (30)           | 05 (6)            | 40 (20)       |

Legend: EAEC = Enteroaggregative Escherichia coli, EIEC = Enteroinvasive Escherichia coli, STEC = Shigatoxinogenic Escherichia coli, ETEC = Enterotoxinogenic Escherichia coli, EPEC= Enteropathogenic Escherichia coli, n = number.
In this present study, *E. coli* pathovars were detected in the first time in drinking water in Burkina Faso. *Escherichia coli* were isolated in 17% and DEC in 1% of drinking water analyzed. This finding could be because sachet water is generally packaged and stored in unsanitary conditions, which allows the contamination and proliferation of bacteria. The lack of safe drinking water is one of the leading causes of death especially in children under 5 years old (WHO, 2008).

The *E. coli* pathovars detected in drinking (sachet water) were mainly composed of EPEC and ETEC. Previous studies in Egypt (Ahmed et al., 2014), Bangladesh (Talukdar et al., 2013) and Brazil (Lascowski et al., 2013) reported the presence of DEC in drinking water in these countries. In Burkina Faso, packaged water is generally intended for direct consumption since they have a reputation to be potable. Sachet water is the most commonly consumed packaged water due to their low prices which made them more affordable than bottled water.

They are often obtained from drilling water, but sometimes obtained from surface water after treatment. It is supposed to be free of pathogenic germs and therefore suitable for consumption. Nowadays, many sachet water conditioning companies have emerged in Burkina Faso. However, some owners ignore the rules of good manufacturing and hygiene practices. Some are produced directly at home without any recipient of hygiene. All these facts could be at the origin of the contamination of these waters by *Escherichia coli* diarrhea. Others studies shown that water from public standpipes, and wells is collected at the source, carried to, and stored in the household affording multiple opportunities for contamination such that final water quality is often worse than in the associated source (Lascowski et al., 2013; Hunter, 2003)

The DEC prevalence in patients with diarrhea (20%) was lower than that (45%) found in our previous study in 2011 in Burkina Faso (Bonkoungou et al., 2011; Bonkoungou et al., 2013). Overall, the decrease in DEC cases over the years in Burkina Faso might be explained by the fact that population has adopted better hygiene measures since the recent Ebola epidemic in west Africa in 2014. In accordance, other studies carried out elsewhere have shown that these pathogens are indicators of poor compliance to hygiene standards (Gomes et al., 2016).  

Of the patients participating in this study, children under the age of 5 years were the most likely to have diarrhea caused by DEC, 65% (26/40) of total DEC. This observation might be explained by the weak immune system in children and supporting the well-documented role of DEC in childhood diarrhea in Burkina Faso (Bonkoungou et al., 2011; Bonkoungou et al., 2013).

In our study, the most frequently detected DEC was EAEC. In recent years, EAEC although specific to travelers’ diarrhea, has mostly been identified as a diarrheal agent causing acute and chronic diarrhea in all age groups and common infection primarily in newborns and immunocompromised patients (Gomes et al., 2016). In other studies, EAEC was associated with diarrhea due to malnutrition in children living in developing countries and in HIV patients (Kaur et al., 2010). Recent studies have shown high prevalence of EAEC in Burkina Faso and elsewhere, for example, in Gambia and United States (Ikumapayi et al., 2017; Imdad et al., 2018; Konaté et al., 2017; Saka et al., 2019; Somda et al., 2017). However, some studies have reported that EAEC is not associated with diarrhea (Bonkoungou et al., 2011; Hien et al., 2008; Keskimäki et al., 2000), and that EAEC was probably endemic among people in local communities and might not be a primary cause of diarrhea.

EPEC was found in 4% and only detected in children ≤ 5 years old. The EPEC prevalence was lower than previous study in Burkina Faso (Bonkoungou et al., 2011; Bonkoungou et al., 2013). It was expected to find EPEC
children since it is known that EPEC are the leading cause of infantile diarrhea in developing countries (Trabulsi et al., 2002). The low prevalence of STEC, 2%, is similar to a previous study in Burkina Faso (Bonkoungou et al., 2011).

Among the samples negative for DEC, other pathogens such as viruses, parasites or bacteria, which were not investigated in this study might be responsible for diarrhea.

In Burkina, previous studies have reported the detection of ETEC in grilled chickens, cow dung and organic manure in Burkina Faso (Bako et al., 2017; Kambire et al., 2017; Somda et al., 2018). The similarity of pathovars found in human stool samples, drinking water, and in cow dung in Burkina Faso could be because the aquatic environments are contaminated with animal fecal droppings. The use of new technologies such as Next-generation sequencing will help researchers from developing countries like Burkina Faso to establish routes of transmission for DEC by sequencing E. coli strains isolated from various samples in the future.

**Conclusion**

This study detected the presence of DEC, particularly ETEC and EPEC, in both diarrheal stool samples and drinking water. These results suggest that routinely consumed water, which should be free of pathogens, is a potential source of DEC contamination in humans with the greatest effect in children under the age of five years. From our findings, drinking water is a potential source of transmission of DEC in Burkina Faso. Therefore, more effort must be made by the public health participants involved in one health approach (environment, human and veterinary medicine) to reduce food and water borne diseases.

**Acknowledgement**

This study was supported by the University Joseph KI-ZERBO (Burkina Faso), National Public Health Laboratory in Burkina Faso and by Polygon Bio Services SARL in Burkina Faso. We thank the staff of National Public Health Laboratory and all patients who participated in this research.

**Conflict of interest:** None.

**Authors’ contributions:** IJOB and NSS: Study concept and design, performing laboratory experiments and analysis, acquisition of data and writing the manuscript. OT, SBZ and ZG: Specimens collection and laboratory experiments. MKD and NB: study concept and design.

**References**

1. Adjuik, M., Smith, T., Clark, S., Todd, J., Garrow, A., Kinflu, Y., Kahn, K., Mola, M., Ashraf, A., and Masanja, H. (2006). Cause-specific mortality rates in sub-Saharan Africa and Bangladesh. *Bulletin of the World Health Organization* 84, 181-188.
2. Ahmed, A. M., Shimamoto, T., and Shimamoto, T. (2014). Characterization of integrons and resistance genes in multidrug-resistant *Salmonella enterica* isolated from meat and dairy products in Egypt. *International journal of food microbiology* 189, 39-44.
3. Antikainen, J., Tarkka, E., Haukka, K., Siitonen, A., Vaara, M., and Kirveskari, J. (2009). New 16-plex PCR method for rapid detection of diarrheagenic *Escherichia coli* directly from stool samples. *European journal of clinical microbiology & infectious diseases* 28, 899-908.
4. Aubry, P., and Gaüzère, B. (2012). Les maladies liées à l’eau. *Médecine tropicale*.
5. Bako, E., Kagambêga, A., Traore, K. A., Bagre, T. S., Ibrahim, H. B., Bouda, S. C., Bonkoungou, I. J. O., Kaboré, S., Zongo, C., and Traore, A. S. (2017). Characterization of Diarrheagenic *Escherichia coli* Isolated in Organic Waste Products (Cattle Fecal Matter, Manure and, Slurry) from Cattle’s Markets in Ouagadougou, Burkina Faso. *International journal of environmental research and public health* 14, 1100.
6. Bonkoungou, I. J., Damanka, S., Sanou, I., Tiendrébéogo, F., Coulibaly, S. O., Bon, F., Haukka, K., Traoré, A. S., Barro, N., and Armah, G. E. (2011). Genotype diversity of group A rotavirus strains in children with acute diarrhea in urban Burkina Faso, 2008–2010. *Journal of medical virology* 83, 1485-1490.
7. Bonkoungou, I. J. O., Haukka, K., Österblad, M., Hakanen, A. J., Traoré, A. S., Barro, N., and Siitonen, A. (2013). Bacterial and viral etiology of childhood diarrhea in Ouagadougou, Burkina Faso. *BMJ pediatrics* 13, 1-6.
8. Brandal, L. T., Lindstedt, B.-A., Aas, L., Stavnes, T.-L., Lassen, J., and Kapperud, G. (2007). Octaplex PCR and fluorescence-based capillary electrophoresis for identification of human diarrheagenic *Escherichia coli* and Shigella spp. *Journal of microbiological methods* 68, 331-341.
9. Cowan, M. K. (2018). "Microbiology: a systems approach," McGraw-Hill.
10. Gomes, T. A., Elias, W. P., Scaletsky, I. C., Guth, B. E., Rodrigues, J. F., Piazza, R. M., Ferreira, L. C., and Martinez, M. B. (2016). Diarrheagenic *Escherichia coli*. *brazilian journal of microbiology* 47, 3-30.
11. Hien, B. T. T., Scheutz, F., Cam, P. D., Serichantalergs, O., Huong, T. T., Thu, T. M., and Dalsgaard, A. (2008). Diarrheagenic *Escherichia coli* and *Shigella* strains isolated from children in a hospital case-control study in Hanoi, Vietnam. *Journal of clinical microbiology* 46, 996-1004.
12. Hunter, P. R. (2003). Drinking water and diarrhoeal disease due to Escherichia coli. *Journal of water and health* 1, 65-72.

13. Ikumapayi, U. N., Boisen, N., Hossain, M. J., Betts, M., Lamin, M., Saha, D., Kwambana-Adams, B., Dione, M., Adegbola, R. A., and Roca, A. (2017). Identification of subsets of enterogroupaggregative Escherichia coli associated with diarrheal disease among under 5 years of age children from Rural Gambia. *The American journal of tropical medicine and hygiene* 97, 997-1004.

14. Imdad, A., Foster, M. A., Iqbal, J., Fonnesbeck, C., Payne, D. C., Zhang, C., Chappell, J. D., Halasa, N., and Gómez-Duarte, O. G. (2018). Diarrheagenic *Escherichia coli* and acute gastroenteritis in children in Davidson County, Tennessee, United States: a case-control study. *The Pediatric infectious disease journal* 37, 543.

15. Jafari, A., Aslani, M., and Bouzari, S. (2012). *Escherichia coli*: a brief review of diarrheagenic pathotypes and their role in diarrheal diseases in Iran. *Iranian journal of microbiology* 4, 102.

16. Kagambégã, A., Lienemann, T., Aulu, L., Traoré, A. S., Barro, N., Siitonen, A., and Haukka, K. (2013). Prevalence and characterization of *Salmonella enterica* from the feces of cattle, poultry, swine and hedgehogs in Burkina Faso and their comparison to human *Salmonella* isolates. *BMC microbiology* 13, 253.

17. Kambire, O., Adingra, A. A., Yao, K. M., and Koffi-Nevry, R. (2017). Prevalence of virulence genes associated with diarrheagenic pathotypes of *Escherichia coli* isolates from water, sediment, fish, and crab in Aby Lagoon, Côte d’Ivoire. *International journal of microbiology* 2017, 1-8. https://doi.org/10.1155/2017/9532170

18. Kaper, J. B., Nataro, J. P., and Mobley, H. L. (2004). Pathogenic *Escherichia coli*. *Nature reviews microbiology* 2, 123-140.

19. Kaur, P., Chakraborti, A., and Asea, A. (2010). Enterogroupaggregative *Escherichia coli*: an emerging enteric food borne pathogen. *Interdisciplinary perspectives on infectious diseases* 2010, 1-10. doi:10.1155/2010/254159

20. Keskimäki, M., Mattila, L., Peltola, H., and Siitonen, A. (2000). Prevalence of diarrheagenic *Escherichia coli* in Finns with or without diarrhoea during a round-the-world trip. *Journal of clinical microbiology* 38, 4425-4429.

21. Konaté, A., Dembélé, R., Kagambégã, A., Soulama, I., Kaboré, W. A., Sampo, E., Cissé, H., Sanou, A., Serme, S., and Zongo, S. (2017). Molecular characterization of diarrheagenic *Escherichia coli* in children less than 5 years of age with diarrhea in Ouagadougou, Burkina Faso. *European Journal of Microbiology and Immunology* 7, 220-228.

22. Lascowski, K., Guth, B., Martins, F., Rocha, S., Irino, K., and Pelayo, J. (2013). Shiga toxin-producing *Escherichia coli* in drinking water supplies of north P araná S tate. B razi. *Journal of Applied Microbiology* 114, 1230-1239.

23. Müller, D., Greune, L., Heusipp, G., Karch, H., Fruth, A., Tschäpe, H., and Schmidt, M. A. (2007). Identification of unconventional intestinal pathogenic *Escherichia coli* isolates expressing intermediate virulence factor profiles by using a novel single-step multiplex PCR. *Applied and environmental microbiology* 73, 3380-3390.

24. Saka, H. K., Dabo, N. T., Muhammad, B., Garcia-Soto, S., Ugarte-Ruiz, M., and Alvarez, J. (2019). Diarrheagenic *Escherichia coli* Pathotypes From Children Younger Than 5 Years in Kano State, Nigeria. *Frontiers in Public Health* 7.

25. Somda, N., Bonkoungou, O., Zongo, C., Kpoda, D., Tapsoba, F., Bassolé, I., Traoré, Y., and Savadogo, A. (2017). Prevalence of *Escherichia coli* virulence genes in patients with diarrhoea in Ouagadougou, Burkina Faso. *African Journal of Clinical and Experimental Microbiology* 18, 179-185.

26. Somda, N. S., Bonkoungou, O. J., Zongo, C., Kagambégã, A., Bassolé, I. H., Traoré, Y., Mahillon, J., Scippo, M. L., Houhouigan, J. D., and Savadogo, A. (2018). Safety of ready-to-eat chicken in Burkina Faso: Microbiological quality, antibiotic resistance, and virulence genes in *Escherichia coli* isolated from chicken samples of Ouagadougou. *Food science & nutrition* 6, 1077-1084.

27. Talukdar, P. K., Rahman, M., Rahman, M., Nabi, A., Islam, Z., Hoque, M. M., Endtz, H. P., and Islam, M. A. (2013). Antimicrobial resistance, virulence factors and genetic diversity of *Escherichia coli* isolates from household water supply in Dhaka, Bangladesh. *Plos one* 8, e61090.

28. Trabulsi, L. R., Keller, R., and Gomes, T. A. T. (2002). 10.321/eid08050. Typical and Atypical Enteropathogenic *Escherichia coli*. *Emerging infectious diseases* 8, 508.

29. Vidal, M., Kruger, E., Durán, C., Lagos, R., Levine, M., Prado, V., Toro, C., and Vidal, R. (2005). Single multiplex PCR assay to identify simultaneously the six categories of diarrheagenic *Escherichia coli* associated with enteric infections. *Journal of clinical microbiology* 43, 5362-5365.

30. World Health Organization: Guidelines for Drinking Water Quality. https://www.who.int/water_sanitation_health/dwq/fulltext. pdf (2008). Accessed on May, 2020.