

RESEARCH ARTICLE

## Burden of acute gastrointestinal infections in Ouagadougou, Burkina Faso

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### ABSTRACT

**Objective:** Gastrointestinal infections are one of the major health problems in developing countries. The present study aims to estimate the prevalence of gastrointestinal infections in Ouagadougou, the capital of Burkina Faso.

**Methods:** A door-to-door survey of selected residents in Ouagadougou city was conducted. Of the Ouagadougou's 30 districts, nine most populated ones were selected to the study. The residents of these districts have middle incomes as those of the secondary cite of Burkina Faso.

**Results:** The overall prevalence of gastrointestinal infections in the 30 days prior to the interview was 77/491 (15.7%); among children 44/223 (19.7%) and among adults 33/268 (12.3%). Diarrhea and abdominal pain were the most common symptoms among 33 adult cases while diarrhea and vomiting were the most common among children. None of the cases were hospitalized and a stool sample was taken in three of 77 cases. Medication for gastrointestinal infections was received by 55% percent of adults and 77% of children.

**Conclusions:** Our results shown that antibiotics with and without prescription were the most common medicine used. Washing hands before meals and boiling milk before drinking had a protective effect against gastrointestinal infections. *J Microbiol Infect Dis* 2016;6(2): 45-52

**Key words:** Gastrointestinal infections, burden, Burkina Faso.

## Burkina Faso Ouagadougouda akut gastroenterit hastalık yükü

### ÖZET

**Amaç:** Gastrointestinal enfeksiyonlar gelişmekte olan ülkelerin önemli sağlık problemlerinden biridir. Bu çalışmanın amacı Burkina Faso'nun başkenti Ouagadougou'da gastrointestinal enfeksiyonların prevalansını araştırmaktır.

**Yöntem:** Ouagadougou şehrinde yaşayan ve çalışma için seçilen şehir sakinleri kapı kapı dolaşarak uygulanan bir anket ile bu araştırıldı. Ouagadougou şehri 30 bölgeden oluşmakta olup bu çalışma için nüfusun en yoğun olduğu dokuzu seçildi. Bu bölgelerin sakinleri orta gelirli olup Burkino Faso'nun ikinci grubunu oluşturmaktaydılar.

**Bulgular:** Genel görüşme öncesindeki 30 gün içinde gastrointestinal enfeksiyon geçirme sıklığı 77/491 (% 15.7) idi: çocuklar arasında 44/223 (% 19.7) ve yetişkinler arasında 33/268 (% 12.3) idi. Hiçbir olguda hastaneye yatma öyküsü yoktu. ve 77 vakadan üçünde dışkı örneği alınmıştı. Gastro-intestinal enfeksiyonlar için ilaç kullanma sıklığı ise yetişkinlerin% 55 oranında ve çocukların% 77 oranında idi.

**Sonuç:** Bizim sonuçlarımız reçeteli veya reçetesiz olarak antibiyotiklerin en sık kullanılan ilaçlar olduğunu gösterdi. Yemekten önce el yıkama ve sütlerin içmeden önce kaynatılması gastroenterite karşı önemli bir koruma sağladığı görüldü.

**Anahtar kelimeler:** Gastrointestinal enfeksiyonlar, hastalık yükü, Burkino Faso

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## INTRODUCTION

Acute gastrointestinal infections (GI) cause significant morbidity, mortality, and socioeconomic burden both in developed and in developing countries [1-3]. Diarrheal diseases are the fifth most common cause of mortality and are responsible for 2.2 million deaths worldwide according to the World Health Organization (WHO) [4]. The majority of these diarrheal deaths (1.5 million, 76%) occur in the developing countries of Africa and Southeast Asia [5]. GI morbidity and mortality vary according to age groups. Small children are a particular high risk group for acute gastrointestinal infections [6-8]. Diarrheal diseases are estimated to result annually in about 1.9 million deaths in children aged less than 5 years, accounting for 19% of total child deaths [5]. However, estimating the true GI prevalence is difficult, due to the under-reporting arising from traditional surveillance techniques in particular, which require cases to seek medical attention [6]. In prevention and control of GI, water and food hygiene play a significant role [9].

Burkina Faso is located in Sub-Saharan Africa and belongs to the semiarid area where the main sources of income are farming, animal husbandry and small scale trade. Burkina Faso's urban population has grown rapidly, averaging 5% growth per year for much of the last two decades, largely resulting from the growth of peri-urban informal settlements. The population of Burkina Faso is relatively young and the proportion of children under 5 years of age is as high as 12%. In 2008, the mortality caused by diarrheal diseases in children aged under five years in Burkina Faso was 16%, being the third highest after pneumonia (18%) and malaria (28%) [10,11]. The role of several etiological agents causing GI in Burkina Faso has been studied, including viruses (rotavirus, norovirus, and adenovirus), bacteria (*Escherichia coli*, *Salmonella* sp., *Shigella* sp., *Campylobacter* sp.) and parasites (*Giardia lamblia*, *Trichomonas intestinalis*, *Entamoeba histolytica* [12,13]. In this study we report the burden of GI in the population of Ouagadougou, the capital city of Burkina Faso. The objectives of the study were to estimate the prevalence of GI in the population, describe the burden and clinical presentation of GI, and protective factors against GI.

## METHODS

### Study area and training of interviewers

A door-to-door survey of selected residents in Ouagadougou city was conducted in November-December 2011 (Fig. 1). Ouagadougou (1,915,102 resi-

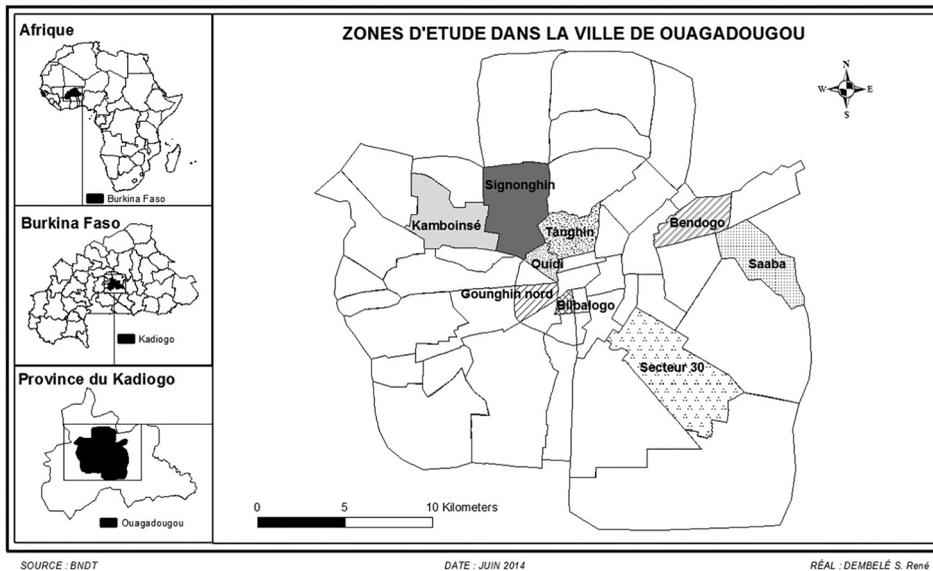
dents) consists of 30 districts of which we selected the nine districts with the highest number of residents. The residents of these districts have middle incomes as those of the secondary cite of Burkina Faso. Given the limited budget, we were able to interview only 500 individuals. The survey was administered in local language: Mooré, Djoula or French. The sampling unit of the survey was a household, which was defined as 'a group of persons living together in the same house or compound, sharing the same housekeeping arrangements and being catered for as one unit', as defined by the Institut National de la Statistique et des Etudes Economiques, INSEE, France. In choosing the first household to be interviewed, the fieldworker tossed a pencil in the air and visited the household in the direction indicated by the pencil when fallen. The subsequent interviews were conducted at the nearest households to the first.

The interviewers underwent methodical training where the objectives of the study and the techniques for interviewing participants using structured questionnaires were discussed and rehearsed in detail.

### Selection of interviewees

The individual in the household with the next birthday is commonly selected to participate in population surveys to achieve a random sample within the household. Since in Burkina Faso birthdays are not always known, we used the following selection method to obtain a random sample within households. The names of all the persons living in the household, both present and absent at the time of interview, were written on paper. The recommendation was to write down persons from oldest to youngest or vice versa so as not to forget anybody; each person was then given a number. All numbers were then written on cards, which were put into a sachet and mixed. One card was blindly taken from the sachet and the number was matched to the person using the list of the household members and their numbers. This person was then interviewed for the survey.

The selected persons were required to have been living in the household for at least 6 months prior to the interview, except in the case of children aged less than six months. In the event the selected individual refused (N=14) or was not reachable (N=31), the neighboring house was selected as the replacement. Individuals aged less than 18 years were classified as children and for them the parent or guardian answered the survey on their behalf.



**Fig.1.** Map of Burkina Faso and Ouagadougou. The nine districts included in the study are indicated.

### Data gathering and analysis

We designed a questionnaire by using other questionnaire studies on the burden of GI as models [14–19]. The questionnaire gathered information on personal demographics (e.g. age, and gender), on disease/symptoms, health-care-seeking behavior, treatment, water, food and general hygiene level in the household, contact with animals, as well as sociodemographic and educational information.

Respondents who reported diarrhea (defined as 3 or more loose stools in 24 h) or vomiting in the previous 30 days were defined as GI-cases [20]. Individuals who suffered chronic diarrhea or diarrhea caused by the use of medications, laxatives, alcohol or due to a medical condition were excluded from the analyses. GI prevalence was also estimated for both 7- and 14-day recall periods. Data were analyzed using the software package Epi Info 7.1.2.0 (Centers for Disease Control and Prevention [CDC], Atlanta). Multivariable logistic regression was used to estimate odds ratios (ORs) with ninety-five percent confidence intervals (95% CI) also calculated. The statistical significance was evaluated using the Fischer exact 2-tailed *p* value and a  $p \leq 0.05$  was considered significant.

### Ethics

The study was approved by the Committee on Human Research Publications and Ethics of Burkina Faso and the Hospital District of Helsinki and Uusimaa, Finland. Local authorities (chiefs, hospital authorities) in the study areas were then approached and the purpose of the study was carefully ex-

plained. Signed, informed consent was obtained from all participants or from the parent/guardian in the event that the participant was a minor.

## RESULTS

### Demographic characteristics of the study population

Interviews were carried out with 500 individuals (274 adults and 226 guardians of children). Nine responses (3 children and 6 adults) were excluded from the final analyses: one with a missing answer concerning vomiting and the rest due to chronic diarrhea, diarrhea associated with medicines or with pregnancy. Thus, responses from 491 persons (relating to 223 children and 268 adults) were included in the analyses. The demographic characteristics are shown in Table 1. When compared to Ouagadougou's general population, children aged 5–9 years and children aged 10–19 years were underrepresented, while younger children were overrepresented in our study population. Educational level and the prevalence of households with latrines turned out to be high in our study population compared to the situation in the whole country.

### GI prevalence

Altogether 77 participants met the case definition (the overall GI prevalence in 30 days was 15.7%). Children showed a higher GI prevalence (19.7%) than adults (12.3%) ( $p=0.02$ ) (Table 2). Vomiting was significantly more common in children than in adults ( $p<0.01$ ), while the difference for diarrhea was not statistically significant ( $p=0.11$ ) (Table 3). GI preva-

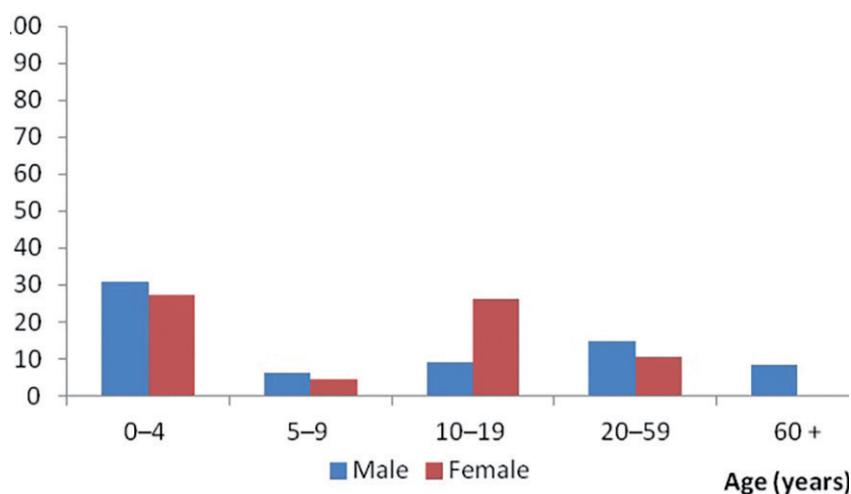
Prevalence was highest among young children aged 0-4 (28.7%). There was no difference between the prevalence of GI among males and females ( $p=1.00$ ) (Fig.2).

**Table 1.** Demographic characteristics of the study population and the population in Ouagadougou and Burkina Faso

Variables	Study population, N (%)	Ouagadougou population* (%)	Burkina Faso population* (%)
<b>Age (years)</b>			
0-4	101 (21)	12.4	14.4
5-9	39 (8)	12.0	13.3%
10-19	90 (18)	23.5	23.3%
20-59	239 (49)	48.9	45.2%
Over 60	22 (4)	3.2	3.3%
Children (0-18 year)	223 (45)	47.9	51.5%
Adults (over 18 year)	268 (55)	52.1	48.5%
<b>Gender</b>			
Female	285 (58)	51.7	49.7%
Male	206 (42)	48.3	50.3%
<b>Education in household**</b>			
No school certificate	94 (19)	NA	NA
Basic school certificate	57 (12)	NA	NA
Vocational school certificate	211 (43)	NA	NA
University degree	127 (26)	NA	NA
<b>Social indicators</b>			
Electricity in household	306 (63)	14.3	53.6%
Bicycle in household	388 (79)	82	71.6%
Motorbike in household	357 (73)	32.4	62.6%
Latrine in household	459 (94)	65.2	37.2%
Municipal tap water	449 (92)	64.7	97.5%

\*Data source: Institut National de la Statistique et du Développement (INSD), Burkina Faso

\*\*Educational in the household, 2 missing answers; NA = Not Available



**Fig.2.** GI prevalence by age groups and gender for 30 day recall period.

**Table 2.** Prevalence of GI by age group during the last 7, 14 and, 30 days before the interview

Prevalence among cases/ interviewees (%)			
Groups	7 days	14 days	30 days
Children	22/223 (9.9)	25/223 (11.2)	44/223 (19.7)
Adults	7/268 (2.6)	11/268 (4.1)	33/268 (12.3)
Total	29/491 (5.9)	36/491 (7.3)	77/491 (15.7)

**Table 3.** Monthly prevalence of diarrhea and vomiting in children and adults

Symptoms	Number of cases/ interviewees (%)
Diarrhea children	31/223 (13.9)
Diarrhea adults	25/268 (9.6)
Diarrhea all	56/491 (11.4)
Vomiting children	35/223 (15.7)
Vomiting adults	14/268 (5.2)
Vomiting all	49/491 (9.9)

**Severity of symptoms and medication among cases**

Diarrhea and abdominal pain were the most common symptoms among 33 adult cases while diarrhea and vomiting were the most common among children. Blood in stool was reported in 6% of adult cases and in 9% of cases among children (Table 4). None of the cases was hospitalized and a stool sample was taken by health care staff only in three of 77 cases (Table 4). Altogether 68% of the cases received medication for gastrointestinal infections; the proportion was higher among children (77%) than among adults (55%). Antibiotics without prescription were the most commonly used medicines among adult cases (9/33). Among children, antibiotics given with prescription (10/44) and without prescription (8/44) were almost equally common (Table 5). In our survey, 64% of adults were absent from work due to GI and 14% of children who attended school were absent from school due to GI (Table 4).

**Table 4.** Symptoms, health care and burden of GI among cases

Symptoms	Adults/all adult cases (%)	Children/all child cases (%)	Total (%)
Diarrhoea	25/33 (76)	31/44 (70)	56/77 (72.7)
Vomiting	14/33 (42)	35/44 (80)	49/77 (63.6)
Fever	10/33 (30)	23/44 (52)	33/77 (42.8)
Abdominal pain	23/33 (70)	21/44 (48)	44/77 (57.1)
Blood in stool	2/33 (6)	4/44 (9)	6/77 (7.8)
Headache	9/33 (27)	7/44 (16)	16/77 (20.7)
Respiratory symptoms	5/33 (15)	3/44 (7)	8/77 (10.4)
Muscle pain	5/33 (15)	1/44 (2)	6/77 (7.8)
Health care			
Visited doctor	0/33 (0)	5/44 (11)	5/77 (6.5)
Visited nurse	3/33 (9)	12/44 (27)	15/77 (19.5)
Hospitalized	0/33 (0)	0/44 (0)	0/77 (0)
Stool sample taken	1/33 (3)	2/44 (5)	3/77 (3.9)
Absent from work due to disease	21/33 (64)	-	21/33 (64)
Absent from school due to disease	-	6/44 (14)	6/44 (14)

**Personal, food and water hygiene**

Washing hands before meals (OR 0.40; 95% CI 0.19-0.85) and boiling milk before drinking (0.24; 0.05-0.77) were the only factors that were significantly protective against GI (Table 6). Washing hands after defecation also had a protective effect, although it did not reach statistical significance (0.62; 0.36-1.06). Use of a water filter was the most

common method to improve the quality of drinking water, but this was used only in 9% (42/488) of households, while only 3% (13/489) of the households boiled drinking water and 2% (8/487) used water disinfectant (Table 6). However, using these methods to improve the quality of drinking water did not have a protective effect against GI in our study population.

**Table 5.** Medication among the cases.

Medication	Adults/adults cases (%)	Children/children cases (%)	Total (%)
No medication	15/33 (45)	10/44 (23)	25/77 (32.4)
Antibiotics with prescription	2/33 (6)	10/44 (23)	12/77 (15.6)
Antibiotics without prescription	9/33 (27)	8/44 (18)	17/77 (22.1)
Analgesic	1/33 (3)	1/44 (2)	2/77 (2.6)
Diarrhea medicine	1/33 (3)	4/44 (9)	5/77 (6.5)
Nausea medicine	0/33 (0)	1/44 (9)	1/77 (1.3)
Other medicine from drugstore	2/33 (6)	2/44 (5)	4/77 (5.2)
Other medicine (herb tea, tisane, etc)	4/33 (12)	6/44 (14)	10/77 (12.9)

**Table 6.** Hygiene practices and socioeconomic conditions of the interviewed<sup>1</sup> and the whole household<sup>2</sup>

Variables	Cases (n=77) exposed /all	non-cases (n=414) exposed /all	p (95% CI)
Washing hands <sup>1</sup>			
- before meals	64/75	379/405	0.40 (0.19-0.85)
- after defecation	51/75	314/405	0.62 (0.36-1.06)
- with running water	2/75	13/405	0.83 (0.09-3.77)
- with soap	48/75	289/405	0.71 (0.42-1.20)
Boiling water before drinking it <sup>2</sup>	2/76	11/413	0.99 (0.10-4.66)
Boiling milk before drinking it <sup>1</sup>	3/75	61/412	0.24 (0.04-0.77)
Use of filter for drinking water <sup>2</sup>	4/76	38/412	0.55 (0.14-1.59)
Use of disinfectant for drinking water <sup>2</sup>	2/76	6/411	1.82 (0.18-10.44)
Drinking water stored in open container <sup>2</sup>	7/75	16/405	2.52 (0.84-6.71)
Swimming in natural waters <sup>1</sup>	1/76	2/413	2.74 (0.05-53.10)
Contact with animal <sup>1</sup>	33/76	154/414	1.30 (0.80-2.13)
Latrine in household <sup>2</sup>	69/76	390/413	0.58 (0.23-1.67)
Electricity in household <sup>2</sup>	47/76	259/412	0.96 (0.58-1.59)
Highest education in household <sup>2</sup>	17/75	110/414	0.81 (0.45-1.45)

For the denominators, n<77 or n<414 because of missing answers

### Educational level and socioeconomic conditions

The study population was quite highly educated, 69% with a vocational school certificate or higher, but the educational level did not have an effect on the prevalence of GI (Table 6). Likewise, having electricity and/or a latrine in the household did not have an effect on the prevalence of GI.

### DISCUSSION

This study is the first to assess GI burden in Ouagadougou, Burkina Faso, using a questionnaire survey. The advantage of the door-to-door survey method used is its high response rate: 98.2% in this study. We detected an overall prevalence of gastrointestinal infections of 15.7% in the 30 days prior to the interview. This is similar to the 14.5% overall

prevalence reported in northeast Brazil 21, though higher than the 9.2% reported in Chile [22], the 10% in an urban center in Canada [15,18], 10.6% in Cuba 19 and the 7.4% reported in northern and southern Australia [23]. As with several studies from other countries [6-8,24], our study showed that GI prevalence varies with age group. Children aged less than five years were the most affected with GI.

In our study, no one was hospitalized due to GI, while a stool sample had been taken by health care agents in 4% of the cases so as to verify the causative agent for GI. This proportion of stool samples taken is lower than in developed countries [6,8,25,26]. People in developing countries, such as Burkina Faso, do not usually consult a health care agent in the case of GI, since they mistrust the quality of care. Besides, they do not consider the illness

to be important and use self-medication instead. Especially antibiotics used without prescription are of great concern. Antibiotics without prescription were the most common medicine used among adult cases (27.3%), more common than antibiotics with prescription (6.3%). Among children, use of antibiotics with prescription was more common (23%) than among the adults. It has been shown that uncontrolled use of antibiotics may be a risk factor for diarrhea while it also promotes the development of antimicrobial resistance [27]. Furthermore, in Burkina Faso, people often use traditional medicine (herbal tea or various natural powders mixed with water), which can even be contaminated with pathogens causing GI, thus actually being harmful to the patient.

Protective factors against GI were washing hands before meals and boiling milk before drinking. Washing hands after defecation also had a protective effect against GI, although there was no statistical significance. Our study reported no evidence of protection from using a water disinfectant and water filter. This result contrasts with reports from other developing countries such as Ghana, Kenya, South Africa and Zimbabwe, which have shown that the use of a water filter was protective [28-30]. This difference may be because the water source for the households interviewed in Ouagadougou was exclusively municipal tap water, while in the mentioned studies the sources were surface water and borehole water.

Our study has some limitations. The study population was selected from among the population of Ouagadougou. In Ouagadougou, there are some socioeconomic characteristics (e.g. high education level, electricity supply, latrine in households) that are uncommon in rural areas. Therefore, the standard of living is better in Ouagadougou than in other parts of the country and the results cannot be directly generalized to the whole population of Burkina Faso. Although the overall selection was not done randomly, individuals were randomized within the households interviewed.

Nevertheless, this study provided valuable information on the occurrence of gastrointestinal infections, the risk factors associated with illness, as well as identifying some means of prevention of GI in Burkina Faso. Estimating the frequency of GI cases in a population in different countries is essential in evaluating the global burden of foodborne illnesses. This information, integrated with data derived from outbreak investigations and laboratory test results on the etiological agents can be used

to evaluate the contribution of different causes to the global burden of foodborne illness. In Burkina Faso, it would be necessary to conduct further studies covering the whole country in order to obtain more information on GI burden and factors associated with the illness in order to better prevent and manage GI. However, from our results obtained in the capital city Ouagadougou, we can conclude that antibiotics are commonly used to treat gastrointestinal infections. Washing hands before meals and boiling milk before drinking showed to be effective ways to prevent these infections.

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**Declaration of Conflicting Interests:** The authors declare that they have no conflict of interest.

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### REFERENCES

1. Guerrant RL, Kosek M, Moore S, et al. Magnitude and impact of diarrheal diseases. *Arch Med Res* 2002;33:351-355.
2. Fischer CLW, Perin J, Aryee MJ, et al. Diarrhea incidence in low- and middle-income countries in 1990 and 2010: a systematic review. *BMC Public Health* 2012;12:220.
3. World Health Organization. World health statistics 2012. [[http://www.who.int/gho/publications/world\\_health\\_statistics/2012/en/](http://www.who.int/gho/publications/world_health_statistics/2012/en/)]
4. World Health Organization. The global burden of disease: 2004 update. Geneva: World Health Organization 2008.
5. Boschi-Pinto C, Velebit L, Shibuya K. Estimating child mortality due to diarrhoea in developing countries. *Bull World Health* 2008;86:710-717.
6. Zhou YJ, Dai Y, Yuan BJ, et al. Population-based estimate of the burden of acute gastrointestinal illness in Jiangsu province, China, 2010-2011. *Epidemiol Infect* 2013;141:944-452.
7. Fletcher SM, Lewis-Fuller E, Williams H, et al. Magnitude, Distribution, and Estimated Level of Underreporting of Acute Gastroenteritis in Jamaica. *J Health Popul Nutr* 2013;31:69-80.

8. Chen Y, Yan W-X, Y-J Zhou, et al. Burden of self-reported acute gastrointestinal illness in China: a population-based survey. *BMC Public Health* 2013;13:456.
9. Käferstein F. Foodborne diseases in developing countries: aetiology, epidemiology and strategies for prevention. *Inter J Env Health Res* 2003;13:161-168.
10. World Health Organization. *World Health Report* 2011.
11. UNICEF. *State of the World's Children*. Epidemiol reports, 2012.
12. Nitiema LW, Nordgren J, Ouermi D, et al. Burden of rotavirus and other enteropathogens among children with diarrhea in Burkina Faso. *Inter J Infect Dis* 2011;15:646-652.
13. Bonkougou IJO, Haukka K, Österblad M, et al. Bacterial and viral etiology of childhood diarrhea in Ouagadougou, Burkina Faso. *BMC Pediatrics* 2013;13:1-6.
14. Imhoff B, Morse D, Shiferaw B, et al. Burden of self-reported acute diarrheal illness in FoodNet surveillance areas, 1998-1999. *Clin Infect Dis* 2004;38:219-226.
15. Majowicz SE, Doré K, Flint JA, et al. Magnitude and distribution of acute, self-reported gastrointestinal illness in a Canadian community. *Epidemiol Infect* 2004;132:607-617.
16. Thomas MK, Majowicz SE, MacDougall L, et al. Population distribution and burden of acute gastrointestinal illness in British Columbia, Canada. *BMC Public Health* 2006;6:307.
17. Jones TF, McMillian MB, Scallan E, et al. A population-based estimate of the substantial burden of diarrhoeal disease in the United States; FoodNet, 1996-2003. *Epidemiol Infect* 2007;135:293-301.
18. Sargeant JM, Majowicz SE, Snelgrove J. The burden of acute gastrointestinal illness in Ontario, Canada, 2005-2006. *Epidemiol Infect* 2008; 136: 451-460.
19. Aguiar P, Finley RL, Muchaal PK, et al. Burden of Self-reported Acute Gastrointestinal Illness in Cuba Study design. *J Health Popul Nutr* 2009;27:345-357.
20. Majowicz SE, Hall G, Scallan E, et al. A common, symptom-based case definition for gastroenteritis. *Epidemiol Infect* 2008;136:886-894.
21. Marcynuk PB, Flint JA, Sargeant JM, et al. Comparison of the burden of diarrhoeal illness among individuals with and without household cisterns in northeast Brazil. *BMC Infect Dis* 2013;13:65.
22. Thomas MK, Perez E, Majowicz SE, et al. Burden of acute gastrointestinal illness in the Metropolitan region, Chile, 2008. *Epidemiol Infect* 2011;139:560-571.
23. Hall GV, Kirk MD, Ashbolt R, et al. Frequency of infectious gastrointestinal illness in Australia, 2002: regional, seasonal and demographic variation. *Epidemiol Infect* 2006;134:111-118.
24. Abba K, Sinfield R, Hart CA, Garner P. Pathogens associated with persistent diarrhea in children in low and middle income countries: systematic review. *J Infect Dis* 2009;9:88.
25. Kuusi M, Aavitsland P, Gondrosen B, Kapperud G. Incidence of gastroenteritis in Norway—a population-based survey. *Epidemiol Infect* 2003;131:591-597.
26. Wilking H, Spitznagel H, Werber D, et al. Acute gastrointestinal illness in adults in Germany: a population-based telephone survey. *Epidemiol Infect* 2013;141:2365-2375.
27. Pickering LK. Antimicrobial resistance among enteric pathogens. *Seminars Pediatr Infect Dis* 2004;15:71-77.
28. Stauber CE, Byron K, Kaida RL, et al. Evaluation of the Impact of the Plastic BioSand Filter on Health and Drinking Water Quality in Rural Tamale, Ghana. *Int J Environ Res Public Health* 2012;9:3806-3823.
29. du Preez M, Conroy RM, Ligondo S, et al. Randomized intervention study of solar disinfection of drinking water in the prevention of dysentery in Kenyan children aged under 5 years. *Environ Sci Technol* 2011;45:9315-9323.
30. du Preez M, Conroy RM, Wright JA, et al. Use of ceramic water filtration in the prevention of diarrheal disease: a randomized controlled trial in rural South Africa and Zimbabwe. *Am J Trop Med Hyg* 2008;79:696-701.