



## Incidence, Mortality, and Burden of Acute Watery Diarrhea and Its Geographical Distribution in Iran during 2009-2016

*Ghobad MORADI<sup>1</sup>, Bakhtiar PIROOZI<sup>1</sup>, Hossein SAFARI<sup>2</sup>, \*Cyrus ALINIA<sup>3</sup>, Mohammad Mehdi GOUYA<sup>4</sup>, Nooshin AGHILI<sup>4</sup>, Siroos HEMMATPOUR<sup>5</sup>, Bushra ZAREI<sup>1</sup>, Farzad KAVEH<sup>4</sup>, Abbas NOROUZINEJAD<sup>4</sup>, \*Babak ESHRATI<sup>4</sup>*

1. *Social Determinants of Health Research Center, Research Institute for Health Development, Kurdistan University of Medical Sciences, Sanandaj, Iran*
2. *Health Promotion Research Center, Iran University of Medical Sciences, Tehran, Iran*
3. *Department of Public Health, School of Health, Urmia University of Medical Sciences, Uremia, Iran*
4. *Center for Communicable Diseases Control, Ministry of Health and Medical Education, Tehran, Iran*
5. *Department of Pediatrics, Faculty of Medicine, Kurdistan University of Medical Sciences, Sanandaj, Iran*

\*Corresponding Authors: Emails: sirwanalinia@gmail.com; Eshratib@sina.tums.ac.ir

(Received 11 Nov 2018; accepted 15 Jan 2019)

### Abstract

**Background:** Diarrhea is a major cause of public health burden, especially in children under 5 yr of age. This study aimed at estimating the incidence, mortality, burden, and geographical distribution of Acute Watery Diarrhea (AWD) in Iran from 2009 to 2016.

**Methods:** This study was conducted in 2018. The data on the incidence and mortality from 2009 to 2016 was obtained from AWD surveillance system of the Centre for Communicable Diseases Control (CCDC), Ministry of Health and Medical Education (MOHME) of Iran. Disability Adjusted Life Years (DALYs) was used to estimate the burden of AWD. The DALYs-related AWD was calculated using a method developed by WHO. The average duration of the disease and its disability weight, respectively, were set at 5 d (0.0137 years) and 0.093 for all age groups.

**Results:** The incidence of AWD had an ascending trend over the studied period. Forty cases of deaths from AWD were reported. The lowest and highest burdens of AWD, respectively, were 436.1 DALYs in 2010 and 975.9 DALYs in 2015. The incidence and burden of AWD did not have an equal distribution across the country, between the provinces.

**Conclusion:** The incidence of AWD had an ascending trend over the studied period that can be attributed to the improvements in the disease surveillance system. Moreover, the incidence, mortality, and burden of AWD did not have an equal distribution in Iran. Hence, it is recommended to strengthen AWD surveillance system. In addition, it is suggested to adopt proper interventions for controlling the disease in areas with a high burden of AWD.

**Keywords:** Incidence; Mortality; Disability-adjusted life years; Acute watery diarrhea; Iran

### Introduction

Diarrhea is a prevalent disease around the world. Only in 2015, it was responsible for more than

1.3 million deaths in the world and its burden was estimated to be 71.59 million Disability Ad-

justed Life Years (DALYs) (1). A significant proportion of diarrheal diseases can be prevented by providing safe drinking water and personal hygiene. A high burden of the disease is observed in low-income countries and among poor populations who are suffering from the lack of access to safe drinking water, unsafe food, and inappropriate hygiene (2-4). Currently, about 1.1 billion people do not have access to safe drinking water and almost 2.4 billion people are deprived of basic sanitation in the world (5).

The measures adopted during the last three decades to prevent and treat diarrhea have dramatically reduced its incidence and mortality. Its incidence had decreased by 20.8% among all age groups and by 34.3% among <5-yr-old children from 2005 to 2015 (1). However, it is still one of the most serious preventable diseases and the second leading cause of death among children under 5 year of age in the world (6). In 2015, under-five mortality rate due to diarrhea was 74.3 (74.1 in males and 74.5 in females) per 100000 population (1).

From the clinical perspective, diarrhea is divided into three categories; acute watery diarrhea, acute bloody diarrhea, and persistent diarrhea. According to the WHO "Acute Watery Diarrhea (AWD) is defined as the passage of three or more loose or liquid stools per day (or more frequent passage than is normal for the individual) which lasts several hours or days, and includes cholera (7)". Moreover, the incidence of this disease is one of the criteria for the assessment of water and sewage status (7, 8). The prevalence of AWD is higher than the prevalence of other types of diarrhea while it is avoidable, hence, it is necessary to pay more attention to this disease. Thus, it is recommended to establish and strengthen a surveillance system for monitoring and continuous assessment of AWD.

Studying the epidemiological status of AWD and estimating its burden can help to monitor its morbidity and mortality rates. In addition, estimating the burden of diarrhea will pave the way for reaching the third goal of the Sustainable Development Goals (SDGs) (Ensure healthy lives and promote well-being for all at all ages) (9, 10).

DALYs is an index developed for calculating the burden of diseases (11, 12). Estimating the burden of diseases is a very practical tool for allocating health resources, setting goals for high priority areas, and assessing the effectiveness of health interventions (13).

In line with this, to our knowledge, this is the first national study that aimed at estimating the burden of AWD at national and provincial levels over period of eight years.

## Methods

This study was conducted in 2018. The data on the incidence and mortality from 2009 to 2016 was obtained from the AWD surveillance system of the Centre for Communicable Diseases Control (CCDC), Ministry of Health and Medical Education (MOHME) of Iran.

DALYs was used to estimate the burden of AWD. The AWD-related DALYs was calculated using a method developed by the WHO for assessing the Global Burden of Disease. It is calculated by adding the Years of Life Lost (YLLs) due to premature death to the Years Lived with Disability (YLDs) (12).

$DALY = YLL + YLD$

YLL is the number of deaths (N) multiplied by Iranian life expectancy at the age of death in years.

$YLL = N \times L$

In this study, YLD is the number of incidences (I) multiplied by the average duration of the disease until remission or death (D) multiplied by disability weight (DW).

$YLD = I \times DW \times D$

We did not apply age weight in calculations; however, a discount rate of 0.03 was applied for discounting health values in future years (12). For each age group, the mean age of that group was considered as mortality age for patients who died from acute watery diarrhea. However, the average mortality age for 0-1 and 1-5 age groups was set at 0.1 and 2.6, respectively. Life expectancy left for each age group was calculated using life tables of Iranians reported by the WHO (11). The average duration of the disease and its disability

weight, respectively, were set at 5 d (0.0137 years) and 0.093 for all the age groups. The data on the population of the country and its provinces during the studied period was obtained from the Statistical Center of Iran (14). The collected data were analyzed using Excel software (ver. 2010).

## Results

Based on the data extracted from the AWD surveillance system, the incidence of AWD varied

from 40 cases per 10000 population in 2009 to 58.8 cases per 10000 population in 2015, indicating an increasing trend for this disease (Table 1). Over the studied period, 40 cases of deaths from AWD were reported. Its DALYs varied from 436.1 in 2010 to 975.9 in 2015 (Table 1). Figure 1 presents the trend of the incidence of AWD by sex. Figure 2 presents the burden of AWD between 2009 and 2016. The figure has many fluctuations due to changes in the number of deaths over the studied period.

**Table 1:** Incidence, mortality, and burden of AWD during 2009-2016

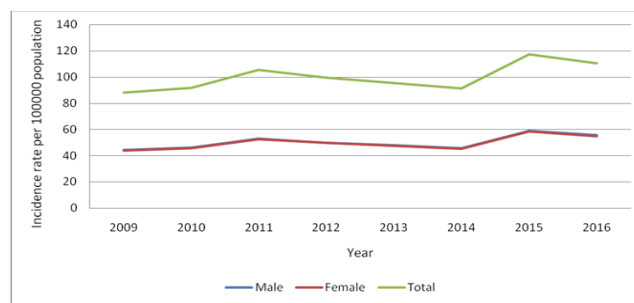
Year	Total AWD* cases	Incidence rate per 10000 population	Total Mortality	Mortality rate per 1000000	Total YLL**	Total YLD***	Total DALYs****	DALYs**** Rate per 100000 population
2016	437804	55.2	1	0.013	29.8	557.6	587.4	0.74
2015	461937	58.8	13	0.165	387.5	591.4	975.9	1.24
2014	354367	45.5	2	0.026	59.8	451.3	511.1	0.66
2013	366447	47.6	9	0.117	268.8	466.8	735.6	0.96
2012	378465	49.8	0	0.000	0	484.0	482.0	0.63
2011	395942	52.7	12	0.160	357.7	504.3	862.0	1.15
2010	340202	45.9	1	0.013	29.8	406.3	436.1	0.59
2009	322686	44.0	2	0.027	59.8	411.0	470.8	0.64

\* AWD: acute watery diarrhea / \*\*YLL: Years of Life Lost (YLL) due to premature death

\*\*\*YLD: Years Live with Disability / \*\*\*\*DALYs: Disability Adjusted Life Years



**Fig. 1:** Trend of changes in the incidence of AWD by sex during 2009-2016



**Fig. 2:** Trend of changes in the burden of AWD by sex per 100000 population during 2009-2016

Figure 3 shows the share of YLL and YLD in the total DALYs caused by AWD over the studied years. In all the studied years, the share of YLD was more than that of YLL. Table 2 and Fig. 4-6 present the burden of AWD by province in 2011, 2013, and 2015. In 2011, the highest burden of AWD was observed in the provinces of Semnan, South Khorasan and Gilan, while Markazi, Char Mahaal and Bakhtiari, and Khorasan South had

the lowest burden of the disease (Fig.4). In 2013, Sistan and Baluchistan, Kerman, and Bushehr had the highest burden of AWD, while Markazi, Qom, and Tehran had the lowest burden of the disease (Fig.5). In 2015, West Azerbaijan, South Khorasan, and Khuzestan had the highest burden of AWD; on the other hand, the lowest burden of the disease was observed in Khorasan Razavi, Markazi, and Tehran (Fig.6).

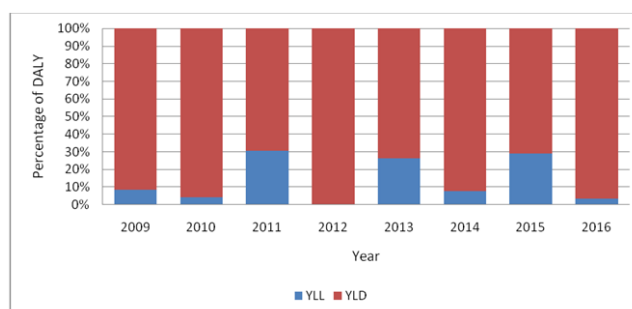
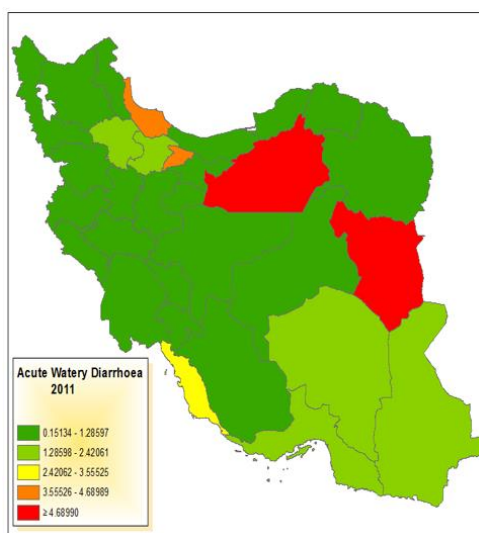


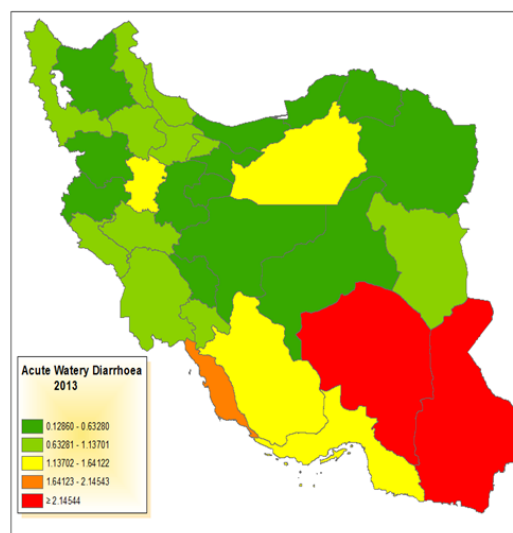
Fig. 3: Share of YLL and YLD in the burden of AWD during 2009-2016

Table 2: Burden of AWD (DALYs per 100000 population) in different provinces of Iran in 2011, 2013, and 2015

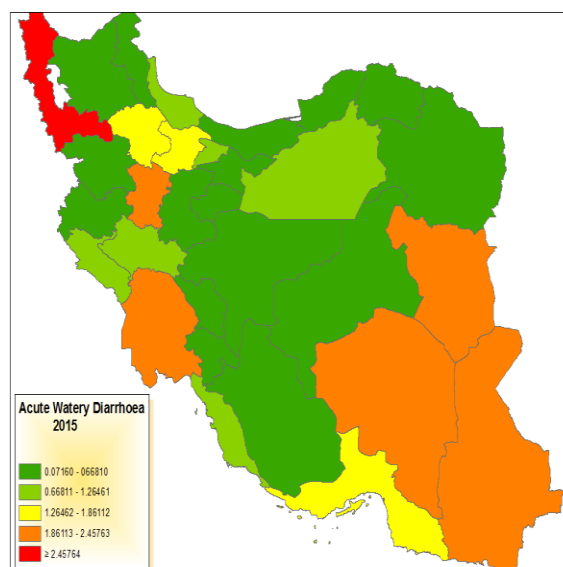
Province	2011	2013	2015
Ardabil	0.9	0.8	0.5
Esfahan	0.4	0.5	0.6
Alborz	3.6	0.9	0.7
Ilam	0.5	0.6	0.7
Azerbaijan, East	0.4	0.3	0.4
Azerbaijan, West	0.8	0.8	11.0
Bushehr	2.8	2.1	1.2
Tehran	1.2	0.2	0.2
Char Mahaal and Bakhtiari	0.3	0.2	0.4
Khorasan, South	5.3	1.0	2.5
Khorasan, Razavi	0.3	0.3	0.1
Khorasan, North	0.3	0.3	0.2
Khuzestan	1.0	0.7	2.4
Zanjan	1.6	0.9	1.5
Semnan	5.9	1.2	1.2
Sistan and Baluchistan	2.0	9.0	2.1
Fars	0.4	1.2	0.4
Ghazvin	1.4	1.1	1.6
Ghom	0.4	0.1	0.2
Kurdistan	0.5	0.5	0.4
Kerman	1.8	3.3	2.0
Kermanshah	0.5	0.4	0.4
Kohgiluyeh and Boyer-Ahmad	0.9	0.8	0.5
Golestan	1.1	0.4	0.2
Gilan	4.7	0.8	0.8
Lorestan	1.2	1.1	0.7
Mazandaran	0.3	0.4	0.4
Markazi	0.2	0.1	0.1
Hormozgan	1.3	1.2	1.3
Hamadan	1.0	1.2	2.4
Yazd	0.5	0.5	0.3



**Fig. 4:** Geographical distribution of the burden of AWD by DALYs/100000 in Iran's provinces in 2011



**Fig. 5:** Geographical distribution of the burden of AWD by DALYs/100000 in Iran's provinces in 2013



**Fig. 6:** Geographical distribution of the burden of AWD by DALYs/100000 in Iran's provinces in 2015

## Discussion

To our knowledge, this is the first study in Iran that aimed at estimating the incidence, mortality, and burden of AWD.

Based on the findings of this study, achieved on the basis of data obtained from AWD surveillance system of the Center for Disease Control, the estimated total DALYs per 100,000 popula-

tion changed from 0.64 in 2009 to 0.74 in 2016. And the largest share of DALYs was attributed to YLL.

In our study, the burden of AWD changed from 436.1 to 975.9 DALYs over the studied period. Based on the GBD 2015 report, diarrhea-related DALYs in Iran, Turkey, Afghanistan, Pakistan, and Iraq were 73826, 69082, 589646, 4115746, and 164043 DALYs, respectively (1). DALYs

observed in Iran is much higher than the values observed in our study. The difference might be attributed to the fact that all types of diarrhea were considered when calculating DALYs in the GBD study, while in our study, only AWD was considered when calculating DALYs.

Although the number of cases with diarrhea has dramatically reduced within the last three decades worldwide, it is still one of the most serious preventable diseases that threaten the life of poor population, especially in developing countries (1). 3.25% of the global burden of diseases in the world is still attributed to diarrhea (15).

DALYs calculated for this disease in Iran is less than the expected value and it has had an increasing trend over the studied years. The low burden of AWD in Iran is probably due to the underreporting of this disease; in addition, the increasing trend over this period is probably due to improvement in the disease surveillance system. Many of the patients refer to private clinics, in which the reporting system is very weak. Since the sensitivity of the disease surveillance system has not been measured in Iran so far, estimating the actual burden of diarrhea is difficult and, of course, can be a good topic for future studies. The increase in the number of reported cases of diarrhea in Iran is similar to the trend observed in the world, also attributed to the improvement in the surveillance system. In Laos, the number of cases with diarrhea increased from 21.5 cases per 10000 population in 2009 to 47.6 cases per 10000 population in 2012 (16).

Based on the findings of our study, the incidence of AWD in males and females was the same. However, it is not in line with the findings of studies carried out in Laos and Indonesia, which reported higher incidence rates among males (16, 17). Forty deaths from AWD were reported in our study. The highest and lowest number of deaths, respectively, were observed in 2015 with 13 deaths (0.165 per million population) and year 2012 with zero death. About 89.5 million cases of acute diarrhea with an estimated annual mortality of 1.45 million were observed in the world in 2010 (18, 19). In Laos, 37 deaths from AWD had been reported between 2009 and 2012. However,

some of the cases might have been underreported might have happened out of health care centers; accordingly, the reported value is expected to be far less than the actual number of deaths (16). In GBD 2015 report, the number of deaths from all types of diarrhea in Iran, Turkey, Afghanistan, Pakistan, and Iraq, respectively, was 873 (11 per million population), 549 (7 per million population), 6747 (207 per million population), 55500 (294 per million population), and 1847 (51 per million population) (1). The number of deaths from diarrhea in Iran is much higher than the number of deaths observed in our study. The observed difference might be attributed to the fact that the GBD study calculated the mortality from all types of diarrhea, while our study only calculated the deaths from AWD (1).

The incidence and burden of AWD were not equal across the country and there were differences between the provinces. Some provinces such as Sistan and Baluchistan, Kerman, South Khorasan, and Khuzestan were the main foci of this disease. Lack of access to safe drinking water and weak public health services (in comparison with other provinces) can be the main potential factors leading to such differences. In order to reduce the number of cases with diarrhea, it is necessary to improve people's access to safe drinking water, promote public health and personal hygiene, promote and encourage breastfeeding, and train people on the routes of the transmission of the infection (7, 9, 20).

According to the findings of our study, the prevalence and burden of this disease are higher in more undeveloped regions of the country. This can be due to problems caused by underdevelopment in these areas. The incidence and burden of diarrhea vary across the world and between the countries; sub-Saharan Africa and East Asia are suffering from the highest rates of mortality from diarrhea (1, 7).

The measures taken to prevent and treat diarrhea may face some challenges due to socio-economic barriers such as the lack of access to health and sanitation services, lack of access to safe drinking water, lack of training, and improper nutrition; the mentioned items are considered as the indica-

tors of injustice and lack of social development (9, 21, 22). About 88% of the total mortality from diarrhea are caused by unsafe drinking water, unhealthy disposal of waste, improper personal hygiene (23). From 2005 to 2015, the number of DALYs caused by diarrhea reduced by 13.4% in the world attributed to improvement in sanitation and people's access to safe drinking water (1).

### Limitations

This study had some limitations, for instance, it used only the data obtained from the AWD surveillance system to estimate the incidence, mortality, and burden of the disease. The AWD surveillance system is suffering from under-reporting because it has a weak coverage for patients referring to private and semi-public health centers; moreover, it does not register the cases practicing self-medication.

### Conclusion

AWD is no longer a fatal disease and does not have a high burden in Iran, however, its burden, calculated on the basis of data from the disease surveillance system, is less than the expected value. In addition, the incidence of AWD had an ascending trend over the studied period. It may indicate an improvement in the diarrhea surveillance system during this time period. However, since diseases like diarrhea can always be a potential threat in emergencies and disasters, it is recommended to strengthen and improve the surveillance system for this disease in Iran. In addition, DALYs of diarrhea did not have an equal distribution across the country and between the provinces. The burden of this disease is particularly higher in provinces with more unfavorable economic and social indicators. Hence, health authorities and policy-makers should shift the resources toward provinces where are the main foci of acute watery diarrhea.

### Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification,

double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

### Acknowledgements

We acknowledge the funding and support of the Centre for Communicable Diseases Control, Ministry of Health and Medical Education of Iran (Grant number:IR.MUK.REC.1395/184).

### Conflict of interest

The authors declare that there is no conflict of interests.

### References

1. GBD Diarrhoeal Diseases Collaborators (2017). Estimates of global, regional, and national morbidity, mortality, and aetiologies of diarrhoeal diseases: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet Infect Dis*, 17(9):909-948.
2. Kotloff KL, Platts-Mills JA, Nasrin D et al (2017). Global burden of diarrheal diseases among children in developing countries: Incidence, etiology, and insights from new molecular diagnostic techniques. *Vaccine*, 35(49 Pt A):6783-6789.
3. Webb C, Cabada MM (2018). A Review on Prevention Interventions to Decrease Diarrheal Diseases' Burden in Children. *Curr Trop Med Rep*, 5(1):31-40.
4. Kumar SG, Subita L (2012). Diarrhoeal diseases in developing countries: a situational analysis. *Kathmandu Univ Med J*, 10(2):83-8.
5. World Health Organization (2018). Water sanitation hygiene. Water-related diseases. [http://www.who.int/water\\_sanitation\\_health/diseases-risks/diseases/diarrhoea/en/](http://www.who.int/water_sanitation_health/diseases-risks/diseases/diarrhoea/en/)
6. Walker CL, Rudan I, Liu Let al (2013). Global burden of childhood pneumonia and diarrhoea. *Lancet*, 381(9875):1405-16
7. World Health Organization (2017). Diarrhoeal disease. <http://www.who.int/news-room/fact-sheets/detail/diarrhoeal-disease>

8. World Health Organization (2005). The treatment of diarrhoea - A manual for physicians and other senior health workers. Geneva, World Health Organization.
9. World Health Organization/UNICEF (2013). Ending Preventable Child Deaths from Pneumonia and Diarrhoea by 2025. The integrated Global Action Plan for Pneumonia and Diarrhoea. World Health Organization/The United Nations Children's Fund.
10. Golding N, Burstein R, Longbottom Jet al (2017). Mapping under-5 and neonatal mortality in Africa, 2000–15: a baseline analysis for the Sustainable Development Goals. *Lancet*, 390(10108):2171-82.
11. Murray CJ, Ezzati M, Flaxman AD et al (2012). GBD 2010: design, definitions, and metrics. *Lancet*, 380(9859):2063-2066.
12. Naghavi M, Abolhassani F, Pourmalek F, Lakeh MM, Jafari N, Vaseghi S, Hezaveh NM, Kazemeini H (2009). The burden of disease and injury in Iran 2003. *Popul Health Metr*, 7(1):9.
13. Rushby JF, Hanson K (2001). Calculating and presenting disability adjusted life years (DALYs) in cost-effectiveness analysis. *Health Policy Plan*, 16(3):326-31.
14. Iran Statistical Yearbook (2016). Statistical Center of Iran. <https://www.amar.org.ir/english/Iran-Statistical-Yearbook>
15. Kyu HH, Abate D, Abate KH et al (2018). Global, regional, and national disability-adjusted life-years (DALYs) for 359 diseases and injuries and healthy life expectancy (HALE) for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet*, 392(10159):1859-922.
16. Houatthongkham S, Sithivong N, Jennings Get al (2016). Trends in the incidence of acute watery diarrhoea in the Lao People's Democratic Republic, 2009–2013. *Western Pac Surveill Response J*, 7(3):6-14.
17. Salim H, Karyana IPG, Sanjaya-Putra IGN et al (2014). Risk factors of rotavirus diarrhea in hospitalized children in Sanglah Hospital, Denpasar: a prospective cohort study. *BMC Gastroenterol*, 14:54.
18. Murray CJ, Vos T, Lozano R et a (2012). Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet*, 380(9859):2197-223.
19. Lozano R, Naghavi M, Foreman K et al (2012). Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet*, 380(9859):2095-128.
20. Kurokawa M, Ono K, Kimura Ket al (2017). Reduction of Diarrheal Diseases Cases by the Introduction of Sand Filtered Drinking Water in a Rural Western Hilly Area in Nepal. *Nepal Med Coll J*, 19(2):59-65.
21. Luby SP, Rahman M, Arnold BF et al (2018). Effects of water quality, sanitation, handwashing, and nutritional interventions on diarrhoea and child growth in rural Bangladesh: a cluster randomised controlled trial. *Lancet Glob Health*, 6(3):e302-e15.
22. Adams NL, Rose TC, Hawker Jet al (2018). Relationship between socioeconomic status and gastrointestinal infections in developed countries: A systematic review and meta-analysis. *PLoS One*, 13(1):e0191633.
23. Centers for Disease Control and Prevention. Diarrhea: Common Illness, Global Killer US Department of Health and Human Services Centers for Disease Control and Prevention. <https://www.cdc.gov/healthywater/pdf/global/programs/globaldiarrhea508c.pdf>