



## Water sanitation, hygiene and the prevalence of diarrhea in the rural areas of the delta region of Myanmar

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### ABSTRACT

Myanmar is an agriculture-based country with 70% of the total population residing in rural areas. Around half of the total population in Myanmar has to consume water from unimproved sources. The prevalence of diarrhea due to contaminated drinking water is high even in urban areas. The urban community may expect the provision of municipal water supply in the near future if the current revolution against military dictatorship succeeds. However, the rural areas have less or no chance to get quality water because of a lot of other prioritized tasks. Household water treatment is encouraged to be implemented as one of the national water safety plans for rural water supply in Myanmar. This study explored the diarrhea prevention awareness of the rural community using a questionnaire survey. The microbial quality parameters of drinking water sources were also examined. Fecal coliform contamination was detected in all examined drinking water sources. A significant association was found between drinking untreated water and the occurrence of diarrhea. The percentage of people who applied the diarrhea preventive measures was low. Even if they knew how to prevent the disease, very few people applied the measures in reality. Therefore, measures to cause behavioral change should be initiated, together with awareness raising, to promote diarrhea prevention in the community.

**Key words:** developing country, diarrhea, drinking water, health education, hygiene, public health

### HIGHLIGHTS

- Insight into the public health system in rural Myanmar.
- Prevalence of diarrhea among the rural community where there is no public water supply.
- Public awareness on diarrhea prevention and treatment.
- Tendency to apply mitigation measures.
- Suggestions to strengthen public health coverage in rural Myanmar.

### INTRODUCTION

Clean and accessible water is critical to human health, a healthy environment, poverty reduction, a sustainable economy and peace and security. 'Ensuring the availability and sustainable management of water and sanitation for all' is one of the sustainable development goals (SDGs) of the United Nations (United Nations 2015). Developing countries are mostly affected by poor water quality and sewage and sanitation facilities. Up to 80% of illnesses in the developing world are linked to inadequate water and sanitation (WHO 2019). Contaminated water is associated with the transmission of waterborne diseases such as diarrhea, cholera, dysentery, hepatitis A, polio and typhoid, which worsen disease burden worldwide. The total number of children (under 5 years of age) who die of waterborne diseases is around 5.3 million in the world and half of these deaths occur in developing countries (UNICEF 2020).

Diarrhea is one of the most common seasonal diseases in Myanmar, which mostly occurs during the summer and rainy seasons (Lwin & Putra 2018). Diarrheal disease accounts for 18% of children under five deaths in Myanmar (Kamp 2017). The Department of Medical Research reveals the high prevalence of acute diarrhea in the North Dagon Township of Yangon Region where drinking water sources are highly contaminated by fecal coliforms (105 out of 112 samples)

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(Sulatt *et al.* 2015). Myanmar is one of the least developed countries (LDCs) in the world, and the decision for upgradation from the LDC category is deferred by committee for development policy (CDP) at the 2021 triennial review meeting (UNESC 2021). However, the situation in Myanmar is likely to worsen as a consequence of the recent coup in February 2021. This will severely affect the development of the country's infrastructure. The probability of access to municipal water supply is expected to be lower for the rural community than for the urban community because of a lot of other prioritized tasks, even if the revolution succeeds in the future.

Diarrheal deaths can be reduced by numerous interventions aimed to protect, prevent and/or treat the disease (Kamp 2017). Diarrhea prevention can be achieved by the promotion of clean water, latrine use and hygiene. According to the estimation for developing countries from a review study (Fewtrell *et al.* 2005), diarrhea episodes can be reduced by improving water supply, sanitary conditions and handwashing to 25, 32 and 45%, respectively. In addition, household water treatment and safe water storage can reduce diarrhea prevalence by 39%.

The percentage of population that consumes water from unimproved sources is high in the rural areas of Myanmar, and 50–70% of the rural communities in the suburb township of Yangon Region receive water from unimproved sources such as ponds, lakes and rivers (DOP 2015). The World Health Organization (WHO) states that the percentage of population following water treatment practices is low in Myanmar, and, therefore, water safety plan follow-up actions are required (WHO 2015). Household water treatment practice is recommended as one of the strategies for comprehensive diarrhea control (WHO 2009). According to a Multiple Indicator Cluster Survey, 39% of the urban population and 32% of the rural population in the country follow household water treatment practices such as boiling, using a filter, adding chlorine/bleach and solar disinfection. In the Yangon region, around 35% of people were using household water treatments (UNICEF 2011). The Government of the Republic of the Union of Myanmar encourages the use of household water treatment in areas where there is no access to safe water as one of the water safety plans in the National Strategy for Rural Water Supply, Sanitation and Hygiene (GRUM 2016). Information regarding the effectiveness of the preventive measures against diarrhea, including household water treatment, can be considered important to strengthen the public health system in the rural areas. However, very little information on this issue is available in Myanmar until now.

In this regard, this study aimed to create public awareness on diarrheal disease prevention in the rural areas of the delta region of Myanmar. The effectiveness of the mitigation measures was observed using a questionnaire survey. The quality of the drinking water sources was also examined by the detection of fecal indicators (coliforms and *Escherichia coli*).

## MATERIALS AND METHODS

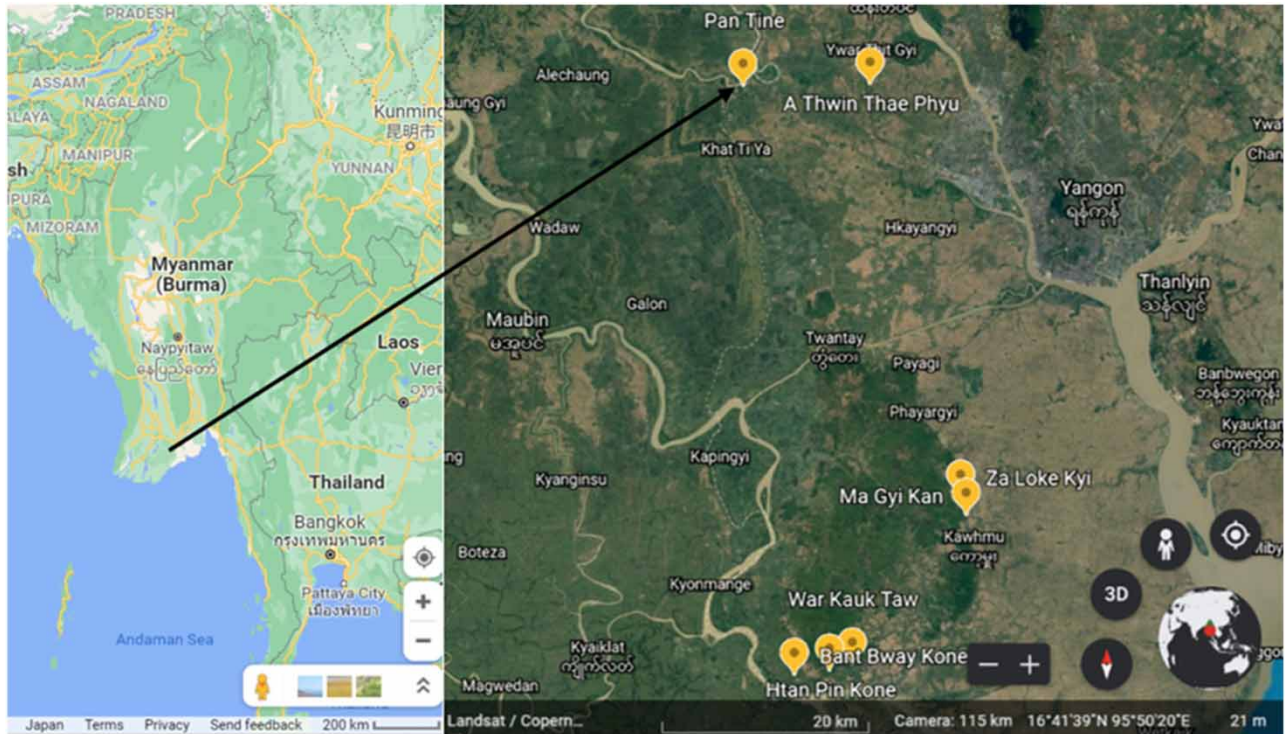
### Water quality survey

Initial screening of the available drinking water sources in the rural areas of the delta region was done in seven villages in three suburb townships of the Yangon Region (Figure 1). They were Pan Tine and A Thwin Thae Phyu villages in Htantabin township, Ma Gyi Kan and Za Loke Gyi villages in Kaw Hmu Township and Bant Bway Kone, Htan Pin Kone and War Kauk Taw villages in Kun Gyan Gon township. Sample collection was conducted in accordance with good sampling techniques to minimize any contamination. Samples were directly taken from rainwater ponds and wells using sterile plastic bags. The samples were then analyzed within the same day at the laboratory of the Food and Drug Administration in Yangon. Bacterial colonies were enumerated by ready-to-use agar plates (Petrifilm, 3M, USA): aqua heterotrophic count plates and *E. coli*/coliform count plates for heterotrophic bacteria and *E. coli*/coliform, respectively.

### Questionnaire survey

The questionnaire survey was conducted in the Pan Tine village of Htantabin township. Htantabin is one of the target townships of the Myanmar National Community-driven Development Project (The New Light of Myanmar 2014). It is located in the northwestern part at around 30 km from the city center of Yangon, and it took about 2 h by road to reach that place. In Myanmar, rural health centers (RHCs) exist only in large villages but not in small villages. Pan Tine village has a population of around 40,000 people and it is considered a large village. There are 1,000 households in this village and representatives from 150 households (female – 108 and male – 42) responded to the questionnaire.

The questionnaire mainly focused on the water treatment practices of the locals using the core questions on drinking water and sanitation for household surveys of WHO and UNICEF (WHO/UNICEF 2006). Examples of the survey items are given in Table 1.



**Figure 1** | Map of the study area (Sources: Google Earth).

**Table 1** | Main study variables with examples of the survey items

Latent variables	Manifest variables (examples of survey items)	Responses
Water treatment practices	Do you use any treatment for drinking water at home? If yes, describe the type of treatment.	Yes/No. If yes (filtering using a filter cloth/boiling/filtering followed by boiling)
Diarrheal occurrence	Do you suffer from diarrheal disease during the last 3 months?	Yes/No
Protection knowledge	Do you know about any preventive measures against diarrheal disease? If yes, describe them.	Yes/No. If yes (drinking boiled water/using an appropriate cover to keep food away from fly access/washing hands properly before meals and after using toilet)
Compliance	Do you usually apply the preventive measures that you know?	Yes/No
Knowledge about fatal complication	Do you know about the life-threatening complication of diarrhea? If yes, describe it.	Yes/No. If yes (dehydration)
Life-saving knowledge	Do you know how to correct/treat the complication (dehydration)? If yes, describe it.	Yes/No. If yes (ORS therapy)

**Data analysis**

The chi-square test of the bivariate analysis was used to find out the associations between the types of water treatment and the prevalence of diarrheal disease.

**RESULTS AND DISCUSSION**

**Drinking water sources in the rural area of Yangon region**

Yangon is one of the highest rainfall regions in Myanmar, with the monthly average rainfall in the rainy season being approximately 400 mm. Since there is no public water supply in the rural areas, villagers have to rely mainly on rainwater for their

needs. They usually dig one or two ponds in each village to collect rainwater for drinking. Villagers collect rainwater with pots or tanks for drinking during the rainy season. For the rest of the year, they rely on rainwater ponds for their daily consumption. Villagers usually use plastic or metal buckets attached to each end of a yoke to collect and bring water from the ponds to their homes.

### Water quality survey

All villages coming under the study area relied on rainwater ponds for drinking, except Htan Pin Kone, where dug well was the major source. The average amount of heterotrophic bacteria in the rainwater ponds was approximately 1,100 cfu/ml, while well water seemed to have lower microbial contamination with approximately 400 cfu/ml (Table 2). According to the Myanmar National Drinking Water Quality Standard (MNDWQS), drinking water must be free from *E. coli* and coliform contamination (MoH 2014). *E. coli* was rarely detected in the examined drinking water sources. However, coliform contamination was found in all examined drinking water sources. The highest number of coliforms was detected in Pan Tine village.

### Water sources of Pan Tine village

A rainwater pond is the major source of drinking water in the village and its surroundings (Table 3). It is approximately 10 m×10 m in area and 3 m in depth, located in the northern part of Pan Tine village (Figure 2). There are no national guidelines on disinfection or chlorination to public drinking water sources in Myanmar. Chlorination is usually done when there is an outbreak of waterborne diseases. In this pond, monitoring of water quality is not being done regularly, and it is chlorinated once a year when the rainy season ends, according to information provided by the RHCs. The WHO stipulates that hazard identification should ideally be performed on a case-by-case basis in non-piped communities and household drinking water systems (WHO 2011). It also suggests that surface waters require at least disinfection, and usually also filtration, to ensure microbial safety.

### Household water treatment and the prevalence of diarrhea

Four different groups of household water treatment practices – boiling, filtering using a filter cloth, filtering followed by boiling and non-treatment groups – were found according to the survey results (Table 4). No significant association was observed between the groups who applied household water treatment and the prevalence of diarrhea. Although applied sanitation

**Table 2** | Microbial parameters of drinking water sources

No.	Village	Township	Amount of bacteria (cfu/ml) in drinking water sources		
			HPC	Coliforms	<i>E. coli</i>
1.	Pan Tine	Htantabin	910	24	0
2.	A Thwin Thae Phyu	Htantabin	900	10	0
3.	Ma Gyi Kan	Kaw Hmu	510	2	0
4.	Za Loke Gyi	Kaw Hmu	900	10	0
5.	Bant Bway Kone	Kun Gyan Gon	1,500	4	1
6.	Htan Pin Kone <sup>a</sup>	Kun Gyan Gon	430	2	0
7.	War Kauk Taw	Kun Gyan Gon	2,200	20	2

<sup>a</sup>Drinking water sources in all villages are rainwater ponds, except Htan Pin Kone village, which uses dug well for drinking.

**Table 3** | Drinking water sources in Pan Tine village

Seasons	Duration	Number of households according to drinking water sources		
		Rainwater storage at home	Rainwater pond	Tube well
Summer	Mar–May	–	147	3
Rainy	Jun–Oct	116	34	–
Winter	Nov–Feb	35	115	–



**Figure 2** | Rainwater pond.

**Table 4** | Water treatment practices and the prevalence of diarrhea

Types of treatment for drinking water	Number (percentage) of respondents with diarrhea	Number (percentage) of non-diarrhea respondents	<i>p</i> -value
Boiling	20 (49%)	21 (51%)	0.058
Filtering	26 (55%)	21 (45%)	0.121
Filtering and boiling	9 (45%)	11 (55%)	0.080
Non-treatment	33 (79%)	9 (21%)	0.001

methods were not statistically effective against diarrhea prevention, a significant correlation was found between the non-treatment groups and the occurrence of diarrhea ( $p < 0.05$ ). Respondents who were not applying any treatment were more likely to suffer from diarrhea. In addition to safe drinking water and improved sanitation, personal hygiene such as handwashing is a useful intervention for diarrheal disease prevention (WHO 2017). Perhaps, people who drink raw water without treatment might have poor personal hygiene awareness, leading to a higher possibility of their getting diarrhea.

### Preventive measures

Regarding the knowledge on preventive measures against diarrhea, a majority of the respondents were aware of the importance of the safe use of water; however, they failed to follow personal hygiene while using water (Table 5). Only 41 respondents applied the preventive measures, and it seemed that most of the residents did not apply them even if they knew how to do so. Since very few respondents followed good personal hygiene practices, it was difficult to justify the effectiveness of good personal hygiene against diarrhea.

**Table 5** | Measures against the occurrence of diarrhea

Measures to prevent diarrhea	Number (percentage <sup>a</sup> ) of respondents who knew about particular interventions	Number (percentage <sup>a</sup> ) of respondents who applied the measures
Drink boiled water	105 (70%)	41 (27%)
Keep food under a cover to protect from fly access	3 (2%)	2 (1%)
Wash hands properly before meal and after toilet	9 (6%)	3 (2%)

<sup>a</sup>Percentages are calculated based on the total number of respondents: 150 respondents.

### Knowledge on the complication of diarrhea and treatment

The number of diarrhea patients who received treatment from the RHCs was around 10–20 for each season. There was no recorded outbreak during the last 3 years. The number of diarrhea patients who received treatment from the RHCs was obviously lesser than those suffering from the disease, according to the survey. A total of 88 out of 150 (59%) respondents revealed that they contracted diarrhea during the last 3 months. They revealed that they usually treat themselves at home instead of going to the RHC. A majority of the respondents (136 out of 150) said that they would visit the RHC only if they suffered severe symptoms. The most severe complication of diarrhea is dehydration, which can pose a risk to the life of a person if it is not treated properly. During a diarrheal episode, water and electrolytes (sodium, chloride, potassium and bicarbonate) are lost through liquid stools, vomit, sweat, urine and breathing. Dehydration occurs when these losses are not replaced, and it can be effectively treated by consuming oral rehydration salt (ORS) (WHO 2017). In Myanmar, diarrhea cases are usually treated with oral rehydration therapy (Kamp 2017). According to our findings, 103 out of 150 respondents already knew that dehydration was the most serious complication of diarrhea, and they also knew how to correct dehydration. It was said that they usually receive health education from RHCs once a year.

Since 59% of the respondents suffered from diarrhea within a 3-month period, the prevalence of the disease in Pan Tine village could be considered high. Although knowledge about the treatment of the fatal complication of diarrhea was high among the locals, their awareness on the personal hygiene aspect for the prevention of this disease was very low. This could be the reason for the high prevalence of diarrhea among the residents in the village under study. It seemed that the locals did not pay much attention to their disease condition since they knew how to treat the complications of diarrhea.

### Public health system in rural Myanmar

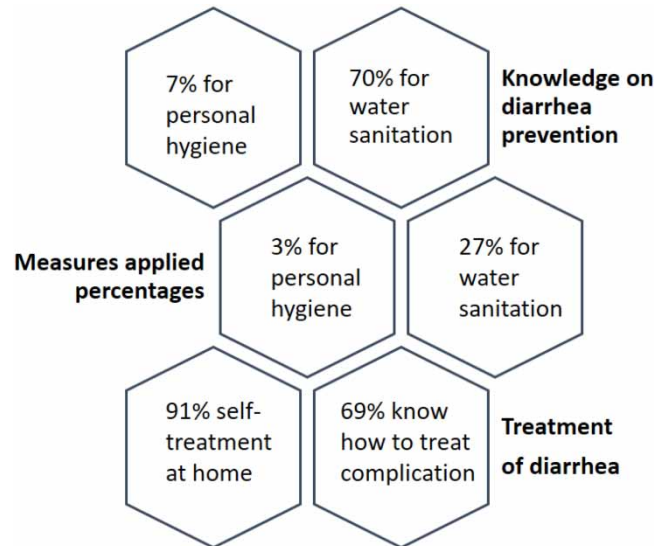
Myanmar has a population of around 60 million, and almost 70% of it resides in the rural areas (DOP 2015). Myanmar is one of the countries where human resources for the health sector is extremely low. The health workforce ratio per population is far behind the WHO-recommended minimum health workforce ratio in most of the regions with approximately 1 per 1,000 people (Saw *et al.* 2019). Rural areas, in particular, are severely handicapped by the unequal distribution of health professionals. Basic health staff are the main health-care providers for the rural communities. Generally, RHCs are led by a public health supervisor, and there are around 3–5 health staff in each RHC. These health workers encounter challenges in providing health services because of meager resources and support (Latt *et al.* 2016).

Social franchising is ‘the application of commercial methods to the delivery of subsidized services with a social benefit goal, such as improving rural health’. The effectiveness of the program was tested in a randomized rural community to promote the use of ORS for diarrhea treatment in Myanmar (Aung *et al.* 2014). The volunteers from villages were trained to be community health workers to prevent or treat diseases such as diarrhea and malaria within their communities. The use of ORS significantly increased in the intervention group compared with that in the control group according to their study. Sommanustweechai *et al.* (2016) also suggested that the Myanmar government should strengthen such initiatives to extend the basic health-care coverage countrywide by considering easy access and cost-effectiveness.

### Public awareness on diarrhea prevention and control

The WHO encourages the promotion of national policies toward the management of diarrhea and its complications as well as increasing access to safe drinking water and sanitation in developing countries (WHO 2017). Community health education is one of the responsibilities of the RHCs for disease prevention and control (Latt *et al.* 2016). According to one finding, health education on diarrhea prevention, especially related to personal hygiene, did not seem to be sufficient in Pan Tine village (Figure 3). Villagers may decide the importance of particular measures based on their own perceptions when they receive health education. This might be the reason why most of them forget about the importance of personal hygiene. Therefore, it seems necessary to make more efforts to promote personal hygiene awareness.

‘Prevention is better than cure’ is a fundamental principle of modern health care across the world. Health education strategies on the prevention of diarrhea should be strengthened in Myanmar. It is also important to ensure that the rural community follows the preventive measures received from health education. According to a study on the effectiveness of the hygiene promotion program, the percentage of people who washed their hands with soap after using their toilets increased from 1 to 17% in West Africa after hygiene awareness promotion to the community (WHO 2001). The WHO recommends that hygiene promotion programs are more likely to be effective if they are built on local research and use locally appropriate channels of communication repeatedly and for an extended time. Considering the poor socioeconomic situation



**Figure 3** | Public awareness on diarrhea.

prevailing in rural areas, villagers hardly read newspapers and watch television. Against this background, holding health talk events and distributing leaflets may be effective ways to provide health education for the villagers in Myanmar. The initiation of behavioral change in daily life such as the introduction of handwashing practice in primary schools may help promote the practice of good hygiene among the locals.

## CONCLUSION

None of the examined drinking water sources was safe for drinking purposes as fecal coliform contamination was detected in all of them. Therefore, it is suggested that the authorities concerned should monitor the quality of drinking water sources regularly and carry out chlorination/disinfection if necessary. The WHO recommends that the mitigation measures on contamination should ideally depend on the characteristics of the source water and the associated catchment. Interventions such as building fences alongside ponds and using protective covers for wells may be applicable for the water sources coming under the study area. Local authorities should also prohibit the use of the land area nearby ponds as pasture land. The practice of household water treatment should be encouraged together with hygiene awareness promotion. The authorities concerned must take steps to increase awareness on diarrhea prevention among the villagers in the study area as the latter seemed to pay less attention to preventive measures.

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## DECLARATION OF INTEREST STATEMENT

All authors declare no conflicts of interest associated with this manuscript.

## ETHICAL APPROVAL

Free and informed consent of the participants or their legal representatives was obtained. Since there is no ethical review board or educational institution in Myanmar, the legal permission for conducting the survey was approved by the village management committee.

## DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

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