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# Analysis and assessment of ground water from Kyanggone region, Myanmar for arsenic contamination

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**Abstract:** Arsenic and many of its compounds are incredibly potent poisons. Arsenic-contaminated groundwater consumption is the main route of human exposure to arsenicosis. Myanmar is also affected by arsenic contamination, mainly in Ayeyarwady Division. This study aims to observe and compare the arsenic concentration of wells in the Kyanggone region with the WHO and Myanmar National Drinking Water Quality Standards (MNDWQS). MNDWQ standards. Also, this study focuses on statics results of the public awareness dealing with arsenic. Some of the wells in the Kyanggone region were tested to investigate the arsenic concentration. Survey data were collected from 138 people using the survey data collection method to know the current association of arsenic with the public in the Kyanggone region. The collected data were analysed using Statistical Package for Social Science (SPSS) software. This paper provides the results of arsenic-contaminated wells and public knowledge on arsenic and arsenic-contaminated drinking water. This study showed that knowledge and information about arsenic are still needed to know the reality and more training must be made to have more awareness of public arsenic. Also, it is claimed that a suitable, economical, and effective treatment method must be applied to prevent the public lives from arsenic poisoning.

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## 1. Introduction

Arsenic groundwater contamination is a global health crisis, affecting millions of people worldwide, particularly in rural regions where safe drinking water is scarce. Life on our planet can't be lived without sufficient water. Arsenic is one of the most widespread heavy metals, which makes it one of the most alarming from both an environmental and a human health point of view. It is also one of the most dangerous (Falkenmark *et al.*, 2019; Sankhla *et al.*, 2018). Geological formations high in arsenic can leak arsenic into the groundwater (Hu *et al.*, 2005). Certain minerals and rocks, such as arsenopyrite and pyrite, can contribute to increased levels of arsenic in water (Ahoulé *et al.*, 2015). Arsenic contamination of water sources is possible in certain regions due to human activities such as mining and industrial operations (Akhtar *et al.*, 2021). Additionally, arsenic-containing herbicides and fertilizers may contribute to this problem (Raab *et al.*, 2007). It is well known that the groundwater in some parts of the globe has naturally elevated concentrations of arsenic (Kim *et al.*, 2011). In some regions of Bangladesh, West Bengal (India), and Southeast Asia, for instance, the presence of excessive arsenic concentrations in the drinking water has been a serious cause for worry concerning the public's health (Rahman *et al.*, 2009). The element arsenic has five possible oxidation states: 3, 0, 3, and 5. Arsenic may be found in the earth's crust in various forms, the most common of which are arsenic sulphide, metal arsenate, and arsenide. When it is found in water, it is most likely in the form of arsenate, which has an oxidation state of 5, if the water also contains oxygen. In reducing circumstances (200 mV), however, it is more likely to be present as arsenide, which has an oxidation state of 3, according to IPCS (2001) (Jiang *et al.*, 2013).

For ages, people have been aware of the acute toxicity of arsenic when it is present in high amounts. Long-term exposure to even extremely low arsenic concentrations has been shown to have a significant negative impact on health, and this association was not recognized as having such a negative impact until quite recently. It is now well acknowledged that drinking water is the primary route through which humans take in arsenic in its most poisonous (inorganic) form. Even in high quantities, arsenic in water does not result in any discernible alteration to the water's flavour, odour, or visual appearance (Smith & Steinmaus, 2011). The sections of our body that are immediately exposed to natural and artificial sources of arsenic include the digestive system, the respiratory tract, and the skin. Less than 97% of people are exposed to arsenic when they consume contaminated food or water via their mouths (Martinez, 2006). Because of this, the presence of arsenic in drinking water might be difficult to detect if the necessary analytical procedures are not carried out (Smith & Steinmaus, 2011).

In order to safeguard the general population's health, several nations have set regulatory limitations for the amount of arsenic that may be found in drinking water (Bosch *et al.*, 2016; WHO, 2022). These limitations are subject to change on a country-by-country basis. For instance, the World Health Organization (WHO) suggests that the acceptable level of arsenic in drinking water should not exceed 10 micrograms per litre (mg/L) or parts per billion (ppb) (Smith *et al.*, 2002; Uddin *et al.*, 2021; Frisbie & Mitchell, 2022). The WHO has set the maximum allowable amount of arsenic in drinking water at 10 micrograms per litre (10 ppb). Ingesting water that has a concentration of arsenic that is higher than the allowable threshold of 50 g/l or ppb, parts per billion (the recommended national standard for Myanmar), may lead to major skin and vascular problems, as well as various forms of cancer (Chiew *et al.*, 2009; Mahanta *et al.*, 2016; Altowayti *et al.*, 2021; Khan *et al.*, 2023; Islam, 2023). Water treatment procedures such as filtration, coagulation, and adsorption are used in regions where arsenic

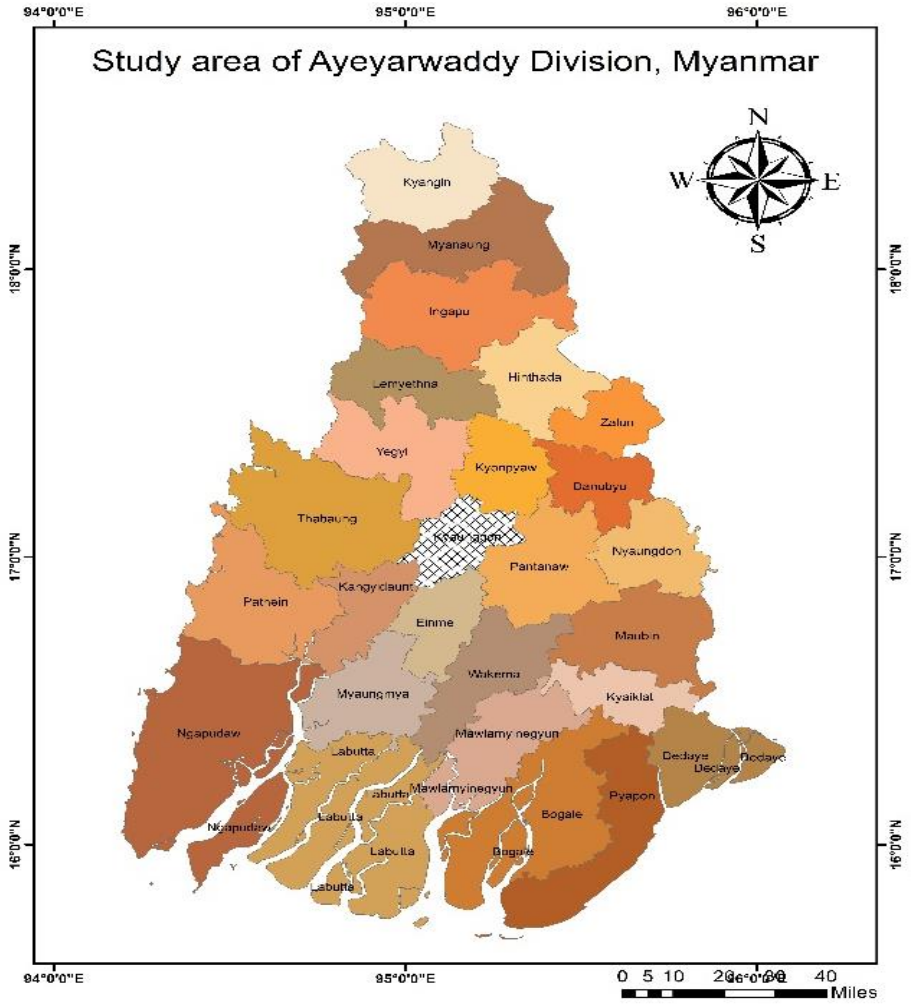
concentrations are found to be dangerously high. This is done in an effort to eliminate or significantly lower arsenic levels. It is crucial to do routine monitoring of the water quality in order to identify regions with high arsenic concentrations and then take the necessary precautions to reduce the associated dangers (Sonone, 2020).

Therefore, this research study aims to observe and compare the arsenic concentration of wells in Kyanggone region with World Health Organisation (WHO) and Myanmar National Drinking Water Quality Standards (MNDWQS). MNDWQS are used to determine public awareness of arsenic and to analyse the survey data using Statistical Package for Social Science **(**SPSS) software.

## 2. Scopes of the study area

Several villages in Kyanggone township of Ayeyarwady region (Figure 1), which occupy the delta region of the Ayeyarwady river were selected to investigate in this study. Arsenic concentration data of wells in this region were collected and compared with WHO standards and MNDWQS. A probability random sampling method was applied to take the survey. A total of 138 persons from Kyanggone Township were interviewed to collect survey data sheets and analyse them using the Statistical Package for Social Science (SPSS) software.

Figure 1: Arsenic concentration in Kyaunggon region

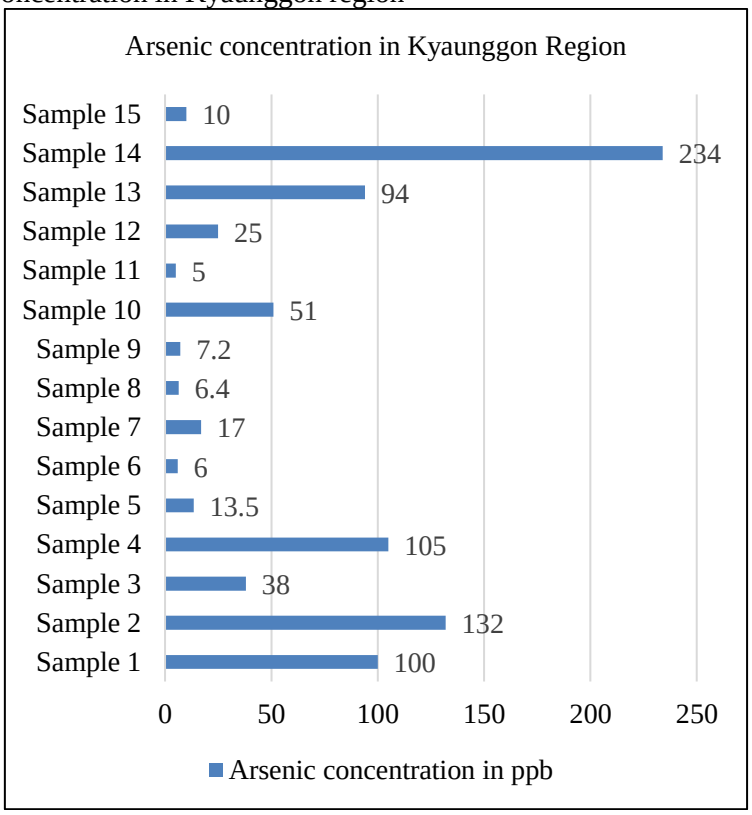


## 3. Contamination of arsenic in the study area

Arsenic contamination of groundwater is one of the naturally occurring problems in Myanmar. Lower Ayeyarwady region was highly affected by arsenic contamination in Myanmar. The highest arsenic-affected townships in Ayeyarwady Division are Kyonpyaw, Kyanggone, Pantanaw, Hinthada, and Zulun townships. Based on a field survey, the arsenic concentrations in most of the wells of Kyanggone Township were higher than WHO standards of 10 ppb and Myanmar National Drinking Water Quality Standards (MNDWQS). Arsenic exposes the public in this township in many different ways. Although Kyanggone township is one of the regions that are highly affected by arsenic, most of the people in this township still need to know and have information about arsenic and reality.

For this study, groundwater samples were collected from a tube well at Kyanggone Township, located in Ayeyarwady Division. Ideally, a laboratory infrastructure should be established at ISO TECH laboratory within a few hours, actually 24 hours of being taken. This study's sampling points of this raw water are different wells from Kyanggone region in Ayeyarwady Division as shown in Figure 2. Before collecting the sample, the groundwater is pumped at least 15 minutes' drive. After that, the tap was opened, and the water from the sample source was left at a fast flow rate of approximately 15 minutes. Finally, the bottle cap is tightened up and it is made to ensure that there was no leaking. The raw water is then tested at the ISO TECH laboratory. The laboratory results of groundwater samples are tabulated below:

Figure 2: Arsenic concentration in Kyaunggon region




According to the results, samples 1, 2, 4, 10, 13 and 14 are higher than those of WHO and MNDWQS. Samples 3, 5. 7 and 11 are higher than WHO but lower than MNDWQS. Furthermore, samples 6, 8, 9, and 11 are lower than WHO and MNDWQS.

## 4. Survey data collection

The preparation of the survey questionnaires (see appendix) and the selection of the survey sampling method were foundational steps in this study. The development of the questionnaire was carefully designed to capture essential information on both the arsenic concentration in the local groundwater and the public's awareness regarding arsenic contamination. A systematic sampling method was employed to ensure that the data collected was representative, targeting key demographic groups within the Kyanggone region. Subsequently, a field survey was conducted, and data was collected directly from the study area. During this phase, the research team visited a selection of wells across the region, tested water samples for arsenic concentration, and simultaneously distributed questionnaires to 138 individuals, ensuring a diverse range of respondents from different socio-economic backgrounds.

Once the field survey was completed, the raw data was organized and entered into Microsoft Excel, creating a structured dataset that would facilitate the analysis process. This step included data cleaning and verification to ensure accuracy and completeness. The next stage involved analysing the compiled data using Statistical Package for the Social Sciences (SPSS) software. Through SPSS, various statistical techniques were applied to evaluate trends, correlations, and patterns in the data. This analysis provided valuable insights into both the levels of arsenic contamination in the local wells and the awareness of the local population regarding the associated health risks. The use of SPSS software allowed for a more comprehensive and rigorous interpretation of the survey results, ensuring the reliability and validity of the study's findings.

## 5. Data analysis using SPSS

In this study, survey data are analysed by descriptive and inferential of hypothesis testing. Descriptive statistics describes the data in simplified and communicative ways. Simplifying ways are organizing and summarizing the data. Organizing and summarizing the data can be done in three ways i.e., tabulation, graphically or numerically. The tabulation way can be used for quantitative or qualitative data. The graphical description depends on the data type. For qualitative data, bar graphs, pie charts, and Pareto charts. For quantitative data, the dot plots, the stem and leaf display, and the histogram.

Hypothesis testing is a statistical technique administered to evaluate a hypothesis about a population based on the sample data. For example, to evaluate the following hypothesis: Education level of women has an impact on women's autonomy. The hypothesis testing procedure conducted in this study is as follows:

- Null hypothesis (H0): No impact; no association; no relation; no change; not increase; not decrease (sense of equality).
- Alternative hypothesis (H1): Impact; association; relation; change; increase; decrease (sense of inequality).

Test statistic:

- Critical value: p-value computed based on the observed data; and α (standard value) equal to 5% (95% confident level) or 1% (99% confident level) or 0.1% (99.99% confident level).

- Decision rule: p-value ≤ α, reject Ho and p-value > α, accept Ho.
- Decision and conclusion.

## 6. Results and discussion

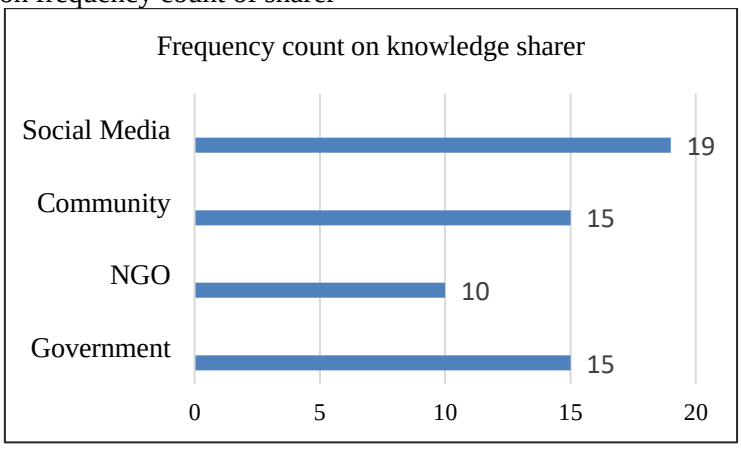
### 6.1. Descriptive statistic results

According to survey data analysis of questions 2 and 4 by SPSS based on 138 people in the Kyanggone region, which is one of the regions with high arsenic concentration, about 66% of people knew about dealing with arsenic. Results are shown in Figure 3 with a pie chart.

Figure 3: Pie chart of the public knowledge on arsenic


Moreover, knowledge of arsenic and its impact was shared by the government, NGO, community and local educated person. Some of them knew the facts from social media such as Facebook and Instagram. The bar chart shown in Figure 4 was the analysis result of question number 3.

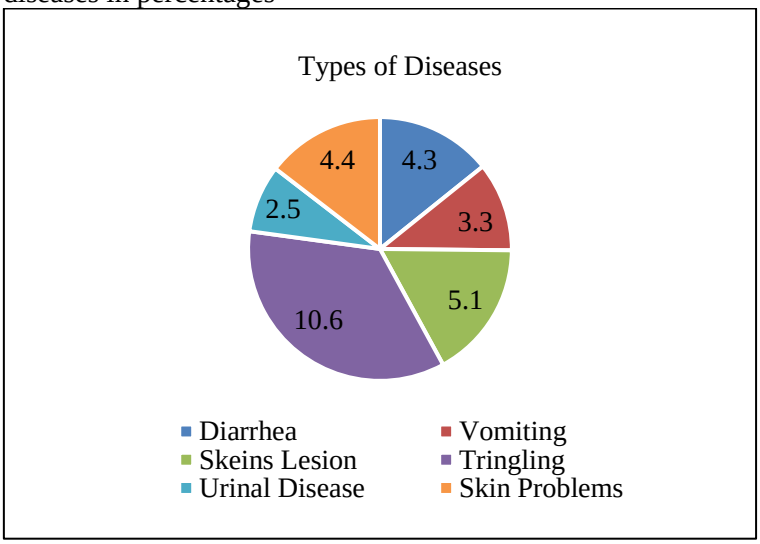
Figure 4: Bar chart on frequency count of sharer




From the analysis of questions 7, 9, and 12, almost all people depend on private wells for drinking water, and about 22% of people use purified drinking water as their alternative source. Furthermore, most people in this area use hand-dug wells rather than driven and drilled ones. Suppose arsenic poisoning causes certain diseases such as vomiting, skeins' lesions, skin problems, and urinal diseases. It is clear that 55.4 percent of people in the study area had

suffered some of these diseases in the past and now. Figure 5 shows the result of questions 11, 12, 13 and 14.

Figure 5: Types of diseases in percentages




### 6.2. Regression and hypothesis results

Regression analysis predicts how many units are changed in a dependent variable if there is one-unit change in an independent variable. Regression analysis is made with multiple linear regression models with multicollinearity. A person who lived a long-time in the study area affects arsenic poisoning. There is a strong relation between time of living and diseases that occur due to exposure of arsenic.

To investigate whether or not education level significantly affects arsenic poisoning causes, one-way ANOVA F-test, one of the hypothesis tests, is used. According to the results From the regression analysis, the public education level dramatically effects on the knowledge about arsenic and its poisoning. Another hypothesis test, two-independent sample t-test, showed that diseases of exposure are more intense in gardeners and farmers rather than government and company officers.

## 7. Conclusion

According to survey data analysis results, the people in rural areas didn't know about the knowledge and impact of arsenic. It is also concluded that people who know about arsenic use purified drinking water instead of private wells for drinking purposes. And also, some of them use slow sand filters to reduce arsenic water contamination from private wells. So, knowledge and information about arsenic is still needed to know the reality. Moreover, arsenic poisoning is higher among farmers and gardeners than government and company staff. The critical finding was that more training about arsenic sharing its impact must be made in this area to conquer the arsenic contamination problem. The significant finding of this study is that most of the people in this region still use arsenic-contaminated water for various purposes. Thus, a suitable, economical, and effective treatment method must be applied to protect the public lives from arsenic poisoning.

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## Appendix

**ARSENIC SURVEY QUESTIONNAIRES**

| Information | Code |
|---|---|
| Respondent's Code ..... | [__\|__] |
| Date ..... | [___/___/___] |
| Interviewer ..... | [__] |
| Start Time(write 24 hr system) ..... | [___:___] |

**Background Information**

1. What is your name? (အမည်)

   _____

2. What is your age in completed years? (အသက်)

   _____

3. What is your date of birth? (မွေးနေ့ )

   _____

4. What is your township? (နေထိုင်ရာ မြို့နယ်)

   _____

**Demographic Information**

5. What is your gender? (လိင်အမျိုးအစား)

   ☐ Male (ကျား) ☐ Female (မ)

6. What is your current marital status? (အိမ်ထောင် ရှိ/ မရှိ)

7. ☐Single (လူလွတ်) ☐ Married (အိမ်ထောင်သည်)

8. What is your occupation? (အလုပ်အကိုင်)

   ☐Government (အစိုးရဝန်ထမ်း) ☐ Private (ကုမ္ပဏီဝန်ထမ်း)

   ☐ Own Business (ကိုယ်ပိုင်စီးပွားရေး) ☐ Dependent (မှီခို)

   ☐ Other (အခြား) ( _____ )

9. To which standard have you studied? (ဆည်းပူးခဲ့ဖူးသော ပညာအရည်အချင်း)

☐ High School (အထက်တန်း) ☐ Graduate (ဘွဲ့ရ)

☐ Other (အခြား) ( _____ )

Environmental History and Health Issues

1. How long have you lived at your current address?

(အခုနေရာမှာ နေတာ ဘယ်နှနှစ်လောက် ရှိပြီလဲ)

_____

2. What type of hose do you live in?

(ဘယ်လိုအိမ်မျိုးမှာ နေတာလဲ)

☐ Own (ကိုယ်ပိုင်အိမ်) ☐ Apartment (အခန်း)

☐ Loan (အိမ်ငှား) ☐ Other (အခြား) (_____)

3. Do you know about arsenic?

(အာဆင်းနစ်အကြောင်းသိလား)

☐ Yes (သိပါသည်) ☐ No (မသိပါ)

4. Who inform you about arsenic?

(အာဆင်းနစ်အကြောင်းကို ဘယ်သူကပြောပြပေးတာလဲ)

☐ Government (အစိုးရ) ☐ NGO (အရပ်ဘက်အဖွဲ့အစည်း)

☐ Local educated people (အသိမိတ်ဆွေ) ☐ Other (အခြား) (_____)

5. Do you know about the impact of arsenic?

(အာဆင်းနစ်ရဲ့ဆိုးကျိုးတွေကို သိလား)

☐ Yes (သိပါသည်) ☐ No (မသိပါ)

6. Do you have any course of trainings about arsenic?

(အာဆင်းနစ်နဲ့ပတ်သက်ပြီး ဟောပြောပွဲ/သင်တန်းတွေ တက်ဖူးလား)

☐ Yes (တက်ဖူးပါသည်) ☐ No (မတတ်ဖူးပါ)

7. Who trained you?

(ဘယ်သူကပို့ချတာလဲ)

☐ Government (အစိုးရ) ☐ NGO (အရပ်ဘက်အဖွဲ့အစည်း)

☐ Local educated people (အသိမိတ်ဆွေ) ☐ Other (အခြား) (_____)

8. What is your source of drinking water?

(သောက်ရေကို ဘယ်ကနေရလဲ)

☐ Municipal well (စည်ပင်မှ ပေးဝေသောရေ) ☐ Private Well (အိမ်မှရေတွင်း)

☐ River water (မြစ်ရေ) ☐ Rain water (မိုးရေ)

☐ Other (အခြား) (_____)

9. If source of drinking water is a private well, what is the depth of well?

(သောက်ရေက ရေတွင်းကရတာဆိုရင် တွင်းအနက်ကဘယ်လောက်လဲ)

_____

10. If source of drinking water is a private well, was it tested for arsenic?

(သောက်ရေက ရေတွင်းကရတာဆိုရင် အာဆင်းနစ်ပါ မပါစစ်ဆေးသလား)

☐ Yes (စစ်ဆေးပါသည်) ☐ No (မစစ်ဆေးပါ)

11. Do you have any alternative source of drinking water?

(တခြားသောက်ရေရနိုင်တဲ့နေရာရှိသလား)

☐ Yes (ရှိပါသည်) ☐ No (မရှိပါ)

12. Do you face any diseases?

(ရောဂါတစ်ခုခုကို ခံစားနေရခြင်းရှိပါသလား)

13. ☐ Yes (ရှိပါသည်) ☐ No (မရှိ)

**14. Do you face any diseases?**

(ယခင်ကရောဂါတစ်ခုခုကို ရှိဖူးပါသလား)

☐ **Yes** (ရှိပါသည်) ☐ **No** (မရှိ)

**15. Can I know your type of disease?**

(ရောဂါအမျိုးအစား သိလို့ရမလား)

☐ Diarrhea (ဝမ်းလျှောခြင်း) ☐Typhoid (အူရောင်ငန်းဖျား)

☐ Dysentery (ဝမ်းကိုက်ခြင်း) ☐Infection (ကူးစက်ရောဂါ)

☐Skeins Problems (အဆစ်အမြစ်နာကျင်ကိုက်ခဲခြင်း) ☐ Muscle cramps (ကြွက်တက်ခြင်း)

☐Height blood pressure (သွေးတိုး)

☐ Tingling of finger or toes (ခြေ/လက်ကျင်ခြင်း)

☐ Other (အခြား) (_____)

**16. Do you face any skin problems?**

(အရေပြားပြဿနာတွေ ခံစားနေရသလား)

☐ **Yes** (ခံစားရ) ☐ **No** (မခံစားရပါ)

**17. Is there any one of your family face any skin problems?**

(မိသားစုဝင်တွေထဲမှာ အရေပြားပြဿနာခံစားနေရတာ ရှိလား)

☐ **Yes** (ရှိပါသည်) ☐ **No** (မရှိပါ)

ဖြေကြားပေးတဲ့အတွက် အားလုံးကိုကျေးဇူးအထူးတင်ရှိပါတယ်။