


Perceptions of water quality, and current and future water consumption of residents in the central business district of Yangon city Myanmar

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ABSTRACT

Public water supply services in Yangon started in 1842, however the practice of drinking tap water has been uncommon until this moment. Currently, Yangon city development committee is upgrading the tap water system in accordance with the greater Yangon water supply improvement project. It is important to know the perceptual driving factors affecting the decision to drink in order to effectively improve the public acceptance of tap water. In this study, household water management practices and their influencing factors for Yangon city residents are revealed through questionnaires. Residence time in Yangon city is significantly associated with water consumption behaviour. Decisions for drinking come from organoleptic perception rather than important safety considerations. The future consumption of tap water is influenced by income and perception of overall quality. Preferred billing method is associated with education, family size, income and willingness to spend more for better quality water.

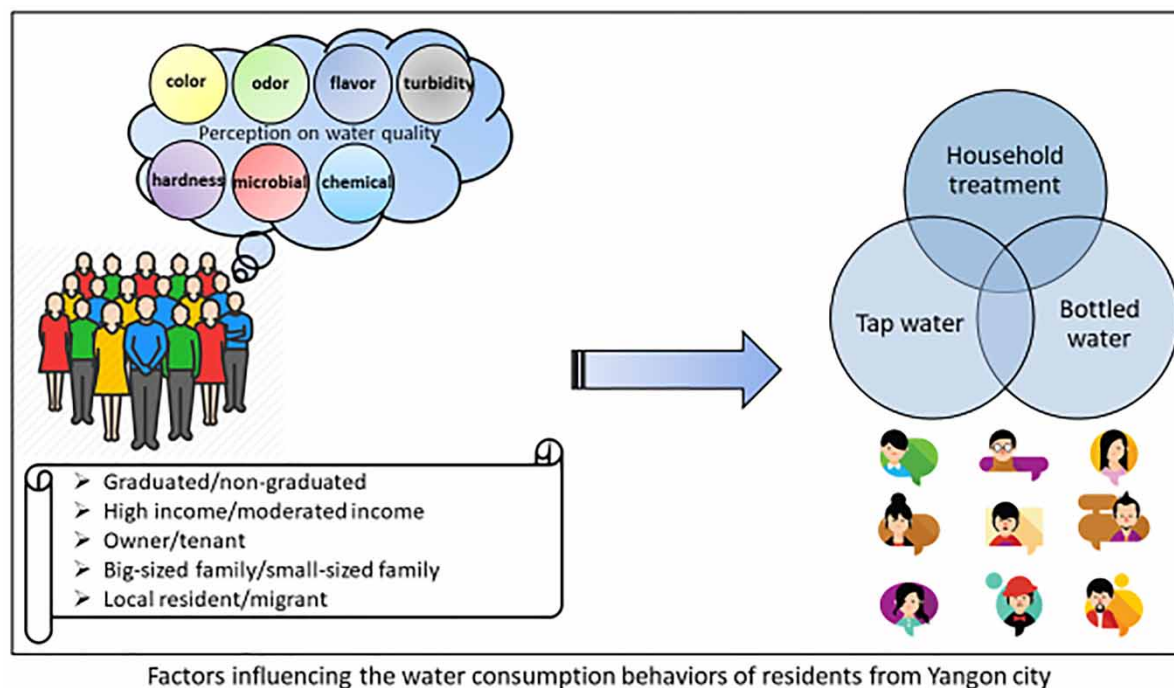
Key words: billing method, bottled water, education, family size, household treatment, tap water

HIGHLIGHTS

- Study conducted in a developing country with 178-year-old public tap water system.
- Decision for consumption based on organoleptic perception rather than safety parameters.
- Familiarity is important, regardless of quality.
- Income and perception play important roles for future consumption.

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GRAPHICAL ABSTRACT



INTRODUCTION

Access to safe water is one of the fundamental measures needed to achieve community development in order to promote health and reduce poverty in developing countries. According to the information from the WHO/UNICEF Joint Monitoring Program for Water Supply, Sanitation and Hygiene, 29% of the global population (2.2 billion (2.2×10^9) people) did not have access to safely managed drinking water (WHO 2019). Myanmar just fulfilled the eligibility criteria for graduation from the least developed country (LDC) category in 2018 for the first time since 1987 and the committee will consider its graduation at the next triennial review in 2021 (UNECOSOC 2018). Yangon, the largest city in Myanmar, has a population of 5.21 million, which represents about 10% of the entire population of the Nation according to a 2014 census (DOP 2015). City infrastructures including the water supply system could not be on par with other modern cities as a consequence of political instability during the last six decades. The Yangon City Development Committee (YCDC) is the responsible government authority for water infrastructure including planning, management and operation of water supply in Yangon City. Public water supply services in Yangon started in 1842 in the British colonial period and are encountering challenges with the provision of sufficient, clean and safe water for the whole city area (JICA 2017). Currently, YCDC is upgrading the water supply system in accordance with the greater Yangon water supply improvement project. In order to fully address the requirements of a tap water system, public perception of water quality together with household water management practices should be studied as a good understanding of them is needed to improve consumer satisfaction and trust.

A number of studies have already stated the importance of perceptions and household characteristics for household water management practices in different countries. The review studies of Doria (2006, 2010) highlighted the influence of public perception for improvements in water management, consumer services and risk communications. Perceived water quality had impacts on water consumption, storage and household treatment practices according to previous studies (Miner *et al.* 2015; Adams *et al.* 2016; Prouty & Zhang 2016) as people seek treatment practices or alternative sources based on their perception of water quality. The public perception of water quality and risks frequently differed from the experts' classifications (Doria *et al.* 2005). This can become a challenge for the communication of risk. Variations in perception, water consumption and storage behaviours of households were found to be related to household characteristics such as residence time and home ownership (Remigio *et al.* 2019). Household determinants such as income, family size, education and home ownership were found to be important factors for improved water access and sanitation practices (Adams *et al.* 2016).

The public perception of water quality has been rarely studied in developing countries, though it is often studied in developed countries. Perhaps, developing countries need to prioritize quantity rather than quality. There is no published study regarding the perception of tap water quality in the South East Asia region as the majority are developing countries. Our team previously studied the perception of a rural community of water treatment technologies provided by donor countries in Myanmar (Shane & Sakai 2020), however the perception of water quality has not been studied directly. Prasetiawan *et al.* (2017) studied the factors affecting decisions relating to the consumption of bottled water in Indonesia, but tap water was not included. According to a study in South Africa, public perception of drinking water safety is primarily related to organoleptic qualities rather than socio-economic or demographic characteristics (Wright *et al.* 2012). Daniel *et al.* (2018) indicated that the interactions between socio-environmental characteristics of households and behaviour determinants should be studied to determine the adoption of household water treatment in developing countries.

Tap water system upgrading should be based on the actual requirements of the current situation which could be revealed through consumer perception. This research aims to study the influencing factors of water consumption of Yangon city residents including household characteristics and perceptual driving factors. It is the first of this kind in Myanmar and the South East Asia region to provide useful information for developing policies and planning of improved consumer services with better understanding of community perception.

METHODS

Study area

The area of approximately 8 km² between Stand Road and Bogyoke Aung San Road located in the southern part of Yangon is identified as the central business district (CBD) of the city (Zaw *et al.* 2014). It is composed of Lanmadaw, Latha, Pabedan, Kyauktada, Botahtaung and Pazuntaund townships. It has a population of about 800,000 residents, with a population density of 34,749 per km² (Zaw *et al.* 2014; JICA 2017). Being a business area of Yangon city, CBD area is usually overcrowded with residents and people who come from other areas of Yangon city to work in this area. Pipes used for the YCDC water supply network in the CBD are very old, many of them are over 100 years old, and the average age of the entire pipeline network in the CBD is around 80 years (JICA 2017). Two adjacent townships (Kyauktada and Botahtaung) in the CBD which receive YCDC tap water from different water reservoirs were chosen as the study area (Figure 1) in accordance with suggestion from the YCDC. According to the information from water resources and the water supply authority of YCDC, Botahtaung receives water supply from Hlawga reservoir while Kyauktada tap water is from Gyobyu reservoir. Tube well water is also used to augment the insufficient supply in some areas of Kyauktada township.

Survey approach and sampling size

A variety of survey conducting options are available in other countries during the COVID-19 pandemic. However, home visit interview was the only way to conduct our survey considering the unfamiliarity with interviews by telephone, internet and public mail in Myanmar. There are around 6000 apartments in the study area according to the 2014 census. For an exploratory study, a margin of error of $\pm 10\%$ might be perfectly acceptable and this could be achieved with a sample of only 100 (Conroy 2015). Questionnaires were answered by respondents from a randomly selected one hundred households during the period of 1/03/2020–20/03/2020.

Questionnaire design

Characteristic of respondents could be categorized according to the types of housing, ownership, education, income, family size and residence time (Table 1). Income and family size were classified based on the minimum wage for labor set by the Myanmar government at 4800 Kyats/day in 2018 (around 3.5 USD/day) (ILO 2018), and according to the Myanmar living conditions survey 2017: key indicators report, which shows average household size for Yangon region is 4.1 (CSO *et al.* 2018).

Questionnaires were composed of both open and close ended questions. The availability of tap water and a storage system, and the application of household water treatment for drinking were recorded. Bottled water consumption, its cost, and method of purchasing were inquired. Main study variables with examples of survey items used for their measurements are displayed in Table 2.

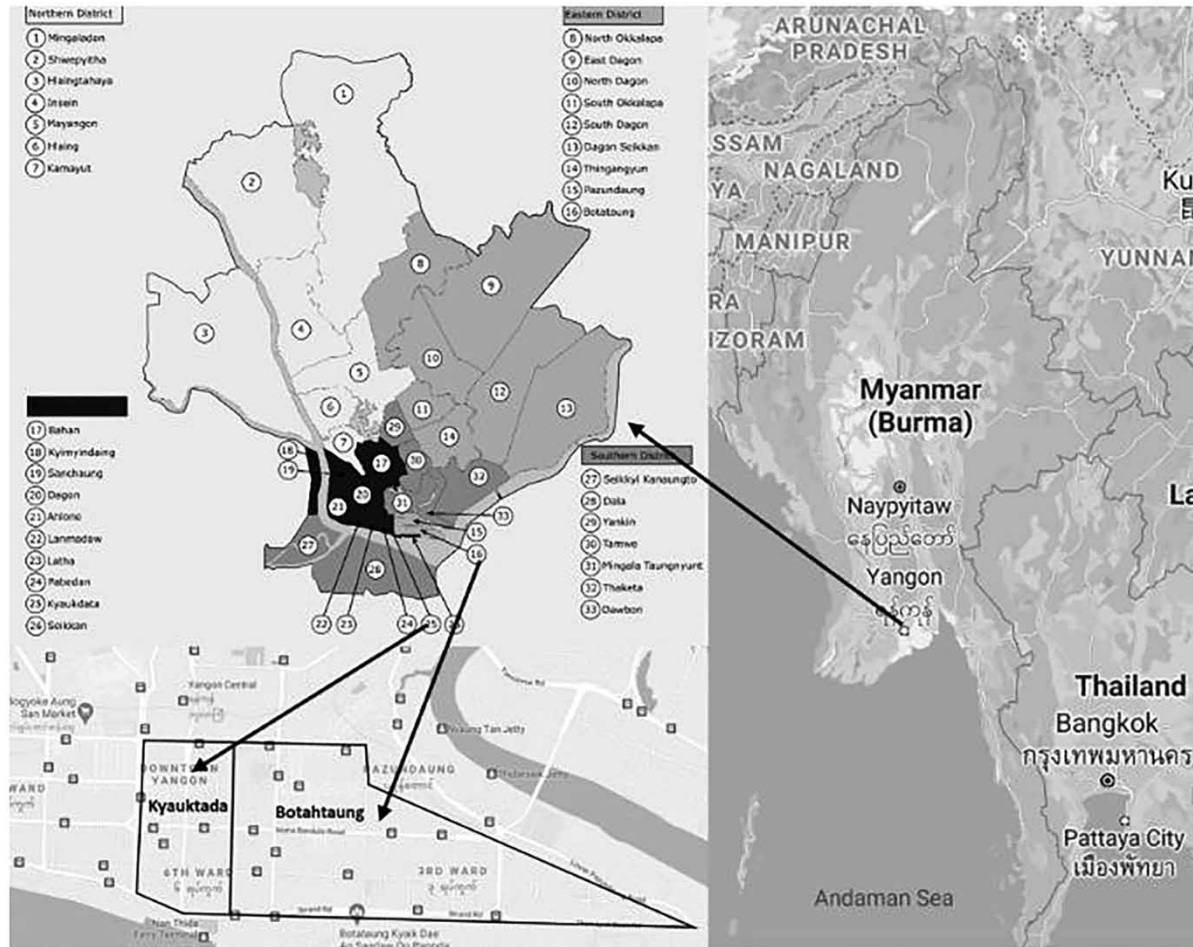


Figure 1 | Map of study area (Source-Google Maps).

Table 1 | Different household characteristic groups

No.	Groups	Criteria	Number of respondents
A1	Residential apartment	Resident who lives in residential apartment	85
A2	Staff housing	Resident who lives in government housing	15
B1	Owner	Apartment owner	31
B2	Tenant	Tenant	69
C1	Graduated	Resident who had bachelor degree as a minimum	75
C2	Non-graduated	Resident who had not completed high school	25
D1	Moderate-income	Monthly family income of less than 500,000 Kyats	34
D2	High-income	Monthly family income of 500,000 Kyats and above	66
E1	Small/medium family	1-4 family members	76
E2	Big sized family	5 and above family members	24
F1	Local	Residence time of 5 years and above in Yangon	75
F2	Migrant	Residence time of less than 5 years in Yangon	25

Table 2 | Main study variables with examples of the survey items

Latent variables	Manifest variables (examples of survey items)	Responses
Quality	[Flavor/color/turbidity/odor/hardness/microbial/chemical/overall] of my [tap water/bottled water] is usually of () quality.	Very unsatisfied/unsatisfied/ satisfied/very satisfied
Consumption	Source of water for [drinking, cooking, making coffee/tea/juice, showering, washing (clothes) and washing (dishes)] purpose in my home is ().	Tap water/treated tap water (treated again with household methods)/bottled water
Future consumption	I am willing to drink tap water when the YCDC tap water system upgrading accomplished.	Yes/No
Tariff	Current water utility rate is ().	Cheap/reasonable/expensive
Expected expenses	I am willing to spend more for better quality tap water.	Yes/No
Billing method	My preference billing method is ().	Meter/fixed

Data analysis

Chi-square tests of bivariate analysis have been applied in many studies to identify perceptions and favorability with respect to household characteristics such as age, education and income levels (Gary 2005; Amanda *et al.* 2019). In this study, Chi-square analysis was used to study the potential influencing factors including perceptions and household characteristics of water consumption behavior, future consumption of tap water, and the preferred billing methods using IBM SPSS software.

RESULTS AND DISCUSSION

General information

Tap water system in buildings

Old residential buildings did not have an underground or a rooftop tank, and apartments in the building made individual connection to the YCDC water pipe directly. Every apartment had to use an electric pump to get water into their individual storage tanks. Unlike old building, new buildings were using an underground tank from which apartments were pumping up water to their storage tanks inside their apartments. Most of the buildings in the study area were old buildings. Custom staff housing has a distinct system to deliver YCDC tap water to the residents. A member of staff is assigned to take responsibility for operating a pump which transport water from YCDC pipe to a rooftop tank for the entire building.

All residential apartments had two tanks inside their bathrooms. One tank in a higher position delivers water to the taps, washing machine and toilet. the other on the floor and is mostly used for showering and washing manually. Upper tanks are usually made of fiber or metal while lower tanks are of a concrete type. Average tank capacity is around 800 L. All apartments usually pump at least one time per day.

Household water treatment

According to our survey, a total of 35 households applied an additional household water treatment for drinking. The types of household water treatment are provided in Appendix Table A. The percentages of people using household treatment for drinking from the different household characteristic groups are shown in Figure 2. The government staff housing had higher numbers of household treatment users than the private buildings. The percentage of households using treatment was higher in apartment owners compared with tenants. Graduated and high-income people were more likely to use household treatments than non-graduated and moderate-income people, respectively. Household treatment was more common in big compared to small families. Local residents seemed to apply household water treatment practices more than migrants did. The results indicated that the apartment owners, local residents, graduated, high-income and big families have higher tendency to use household water treatment than the tenants, migrants, non-graduated, moderate-income and small families, respectively.

Bottled water purchasing

The most common method to purchase bottled water is by making an order by telephone. The price ranges from 500 Kyats (0.4 USD) to 1000 Kyats (0.8 USD) per bottle (20 L) depending on the popularity of the brand name. Monthly total

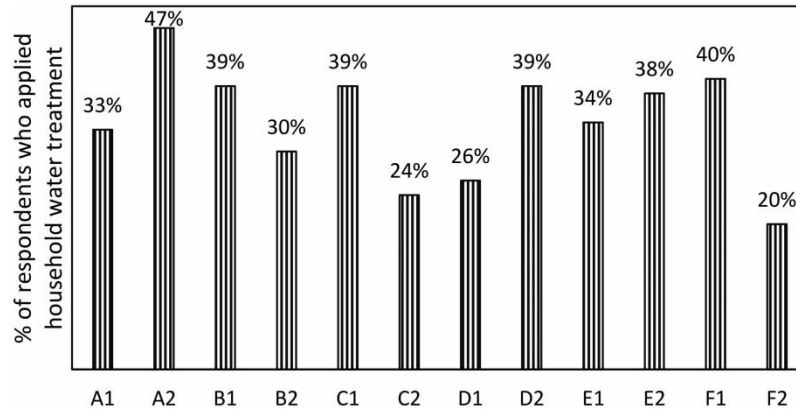


Figure 2 | Percentages of household water treatment application in CBD area. A1: Private building, A2: Staff housing, B1: Owner, B2: Tenant, C1: Graduated, C2: Non-graduated, D1: Moderate-income, D2: High-income, E1: Small/Medium family, E2: Big family, F1: Local, F2: Migrant.

expenditure of a family with bottled water only consumption ranges from a minimum of 5600 Kyats (4 USD) to a maximum of 16800 Kyats (12 USD) which is obviously more expensive than tap water. Although bottled water purchasing is convenient in the study area, it seems costly for the majority. Customers are likely to choose cheaper tap water if the YCDC can upgrade the current tap water system efficiently.

Perception of water quality

Regarding perception of quality of tap water, 73% of the respondents were satisfied by water hardness and it earned the highest satisfaction. Odor and flavor satisfied 70 and 68% of the respondents, respectively. Color of tap water satisfied 56% of the respondents. Chemical quality of tap water was found satisfactory by half of the respondents. However, turbidity and microbial quality of tap water were found satisfactory for lower percentages of respondents with 39 and 43%, respectively. Overall, quality of tap water was regarded as satisfactory by 57% of respondents. Flavor, color, odor and hardness of tap water were accepted by majorities of customers while turbidity and microbial quality were the most disliked qualities (Figure 3).

When it comes to satisfaction of quality of bottled water, almost all participants responded as satisfied or very satisfied (Figure 4). Only 6% of respondents were unsatisfied with the flavor of bottled water while 1% of respondents disliked the odor of bottled water. Microbial quality was one of the most disliked parameters for the tap water; however it became the highest favorable quality of bottled water as 25% of the respondents regarded it as very satisfactory. Customers’ perception of the quality of bottled water was higher to that of current tap water quality.

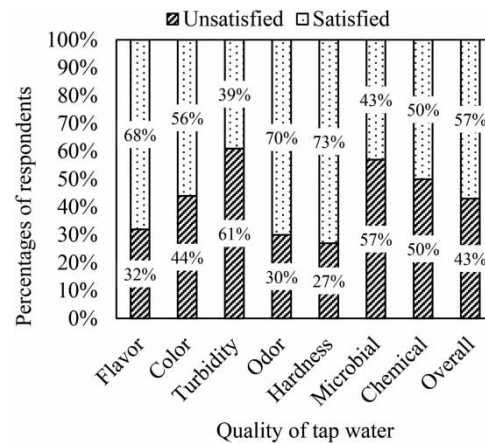


Figure 3 | Consumer perception of quality of tap water in the CBD area.

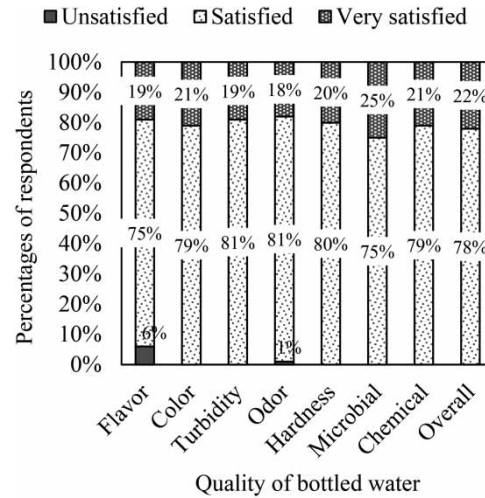


Figure 4 | Consumer perception of the quality of bottled water in the CBD area.

Water consumption behaviors

Differences in water consumption behavior among residents of different household characteristic groups are shown in Table 3. Overall, 65% of respondents in the CBD area consumed bottled water only, while 15% of respondents relied on treated tap water. The remaining 20% consumed both bottled water and treated tap water (mixed consumption). No residents drank tap water without any further household treatment.

Residents from private building and government staff housing had similar percentages of treated tap water only consumption with 15 and 13%, respectively. Percentages of bottled water only consumption was higher in the private building (67%) compared to the government staff housing (54%). The residents from staff housing had a higher percentage of mixed consumption behavior (33%) in comparison to those in private buildings (18%).

Treated tap water only consumption was more common in apartment owners (20%) compared with tenants (9%). The percentage of the tenant families with bottled water only consumption was 69% while that of apartment owners was 61%. The percentages of mixed consumption behavior did not differ between apartment owners and tenants with 19 and 22%, respectively.

Table 3 | Sources of drinking water in the CBD area according to household characteristics

No.	Household characteristics	Treated tap water	Bottled water	Both	Number of respondents
A1	Private apartments	15%	67%	18%	85
A2	Government staff housing	13%	54%	33%	15
B1	Owners	20%	61%	19%	31
B2	Tenants	9%	69%	22%	69
C1	Graduated	16%	61%	23%	75
C2	Non-graduated	12%	76%	12%	25
D1	Moderate-income	9%	70%	21%	34
D2	High-income	18%	62%	20%	66
E1	Small/medium sized family	16%	66%	18%	76
E2	Big sized family	13%	62%	25%	24
F1	Locals	20%	60%	20%	75
F2	Migrants	0%	80%	20%	25
All respondents (all household characteristics)		15%	65%	20%	100

Treated tap water was consumed by 16% of graduated respondents and 12% of non-graduates. Non-graduated respondents had a higher percentage of bottled water only consumption (76%) compared with graduated respondents (61%). Mixed consumption was more common in graduated respondents (23%) compared to 12% in non-graduates.

Treated tap water only consumption was more common in high-income families (18%) than moderate-income families (9%). The percentage of bottled water only consumption in moderate-income families was 70% while those of high-income families was 62%. The percentages of mixed consumption was similar for moderate-income families and high-income families with 21 and 20%, respectively.

The percentages of treated tap water only consumption between small/medium sized families and big sized families did not differ much with 16 and 13%, respectively. They also had similar percentages for bottled water only consumption with 66 and 62%, respectively. Big sized families had a higher percentages in mixed consumption (25%) compared to those of small/medium sized families (18%).

Migrants from other regions did not consume treated tap water only while it was consumed by 20% of local residents. Bottled water only consumption was more common for migrant people (80%) compared to local residents (60%). Both migrants and local residents had the same percentage in mixed consumption, with 20%.

Sources of water for other purposes apart from drinking are shown in Appendix Table B. When it comes to water for cooking, 77% of the households used tap water for cooking while the remaining households used bottled water. For making coffee or tea or juice, 75% of households used bottled water and the remaining 25% used tap water. Tap water was the only source for showering, washing dishes and washing clothes of all respondents.

In previous studies, the use of tap water to drink was influenced by perceived water quality (Doria *et al.* 2005; Prouty & Zhang 2016). A similar finding was revealed in our study, in which perception of overall quality of tap water had a significant association with the consumption behaviors of the residents ($p < 0.05$) (Table 4). The percentage of tap water consumption was higher in the group of respondents who were satisfied with overall quality of tap water compared to the group of respondents who were unsatisfied with overall quality of tap water. In addition to overall quality, perceptions of flavor, color, odor and turbidity of tap water also had significant impacts on water consumption behaviors ($p < 0.05$). However, perceptions of hardness, and microbial and chemical qualities were not statistically associated with water consumption behaviors. It could be concluded that selection of drinking water source was determined by a judgement based on organoleptic characteristics of water rather than other parameters such as hardness, microbial and chemical qualities. Considering safety for customers, and

Table 4 | Influencing factors of water consumption behaviors in the CBD area

Influencing factors		Treated tap water	Bottled water	Both	P-value (Chi-square)
Residence time	Locals	20%	60%	20%	0.046*
	Migrants	0%	80%	20%	
Perception (overall quality)	Satisfied	25%	54%	21%	0.005*
	Unsatisfied	2%	79%	19%	
Perception (flavor)	Satisfied	22%	59%	19%	0.015*
	Unsatisfied	0%	78%	22%	
Perception (color)	Satisfied	23%	55%	22%	0.022*
	Unsatisfied	5%	77%	18%	
Perception (turbidity)	Satisfied	26%	54%	20%	0.048*
	Unsatisfied	8%	72%	20%	
Perception (odor)	Satisfied	21%	59%	20%	0.019*
	Unsatisfied	0%	80%	20%	
Perception (Hardness)	Satisfied	19%	59%	22%	0.075
	Unsatisfied	4%	81%	15%	
Perception (Microbial)	Satisfied	19%	60%	21%	0.630
	Unsatisfied	12%	69%	19%	
Perception (Chemical)	Satisfied	22%	54%	24%	0.052
	Unsatisfied	8%	76%	16%	

*significant p -value.

microbial and chemical qualities should be prioritized ahead of organoleptic qualities. However, people prioritized organoleptic qualities for drinking instead of microbial and chemical qualities according to our findings. In addition to perception of organoleptic and overall qualities, residence time was significantly associated with water consumption behavior ($p < 0.05$). This could be the consequence of an unfamiliarity with tap water amongst migrant people which leads to a higher percentage of bottled water only consumption. A corresponding study conducted in Indonesia highlighted the fact that even when piped water companies could upgrade the quality of tapped water in accordance with drinking water standards, efforts were still needed to attract customers unfamiliar with drinking piped water (Prasetyawan *et al.* 2017). Education, income, family size and apartment ownership did not show significant impacts on water consumption behavior statistically. Water consumption behavior of residents in the study area was influenced by residence time, and on perception of organoleptic and overall qualities.

Future consumption

98% of the respondents agreed with the fact that tap water quality will be improved after the YCDC tap water system upgrading. Regardless of their perceptions of current tap water quality, 88% of the respondents are willing to drink tap water if the YCDC can improve tap water quality to meet drinking water standards. However, 12% of the respondents insisted on drinking bottled water even after the tap water system upgrading for reasons of lack of trust of the YCDC, satisfaction with bottled water quality and unfamiliarity with drinking tap water (details of the reasons are provided in Appendix Table C).

The associations between household characteristics and willingness to drink tap water after upgrading of the tap water system are shown in Table 5. Income of the residents had a significant impact on willingness to drink tap water after upgrading of the tap water system ($p < 0.05$). The majority of the respondents of moderate-income families (97%) are willing to drink tap water after upgrading while 83% of the respondents from high-income families were willing to do it. The current tap water price (1,800 Kyats/1.3 USD) is obviously cheaper compared with the minimum monthly expenditure for bottled water (5,400 Kyats/3.9 USD), and this might be the reason why moderate-income people have a higher tendency to drink tap water if the YCDC could upgrade the tap water system effectively. Moreover, perception of overall quality of tap water also had a significant impact on willingness to drink tap water after upgrading of the tap water system ($p < 0.05$). The tendency to drink tap water in the future is influenced by income and the perception of overall quality of tap water according to the findings in this study.

Methods to encourage the use of tap water

Meanwhile, tap water system upgrading is ongoing and no official announcement regarding tap water quality for safety concerns has been provided by the YCDC. Once system upgrading has been accomplished, the YCDC needs to encourage the residents to consume tap water. Madenli & Muhammetoglu (2008) suggested that organizing public awareness campaigns,

Table 5 | Influencing factors on willingness to drink tap water in the CBD area

Influencing factors		Willingness to drink tap water after upgrading the YCDC service		
		Yes	No	P-value (Chi-square)
Income	Moderate-income	97%	3%	0.045*
	High-income	83%	17%	
Education	Graduated	89%	11%	0.736
	Non-graduated	84%	16%	
Family size	Small/medium	89%	11%	0.420
	Big	83%	17%	
Apartment-ownership	Owner	81%	19%	0.089
	Tenant	97%	3%	
Residence time	Local	85%	15%	0.155
	Migrant	96%	4%	
Perception (overall quality)	Unsatisfied	79%	21%	0.017*
	Satisfied	95%	5%	

*significant p -value.

informing the public about the maintenance and renewal of old parts of the previous distribution network and the results of potable water quality monitoring could improve the public acceptance of tap water in the community unfamiliar with tap water consumption. The YCDC should pay attention to these strategies for improving the consumer perception and trust of tap water, since the decision to consume tap water was greatly influenced by the perception of its quality.

Current water utility rate and billing methods

Almost all respondents agreed that the current water utility rate is reasonable and 80% of the respondents were willing to pay more for better quality tap water. The associations between household factors and willingness to spend more for better quality tap water are shown in Table 6. Education level, family size and income are significantly associated with willingness to spend more for better quality tap water ($p < 0.05$). Graduated people have a higher percentage of willingness to spend more for better quality tap water than non-graduated people with 88 and 56%, respectively. This could be the consequence of a higher awareness of water quality amongst educated people. To spend more for better quality water was voted by 86% of small/medium sized households while 62% of big families agreed on it. Probably big families have to limit the expenditure which could lead them to spend a lesser amount on water bills compared with small families. High-income families also had a higher tendency (86%) to pay more for better quality water than moderate-income households (68%).

Two kinds of billing methods are found within the study area: (1) fixed rate - 1800 Kyats/1.3 USD per month (which was collected quarterly) and (2) a meter system. According to the respondents who use the meter system, the amount of monthly water meter bills ranged from 1,500 Kyats/1.1 USD to approximately 3,000 Kyats/2.2 USD depending on water consumption level. The majority of households (63%) were still using a fixed rate while the rest 37% already changed to the meter system. Regarding preference for billing method, 53% of the respondents preferred to use the meter system while the remaining 47% insisted on paying the fixed rate for the reasons shown in Table 7.

Table 6 | Influencing factors on willingness to pay more for better quality tap water in the CBD area

Influencing factor		Willingness to spend more for better quality water		
		Yes	No	P-value (Chi-square)
Income	Moderate-income	68%	32%	0.027*
	High-income	86%	14%	
Education	Graduated	88%	12%	0.002*
	Non-graduated	56%	44%	
Family size	Small/medium	86%	14%	0.014*
	Big	62%	38%	
Apartment-ownership	Owner	81%	19%	0.903
	Tenant	78%	22%	
Residence time	Local	77%	23%	0.248
	Migrant	88%	12%	

*significant p -value.

Table 7 | Reasons for preference of billing methods of consumers in the CBD area

No.	Reason	Percentage of respondents	Preference method
1	Fair	46%	Meter
2	Internationally accepted system	2%	Meter
3	Accepting government policy	4%	Meter
4	Save water	1%	Meter
5	Cheaper	40%	Fixed rate
6	Afraid of meter error	7%	Fixed rate

Table 8 | Influencing factors on preferred billing method of consumers in the CBD area

Influencing factor		Preferred billing method		P-value (Chi-square)
		Fixed	Meter	
Income	Moderate-income	68%	32%	0.003*
	High-income	36%	64%	
Education	Graduated	37%	63%	0.003*
	Non-graduated	76%	24%	
Family size	Small/medium sized	39%	61%	0.007*
	Big sized	71%	29%	
Apartment-ownership	Owner	43%	57%	0.553
	Tenant	55%	45%	
Residence time	Local	47%	53%	0.908
	Migrant	48%	52%	
Pay more for better quality	Willing	34%	66%	0.000*
	Not willing	100%	0%	

*significant *p*-value.

The associations between the household factors and the preference billing method are shown in Table 8. The preferred billing system of the residents was significantly associated with education level, family size and monthly family income ($p < 0.05$). A water meter system was preferred by the majority of graduated respondents (63%). However, the majority of non-graduated respondents (76%) chose a fixed water bill as their preference. The majority of graduated people (55%) believed the water meter system to be a fair system and this could be the reason of choosing a meter system as their preference. On the other hand, ungraduated people prioritized the reason of cheaper cost and this led them to insist on preferring the fixed rate.

The meter system was preferred by 61% of small households while a fixed water bill was preferred by 71% of big families. This could be related to the consequence of lesser willingness to spend more on water of big families as they probably had a larger water consumption compared to small families.

The percentage of households which liked to use the meter system was higher in high-income families than moderate-income families with 64 and 32%, respectively. Unlike for the high income earners, the smaller budget for water of moderate-income households led them to choose the potentially cheap fixed water price.

In addition, there was a strong relationship between willingness to spend more for better quality water and preferred billing method ($p < 0.001$). The majority of the residents who were willing to pay more for better quality (66%) preferred the meter system. However, all residents who were not willing to pay more for better quality chose the fixed rate as their preference. Our findings indicated that the preferred billing method of the residents was influenced by education, family size, income and willingness to spend more for better quality tap water.

CONCLUSIONS

Water supply policies for Yangon city should be developed based on the concept of promoting tap water consumption. This could be achieved by improving the quality of tap water and providing quality information to the consumers, since decisions about consumption came from perceptions of quality according to our study. Regarding the quality improvement, not only safety parameters but also organoleptic parameters should be taken into consideration according to the findings. The YCDC should conduct appropriate studies to find out the most effective way to deliver the quality information to the residents of Yangon city.

In addition to water consumption, this study revealed the influencing factors for the preferred billing method. The YCDC could use this information to set or adjust the water utility rate classification accordingly. Since family size was one of the influencing factors for the preferred billing method, setting a standard rate for a particular amount of water per person with a higher rate for the exceeding amount, and a discount rate for a large family could be helpful to convince the residents to use the water meter system.

This study is one of only a few in the world that use a questionnaire to reveal the social influencing factors of tap water consumption. Based on the findings of this study, water authorities in the developing world can get ideas to develop not only the methodology to study factors influencing water consumption but also the policy to improve tap water systems with better understanding of public perceptions.

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DECLARATION OF INTEREST STATEMENT

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

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DATA AVAILABILITY STATEMENT

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

REFERENCES

- Adams, E. A., Boateng, G. O. & Amoyaw, J. A. 2016 Socioeconomic and demographic predictors of potable water and sanitation access in Ghana. *Social Indic. Res.* **126**, 673–687.
- Amanda, R., Varadraj, G., Steven, L. F. & Tina, Y. 2019 Utilizing telemedicine in oncology settings: patient favourability rates and perceptions of use analysis using chi-square and neural networks. *Technol. Health Care* **27** (2), 115–127.
- Conroy, R. 2015 Sample size: a rough guide. Ethics (Medical Research) Committee, RCSI, Dublin, Ireland. Available from: <http://www.beaumontethics.ie/docs/application/samplecalculation.pdf> (accessed 22 October 2020).
- CSO (Central Statistical Organization), UNDP (United Nations Development Programme) and WB (World Bank) 2018 *Myanmar Living Conditions Survey 2017: Key Indicators Report*. Nay Pyi Taw and Yangon, Myanmar.
- Daniel, D., Marks, S. J., Pande, S. & Rietveld, L. 2018 Socio-environmental drivers of sustainable adoption of household water treatment in developing countries. *npj Clean Water* **1**, 12. doi:10.1038/s41545-018-0012-z. (accessed 20 Jun 2021).
- DOP (Department of Population) 2015 *The 2014 Myanmar Population and Housing Census. Yangon Region Report. Census Report*. Nay Pyi Taw, Myanmar.
- Doria, M. d. F. 2006 Bottled water versus tap water: understanding consumers' preferences. *J. Water Health* **4** (2), 271–276.
- Doria, M. d. F. 2010 Factors influencing public perception of drinking water quality. *Water Policy*. **12**, 1–19.
- Doria, M. d. F., Pidgeon, N. & Hunter, P. 2005 Perception of tap water risks and quality: a structural equation model approach. *Water Sci. Technol.* **52** (8), 143–149.
- Gary, R. W. 2005 Satisfaction, academic rigor and interaction: perceptions of online instruction. *Spring* **125** (3), 460–468.
- ILO (International Labour Organization) 2018 *Minimum Wage A Step Forward for Democracy and Sustainable Development*. ILO, Geneva, Switzerland. Available from: https://www.ilo.org/yangon/press/WCMS_630131/lang-en/index.htm (accessed 22 October 2020).
- JICA (Japan International Cooperation Agency) 2017 *Final Report on Preparatory Survey for Greater Yangon Water Supply Improvement Project (Phase 2)* JICA, Tokyo, Japan.
- Madenli, E. C. & Muhammetoglu, H. 2008 Improving public perception of tap water in Antalya city, Turkey. *Aqua* **57** (2), 10.2166.
- Miner, C. A., Dakhin, A. P., Zoakah, A. I., Afolaranmi, T. O. & Enzuladu, E. A. 2015 Household drinking water; knowledge and practice of purification in a community of Lamingo, Plateau state, Nigeria. *EJERM* **6** (3), 230–236.
- Prasetyawan, T., Nastiti, A. & Muntalif, B. S. 2017 'Bad' piped water and other perceptual drivers of bottled water consumption in Indonesia. *WIREs Water* **4**, e1219. doi: 10.1002/wat2.1219.
- Prouty, C. & Zhang, Q. 2016 How do people's perceptions of water quality influence the life cycle environmental impacts of drinking water in Uganda? *Resour. Conserv. Recycl.* **109**, 24–33.
- Remigio, R. V., Rabello, R. S., Zulaika, G., Carvalho, M. S., Barrocas, P. R. G. & Lovasi, G. S. 2019 Household-level drinking water quality, access, and management practices within an informal community: a case study at Rio das Pedras, Rio de Janeiro. *J Water Sanit. Hyg. Dev.* **9** (2), 80.
- Shane, H. K. & Sakai, H. 2020 Water treatment practices in rural Myanmar and residents' perceptions of technologies from donor countries. *Desalin. Water Treat.* **208**, 337–344.
- UNECOSOC (United Nations Economic and Social Council) 2018 *Committee for Development Policy: Report on the Twentieth Session*. Available from: <https://undocs.org/en/E/2018/33> (accessed 22 October 2020).

- WHO 2019 *1 in 3 People Globally do not Have Access to Safe Drinking Water* – UNICEF, WHO. WHO news release (18 June 2019). Available from: <https://www.who.int/news-room/detail/18-06-2019-1-in-3-people-globally-do-not-have-access-to-safe-drinking-water-unicef-who> (accessed 22 October 2020).
- Wright, J. A., Yang, H., Rivett, R. & Stephen, W. G. 2012 *Public perception of drinking water safety in South Africa 2002–2009: a repeated cross-sectional study*. *BMC Public Health* **12**, 556. <https://doi.org/10.1186/1471-2458-12-556> (accessed 20 June 2021).
- Zaw, L., Shwe, T. & Hlaing, M. 2014 *Studies of the status of central business district area (CBD) in Yangon, Myanmar*. *Int. J. Emerging Technol. Adv.* **4** (5), 2250–2459.

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