

Seasonal patterns of drinking water consumption pattern in Mysore City, Karnataka, South India

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ABSTRACT

The aim of this study is to determine the general drinking water consumption pattern in Mysore city, Karnataka, South India with special reference to cold water (without boiling), and to construct a data base for water consumption habits of Mysore people. In developing countries microbial risk assessment studies, water intake values are often adopted from developed countries. However, these values may not be suitable for the risk characterization of human populations from tropical regions of developing countries. Hence, the present study aimed to assess the water consumption pattern among the general population in Mysore city as a first attempt in this region. To compare seasonal variations in water consumption patterns, our study was carried in two major seasons, i.e. in the summer ($n = 1,256$) and winter ($n = 1,230$) of 2012–2013. Cold water intake rates were assessed by age, gender and season. The results of this study indicate that the average cold water consumption rate during the summer was 1.12 L/day per person and in the winter season was 0.92 L/day per person. The present survey study is believed to be the first attempt to quantify the intake of cold water consumption in Mysore city, Karnataka, South India.

Key words | cold water intake, drinking water, risk assessment, water consumption

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INTRODUCTION

The quality of drinking water is an essential determinant for better health (Popkin *et al.* 2010). Contaminated drinking water serves as an important vehicle for transmitting diseases in humans. The associations between demographic characteristics and drinking water consumption patterns indicate potential differences in risk of exposure to water-borne pathogens in the population (Jones *et al.* 2006). In order to determine the microbial risk assessment from drinking water, both the dose of pathogens and the volume of consumed cold water are essential parameters (Mons *et al.* 2007). According to WHO and USEPA the standard quantity of water intake for adult was 2 litres per day and 1 litre per day for children. This standard quantity of drinking water may vary according to various environmental factors.

There are many factors, such as physiological and cultural issues, that may influence the water consumption

pattern. It also varies according to different geographic locations and climate. The water consumption pattern may vary between countries (Westrell *et al.* 2006). It may be varied within the country based on the difference in climatic conditions, cultural differences, and demographic variables. Due to such differences in water intake levels the WHO suggested 'local adjustments' to set the local standard value for drinking water consumption rates (WHO 2011; Hossain *et al.* 2013). In India drinking water consumption pattern studies seem to be very scarce and not much documentary evidence is on a survey scale. Therefore, it was necessary to carry out a water consumption survey in Mysore, Karnataka, South India.

Direct intake of drinking water leads to health hazard impacts mainly due to microbial and bacteriological impurities and the presence of pathogenic or disease

producing bacteria. In recent years many studies have been carried out to determine the potential impact on health through drinking water consumption habits (Jarosinska *et al.* 2004; Lee *et al.* 2004; Watanabe *et al.* 2004; Ahsan *et al.* 2006; Jones *et al.* 2006; Milton *et al.* 2006; Westrell *et al.* 2006; Kile *et al.* 2007; Ohno *et al.* 2007; Xu *et al.* 2008; Barraji *et al.* 2009; Mondal *et al.* 2010; Kyunghee *et al.* 2010; Azlan *et al.* 2012; Hossain *et al.* 2013; Liangxin *et al.* 2014). To determine the risk of infection from waterborne pathogens, both water consumption rates and pathogen concentrations in drinking water are important parameters (Smeets *et al.* 2008). In developing countries microbial risk assessment studies water intake values are often adopted from developed countries. However, these values may not be suitable for the risk characterization of human populations from tropical regions of developing countries. Hence, the present study aimed to assess the water consumption pattern among the general population in Mysore city as a first attempt in this region.

The average cold water consumption rate was an important parameter to study the Quantitative Microbial Risk Assessment (QMRA) through drinking water. The first QMRA study on drinking water was carried out by Regli *et al.* (1991), who used the water consumption rate of 2 L per person per day. Later Roseberry & Burmaster (1992) used the average value of 0.96 L per person per day. In the Netherlands Teunis *et al.* (1997) obtained data on average cold water consumption values at 0.153 L per person per day (Mons *et al.* 2007). The objective of this study is to assess the water consumption pattern among the general population in Mysore city. The data used in this study is based on the survey regarding the water consumption pattern in Mysore city during the period 2012–2013.

The aim of this study is to determine the general drinking water consumption pattern in Mysore city, Karnataka, South India with special reference to cold water (without boiling), and to construct a database for the water consumption habits of Mysore people. This study also focused on the demographic and seasonable variables. This study will be useful for further research on QMRA and calculate the burden of risk associated with the consumption of drinking water.

MATERIALS AND METHODS

Study area

The present study was carried out in an urban area of Mysore City Corporation. Mysore city covers an area of 128.42 km² and is located at 12°18'N 76°39'E, 12.30°N 76.65°E and has an average altitude of 770 m. The water supplies of Mysore are met by three water treatment plants (Jessen *et al.* 2016). The total length of the distribution mains of these water treatment plants is about 1,281 km, which supplies 125.98 MLD from the centralized Vani Vilas Water Works (Jessen *et al.* 2015).

Water consumption pattern and demography

The survey was carried out through a set of questionnaires. More than 600 questionnaires were handed over personally to the respondents. The survey was carried out during two seasons of the years 2012–2013 (winter and summer period). A total of 1,256 persons participated in the summer survey and 1,230 persons in the winter survey.

Household selection

A total of 1,256 persons from 300 families participated in the summer survey and 1,230 persons from 294 families participated in the winter survey. In the selection process, households having at least three members were included to ensure at least one adult male, one adult female, and a child from each household were study subjects.

The questionnaires contained questions on water intake mode such as cold water (water consumed directly as drinking water without boiling), type of water consumption (Cauvery water, bore well and bottled water) and volume of daily water consumption. Five alternatives were provided to determine the volume of cold water intake rate. They were less than 1, 1, 2, 3 and more than 3 L, respectively.

The demographic variables considered in this study were age groups, gender and area of residence among the population of Mysore city. The city was divided into 65

administrative wards. The coverage of water supply for domestic connection is about 67% in urban limits. The existing distribution of water to the city is not uniform in all areas and the total numbers of domestic tap water connection is about 0.13 million. Based on these proportions we segregated the study populations into six zones. They were Zone A (CSR-Vijayanagar), Zone B (GLSR), Zone C (Vani Vilas), Zone D (Kuvempu Nagar), Zone E (Devanur), and Zone F (Yadava giri). The details of the demographic characteristics are shown in Table 1.

Table 1 | Demographic characteristics of participants

| Demographic characteristics | Summer survey (n = 1,256) | | Winter survey (n = 1,230) | |
|-----------------------------|---------------------------|----------------|---------------------------|----------------|
| | Frequency (n) | Proportion (%) | Frequency (n) | Proportion (%) |
| Sex | | | | |
| Male | 632 | 50.3 | 618 | 50.2 |
| Female | 624 | 49.7 | 612 | 49.8 |
| Age group (year) | | | | |
| 0–9 | 114 | 9.0 | 112 | 9.1 |
| 10–19 | 130 | 10.4 | 128 | 10.4 |
| 20–29 | 220 | 17.5 | 218 | 17.8 |
| 30–39 | 184 | 14.6 | 180 | 14.6 |
| 40–49 | 222 | 17.7 | 218 | 17.8 |
| 50–59 | 186 | 14.8 | 180 | 14.6 |
| 60–69 | 120 | 9.6 | 118 | 9.6 |
| 70+ | 80 | 6.4 | 76 | 6.1 |
| Location of residence | | | | |
| Zone A | 358 | 28.6 | 350 | 28.5 |
| Zone B | 226 | 18.0 | 220 | 17.9 |
| Zone C | 84 | 6.7 | 80 | 6.5 |
| Zone D | 168 | 13.3 | 166 | 13.4 |
| Zone E | 168 | 13.3 | 164 | 13.3 |
| Zone F | 252 | 20.1 | 250 | 20.3 |
| Water source | | | | |
| Municipal supply | 1,030 | 82 | 1,028 | 83.5 |
| Bore well water | 100 | 8 | 75 | 6.1 |
| Bottled water | 126 | 10 | 127 | 10.4 |
| Total | 1,256 | 100 | 1,230 | 100 |

RESULTS AND DISCUSSION

Characteristics of participants

The demographic characteristics of participants are shown in Table 1. Participants were segregated according to their gender, age groups and place of living. A total of 1,256 persons from 300 families participated in the summer survey and 1,230 persons from 294 families participated in the winter survey. For all age groups, half of the participants were men and the remaining half were women.

In both surveys, about 19% of the participants were less than 20 years of age, 65% were 20–59 years old, and 16% of them were 60+ years old.

The residence of surveyed populations was segmented into six zones. Zone A represents 28.5% of participants for both surveys. The subsequent zones represent 18, 6.6, 13.4, 13.3 and 20.2%, respectively. In the summer survey 82% of participants depend on the municipal tap water supply and this increased by 1.5% during the winter survey. In the summer survey about 8% of participants depend on bore well water for drinking purposes and this decreased by 2% during the winter survey.

Consumption of drinking water

The cold water consumption rate is influenced by various factors including age, gender, and seasonal variables. The water consumption rates of eight age groups are presented in Tables 2 and 3. Out of 1,256 respondents in the summer survey 66.4% people answered that they drink cold water directly without boiling. In the winter survey,

Table 2 | Daily consumption of water among gender groups in Mysore City, South India

| Type of water consumption (L/day/person) | Summer survey (n = 1,256) | | Winter survey (n = 1,230) | |
|--|---------------------------|------------------|---------------------------|------------------|
| | Male (n = 632) | Female (n = 624) | Male (n = 618) | Female (n = 612) |
| Municipal tap water | 1.20 ± 0.5 | 1.05 ± 0.6 | 0.96 ± 0.5 | 0.88 ± 0.4 |
| Bore well | 0.80 ± 0.4 | 0.75 ± 0.4 | 0.77 ± 0.4 | 0.62 ± 0.3 |
| Bottled water | 1.50 ± 0.6 | 1.30 ± 0.3 | 1.00 ± 0.5 | 1.00 ± 0.4 |
| Average | 1.16 ± 0.4 | 1.03 ± 0.3 | 0.96 ± 0.2 | 0.88 ± 0.2 |

Table 3 | Average cold water intake (L/day) of the surveyed participants of Mysore city during summer

| Type of water | Age groups (years) | | | | | | | | Total (n = 834) |
|---------------------|--------------------|----------------|-----------------|-----------------|-----------------|-----------------|----------------|--------------|-----------------|
| | 0-9 (n = 22) | 10-19 (n = 54) | 20-29 (n = 186) | 30-39 (n = 166) | 40-49 (n = 142) | 50-59 (n = 122) | 60-69 (n = 86) | 70+ (n = 56) | |
| Municipal tap water | 0.65 ± 0.5 | 0.78 ± 0.4 | 1.7 ± 0.6 | 1.35 ± 0.5 | 1.8 ± 0.5 | 1.1 ± 0.4 | 0.86 ± 0.3 | 0.76 ± 0.4 | 1.125 ± 0.4 |
| Bottled water | 0.5 ± 0.4 | 0.6 ± 0.4 | 2.0 ± 0.5 | 1.5 ± 0.4 | 2.0 ± 0.5 | 1.5 ± 0.5 | 1.0 ± 0.5 | 0.5 ± 0.5 | 1.2 ± 0.6 |

out of 1,230 respondents 56.4% of people answered that they drink cold water during the winter period (Figure 1).

The total cold water consumption rate was greatest among the 20-29 and 40-49 age group and the consumption rate decreased in the 60+ age group. Similar trends of results were also reported by Ershow & Cantor (1989) and Kyunghee et al. (2010). In the studies carried out in western countries and colder regions, the authors reported that those aged 60+ years had a tendency to consume more water (USDA 1995; Westrell et al. 2006). This study noted that there was no clear trend associated with age in the consumption of cold water; however there was a tendency of decreasing water consumption in the 60+ age group.

The water consumption rates among gender groups are summarized in Table 2. The water consumption rates for

males are greater than for females. This observation is comparable to EPA (2000), Levallois et al. (1998), Kyunghee et al. (2010) and Hossain et al. (2013). However, Gofiti-Larocche et al. (2001) and Beaudeau et al. (2003) found that there was no significant difference between sexes. Our study clearly indicates that males consumed more water than females. This may be due to physical activity and body weight. The average body weight and height for Indian men is 64.0-68.5 kg and 1.700 m, respectively, and 60.8-65.3 kg for women) (as compiled by the LIC of India and accepted as the standard weight chart for all of India).

The seasonal variations of water consumption rates are summarized in Tables 3 and 4. In summer, people tended to drink more water compared to the winter season. The average cold water consumption rate during summer was 1.12 L/day per person and in the winter season was 0.92 L/day per person. The seasons greatly affected the consumption of water. Our observation clearly shows that in the summer season people drink more cold water. Similar trends of observations were also reported by Gofiti-Larocche et al. (2001), Xu et al. (2008) and Kyunghee et al. (2010).

The water intake rate is influenced by many factors. In recent years many studies have been carried out to determine the potential impacts of health through drinking water consumption habits. The mode of consumption of tap water (without boiling) varies between countries

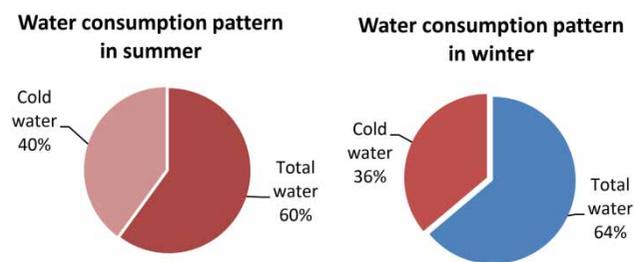


Figure 1 | Cold water consumption in summer and winter seasons.

Table 4 | Average cold water intake (L/day) of the surveyed participants of Mysore city during winter^a

| Type of water | Age groups (years) | | | | | | | | Total (n = 694) |
|---------------------|--------------------|----------------|-----------------|-----------------|-----------------|-----------------|----------------|--------------|-----------------|
| | 0-9 (n = 18) | 10-19 (n = 46) | 20-29 (n = 162) | 30-39 (n = 136) | 40-49 (n = 114) | 50-59 (n = 108) | 60-69 (n = 62) | 70+ (n = 48) | |
| Municipal tap water | 0.6 ± 0.4 | 0.7 ± 0.3 | 1.4 ± 0.4 | 1.06 ± 0.4 | 1.16 ± 0.4 | 1.02 ± 0.3 | 0.78 ± 0.4 | 0.70 ± 0.3 | 0.92 ± 0.3 |
| Bottled water | 0.5 ± 0.3 | 0.60 ± 0.4 | 1.5 ± 0.5 | 1.3 ± 0.6 | 1.6 ± 0.4 | 1.0 ± 0.4 | 1.0 ± 0.5 | 0.5 ± 0.3 | 1.00 ± 0.4 |

^aMunicipal tap water and bottled water were included.

(Table 5). Therefore our study intended to focus on the seasonal patterns of drinking water consumption.

CONCLUSIONS

The present survey study is believed to be the first attempt to quantify the intake of cold water consumption in Mysore city,

Karnataka, South India. The intake rate of cold water in Mysore was 66.4% during summer and 56.4% during winter. This proportion was higher when compared to other regions of the world. This may be due to lack of awareness about possible microbial contaminants in cold water. The limitation of our study was that it was performed over only a one-year period. To determine the water intake rate, the contributing factors are most important for any risk

Table 5 | Cold tap water intakes reported from other countries (L/day/person)

| Country and study population | Cold tap water | References |
|---|--------------------|---|
| England and Wales | 0.19 | Westrell <i>et al.</i> (2006) |
| United Kingdom, <i>n</i> = 416 | 0.70 | Hunter <i>et al.</i> (2004); Mons <i>et al.</i> (2007) |
| United Kingdom, <i>n</i> = 421 | 1.18 | Hunter <i>et al.</i> (2004); Mons <i>et al.</i> (2007) |
| United Kingdom, <i>n</i> = 143 ^a | 0.81 | Kaur <i>et al.</i> (2004) |
| Canada, <i>n</i> = 125 | 0.386 | Levallois <i>et al.</i> (1998) |
| USA, <i>n</i> = 33 ^b | 0.47 | Shimokura <i>et al.</i> (1998) |
| USA, <i>n</i> = 15,303 | 0.506 ^c | USEPA (2000) |
| USA, <i>n</i> = 70 ^a | 0.81 | USEPA (2000) |
| Newzeland, <i>n</i> = 6,250 | 0.17 | Mons <i>et al.</i> (2007) |
| Netherlands | 0.153 ^d | Westrell <i>et al.</i> (2006) |
| Australia, <i>n</i> = 253 | 0.99 | Robertson <i>et al.</i> (2000a, 2000b); Mons <i>et al.</i> (2007) |
| Australia (Melb) ^e <i>n</i> = 950 | 0.84 | Robertson <i>et al.</i> (2000a, 2000b, 2002); Mons <i>et al.</i> (2007) |
| Australia, (Adel) ^e <i>n</i> = 644 | 0.71 | Robertson <i>et al.</i> (2000a, 2000b, 2002); Mons <i>et al.</i> (2007) |
| France (winter) | 0.77 | Gofti-Laroche <i>et al.</i> (2001) |
| France (spring) | 0.90 | Gofti-Laroche <i>et al.</i> (2001) |
| France, <i>n</i> = 1809 | 0.27 | Beaudeau <i>et al.</i> (2003) |
| Sweden, <i>n</i> = 35 | 1.44 | Mons <i>et al.</i> (2007) |
| Sweden, <i>n</i> = 40 | 1.55 | Mons <i>et al.</i> (2007) |
| Sweden, <i>n</i> = 157 | 0.86 | Westrell <i>et al.</i> (2006) |
| Denmark, <i>n</i> = 195 | 0.5 | Dangendorf (2003); Mons <i>et al.</i> (2007) |
| China | 1.75 | Xu <i>et al.</i> (2008); An <i>et al.</i> (2011) |
| China | 2.72 | Duan <i>et al.</i> (2010); Shumin <i>et al.</i> (2012) |
| Korea (spring) <i>n</i> = 1,092 | 1.01 | Kyunghee <i>et al.</i> (2010) |
| Korea (summer) <i>n</i> = 1,148 | 1.21 | Kyunghee <i>et al.</i> (2010) |
| India, West Bengal | 3.12 ^f | Hossain <i>et al.</i> (2013) |
| India, Karnataka, Mysore city (winter) | 0.92 ^c | Present study |
| India, Karnataka, Mysore city (summer) | 1.12 ^c | Present study |

^aStudies carried out in pregnant women.

^bStudies carried out in male adult population.

^cWater supplied from the municipal water supply.

^dMedian cold water consumption.

^eStudy carried out in one city.

^fMean direct water intake.

assessment studies. Much of the water intake data are available from developed countries rather than developing countries. The current study of drinking water consumption pattern will be useful for further research on QMRA and calculate the burden of risk associated with the consumption of cold drinking water. Furthermore, this study also revealed the consumption of bottled water intake in Mysore, South India.

ACKNOWLEDGEMENTS

The authors are grateful to the volunteers in this study and also wish to thank the Authorities of Vani Vilas Water Works, Mysore, Govt. of Karnataka for their support in carrying out this study. We acknowledge the Indian Council of Medical Research (ICMR) (Project: 2012-14060) for financial support provided to the first author.

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First received 17 May 2016; accepted in revised form 7 October 2016. Available online 16 November 2016