The construct validity of a novel method for quantifying water consumption in slum settlements in Mumbai, India

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Background

• Use of an inadequate quantity of water is associated with poor health outcomes, due to deterioration in hygiene of the hands, body, clothes, and eating utensils, which promotes diarrheal, parasitic, and skin diseases.

• Quantifying water consumption in urban slums is difficult, as water meters are often absent and hundreds of people may use a single tap.

• We have developed a novel method for quantifying water consumption using an inventory of water storage containers, estimation of each container's volume, and a count of how many times each container was filled in the last week (*"the container enumeration method"*).

Study Aim

• To assess the container enumeration method's *construct validity* as applied for measuring water consumption in Kaula Bandar (KB), a slum settlement of 12,000 people

• "Construct validity" is an assessment of the extent to which a test measures a given construct, based on pre-specified observation-based hypotheses about that construct

• In KB, most people have water delivered to their homes on an intermittent basis by informal water vendors ("hose water recipients") and a smaller proportion of people fetch water from taps outside of the slum ("water fetchers").

Figure 1: (A) Hose water recipients, (B) Water fetchers

Methods

Hypothesis Generation

• We performed 40 qualitative individual interviews and 6 focus group discussions with KB residents in mid-2011, to understand causes of use of inadequate water quantity

Table 1: Representative quotations that facilitated hypothesis generation

Cost
"If you pay money then you get water . . . It all depends on how many containers you want . . . Buying water every day is too expensive for us. I don't get water every day in order to save money. I fill water every third or fourth day and manage with that amount." - *35 year old Muslim woman from Uttar Pradesh*
Frequency of water access
"We never receive water every day. Sometimes we only receive water after five or six days of waiting. So you need to adjust your life to that small amount of water." - *45 year old Muslim man from Maharashtra*
Mode of access
"We never get water daily; it comes through the hoses once or twice a week, but at those times everyone is shouting and fighting each other to get the hose, so we never get to fill all our containers. Sometimes we only get water after fifteen days." - *30 year old Muslim woman from Uttar Pradesh (a hose water recipient)* "We spend three or four hours of the day just fetching that water . . . We only get water regularly because we go every day to fetch water from the taps just outside of Kaula Bandar. Otherwise we would not get water regularly." - *42 year old Muslim man from Uttar Pradesh (a water fetcher)*
Number of people in the household
"Since there are so many people in this house, we have to buy six drums of water at a time. And this only lasts us two or three days." - *48 year old Hindu woman from Tamil Nadu*

Based on the qualitative data, we hypothesized that severe water poverty (using ≤20 liters per capita per day, or LPCD) is a positive function of: (a) water costs, (b) being a hose water recipient, (c) number of people in a household, (d) the infrequency of securing water, and (e) renting (as opposed to owning) one's home.

Hypothesis Testing

• In 2012, we surveyed 521 randomly sampled households

• Quantity of water used in the last week was measured using the container enumeration method

• We performed a multivariable logistic regression analysis to identify predictors of severe water poverty (use of ≤20 LPCD of water)

Results

Descriptive statistics for KB

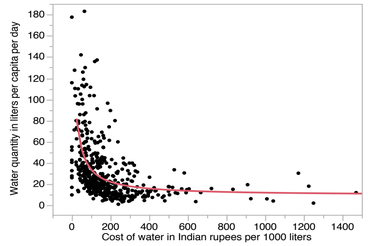
• Median (IQR) water quantity used: 23.4 (13.9-38.6) LPCD
• Use of ≤20 LPCD of water: 42% of households
• Use of ≤50 LPCD of water: 84% of households
• Median cost of water: Rupees 135.1 ($2.20) per 1000 liters of water
• Water spending as a percentage of household income: 9.5%

Predictors of water poverty (use of ≤20 LPCD)

Risk factor	Multivariable regression model findings *Odds Ratio (CI)*
Number of people in household	
<=3	--
4-5	4.35 (1.98-9.57)*
>=6	15.70 (5.88-41.95)*
Home ownership status	
Owns his/her living space	--
Rents his/her living space	2.10 (1.10-3.83)*
Cost of water in rupees per 1000 liters of water	
INR <100 per 1000 liters	--
INR 100-199 per 1000 liters	7.93 (3.75-16.77)*
INR 200+ per 1000 liters	57.42 (23.22-141.96)**
Method of obtaining water	
Water delivered	--
Carries containers a distance to fetch water	0.24 (0.12-0.45)**
Number of times in a week water was obtained	
1 time	--
2-3 times	0.17 (0.09-0.33)*
4 or more times	0.04 (0.01-0.12)**

Note: Household income and demographic variables included in the model but not shown

Relationship between water price and quantity



TAKE HOME POINTS

Water Poverty in Slums

• *Cost of water* is the strongest predictor of the quantity of water used by slum households

• *Reliability* of the water supply (i.e., number of time water was obtained in the last week) and *mode of access* are also strong predictors of use of ≤20 LPCD of water

The "Container Enumeration Method" for measuring water use

• Findings from the quantitative analysis of data gathered using the container enumeration method are *concordant* with the hypotheses generated from the qualitative data

• This concordance suggests that the container enumeration method has a reasonable level of *construct validity*, such that it may have utility for identifying sub-populations in slums that are relatively vulnerable to water poverty

• Future research should assess the *precision* and *reliability* of this method, which involves one-week recall of water use, to a "gold standard" of daily assessment of water use

• This method may be useful for *monitoring and evaluation* of water service delivery in settings where water supply is intermittent, requiring storage of most water prior to use.

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