One step toward rethinking alternative MDG water accessibility indicator and its health issues

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Abstract

Water access is a challenge for poverty reduction in developing countries. According to the estimates, 783 million people at the global level do not have access to clean water. Sub-Saharan Africa has some of the worst deficits. Meeting the Millennium Development Goal (MDG) drinking water target would improve health and well-being. The proportion of people without sustainable access to *improved water* is used as a measurement indicator for the monitoring of achieved progress toward the water MDGs. However, this statistic is incomplete because it does not take into account all the aspects regarding accessibility and also the criteria on which it was defined are so ambiguous.

As far as this paper is concerned, we aim to complement and attempt to overcome the shortcomings of the MDG indicator by computing a multidimensional measurement based on an objective weighting scheme and including sanitary issue, quality and distance through an explanatory analysis and a general covariance structure model or Structural Equation Modeling (SEM). This latter includes a Confirmatory Factor Analysis (CFA). We tested how well the classes of *water accessibility* were characterized by the factors from the CFA and also assessed empirically the linkage between water accessibility and health. This investigation on the multi-dimensional nature of access to water provides a response to the partial nature of the MDG indicator.

We find that the indicator used in the MDG framework overestimates water access when using Demographic and Health Survey in Senegal for illustration. The results of the general covariance structure model also establish a significant relationship between the latent variable of water accessibility and latent household health status. The availability of water would be one of the prerequisites for achieving the MDGs related to health. Our analysis provides a method that would allow policy makers to get an efficient estimate the access rate and to effectively identify households at the margin. Health issues related to drinking water access indicate that existing interrelations between MDG targets (the link between MDG goal 7 that includes target 10 on water access and MDGs sanitation related targets 4,5 and 6) should be considered for optimal resource allocations. Hence, this framework can be a valuable contribution to the monitoring of drinking water access after 2015 with the post-2015 Development Agenda by providing a more appropriate measure of the global efforts toward the achievement of the water MDGs for efficient and targeted public interventions.

Keywords: water, accessibility, multidimensional, health

1. Introduction

Under the Millennium Development Goals (MDGs), the international community pledged to halve the proportion of people without access to water by 2015. This faces the existence of a global water crisis affecting people's abilities to meet their most basic needs. Water is crucial for health and welfare of human beings. Indeed, most human and economic activities use it. However, it appears that many people still have no access to drinking water to this day. The World Health Organization (WHO) defines the drinking water as water that does not contain pathogens or chemical agents at concentrations that may affect health.

To enable monitoring of the evolution of progress and improve decision making an indicator of access to safe drinking water, that represents the share of the population that has access to an "improved” water source, is used in the MDGs. The category “improved” drinking water source includes the following structures: household connection to a water supply network (in house, plot or yard), public tap or standpipe, tube well or borehole, protected well, protected spring, rainwater collection). According to this measure, 13% of the world population representing 884 million people, lacked access to safe drinking water in 2008. While it is estimated that the entire population of the developed countries have access to safe drinking water, only 84% benefit in developing countries, with an access rate of 60% in sub-Saharan Africa (WHO and UNICEF , 2010). An implicit technical assumption is done and assumes that access to an "improved" source of water is likely to provide a minimum amount of 20 liters per person per day, to be located at a distance of less than 1000 meters from the residence and not be a large share of household income (WHO and UNICEF, 2000).

This statistic of water access (the share of the population that has access to an "improved” water source) has a partial nature and based on fuzzy criteria; as the definition of this access is not clearly established. The MDG indicator should be taken as a statistical artifact rather than an access to water measurement (Dos Santos, 2009). The shortcomings of this indicator raise the need to build a more complete statistical measure, taking into account all manners deemed as relevant as the type of supply to evaluate the accessibility of water and thereby best meet the socio-sanitary challenges. The present study reveals a methodological break of water access measurement and shed new light on the linkage between household health and the appropriate measure of water accessibility. The analyses are conducted using the Senegalese Demographic and Health Survey (DHS), which includes a module for access to drinking water. The advantage of this adopted approach is to try to provide an alternative indicator and overcome the reliance on the statistics used in the MDG framework as the only tool measuring access to drinking water. Therefore, the two major objectives of this paper are to develop a composite accessibility measure summarizing the multidimensional issues involved in access to drinking water and to raise concerns about its implications for health.

The study will first try to show the scope of the reformulation of the water access indicator used in the context of the Millennium Development Goals by showing its limits. The need to integrate other relevant aspects to assess the level of access to safe drinking water will be exposed. Then, access will be measured using a multiple correspondence analysis and a confirmatory factor analysis. It will be considered as a latent variable measured with observable indicators also called manifest variables. The last part of the study will focus on the health issues of access to water by the implementation of a structural covariance model or Structural Equation Modeling (SEM) that considers the linkage between the accessibility and the household health status, considered as a latent variable. Throughout the document, attempts to shed light on conceptual issues will be made: What are the dimensions reflecting accessibility to drinking water? Which methods are used to synthesize the accessibility of individuals to water? How accessibility influence the stock of household health?

2. Conceptual framework

2.1. Measuring water Accessibility

For determining a threshold accessibility and upstream of SEM estimation, a hierarchical cluster analysis is performed. Meanwhile, an indicator based on the approach of inertia with Multiple Correspondence Analysis (MCA) will also be built. We will test the consistency between accessibility classes and factors from the confirmatory factor analysis estimated in the SEM. The hierarchical cluster analysis (Ward criterion) is used to determine the weight of different classes in the threshold[1] calculation S_{IA}.

[1] S IA = (Maximum of IA in the non-accessibility cluster) * weight of the non-accessibility + (Minimum of IA in the accessibility class)*weight of the accessibility class.

Classification methods are statistical techniques determining a definition and a simplistic division of the "reality" studied on a set of individuals.

The access to drinking water is a concept to be measured as a latent variable that cannot be directly observed. Observable variables will be used for that. In consideration of a possible measurement error, a confirmatory factor analysis is performed to estimate the relationship between a set of observable measures D, including variables such as water collection time or quality, and the latent variable of accessibility (A). This relationship is described as follows:

$$D = \vartheta A + \varepsilon \qquad (ib)$$

Observed variables (D) are linked to the latent variable A through the matrix parameter ϑ as specified by equation *(ib)* and ε is a random term. This equation *(ib)* is a component of general covariance structure model or SEM presented below. The matrix of parameters (loadings) ϑ determines the relationship between the latent variable A and the observable measures. The availability of drinking water will be an aggregate of indicators that highlights the different dimensions of safe drinking water access.

2.2. Health Issue of access to drinking water

The relationship between accessibility and health is estimated to evaluate health issues of access to drinking water. Households with less accessibility (within the meaning of accessibility indicators presented above) have a priori a lower stock of health.

Following Baldacci et al. (2003), household health production function was estimated by considering the stock of health as latent and using a general covariance structure model or SEM:

$$H = \varphi X + \beta A + \zeta \qquad (ia)$$

$$D = \vartheta A + \varepsilon \qquad (ib)$$

$$I = \alpha H + \mu \qquad (ic)$$

Where φ represents the parameters linking the household latent health variable (H) to the exogenous variables (X), including demographical household characteristics, ζ a random term. The observed variables (I) are linked to the latent health variable H through the matrix of parameters α as specified in the equation *(ic)*. The parameter β represents the effect of accessibility A on health$H$. ε and μ are also random terms.

3. Results

The results of the structural covariance model are presented in Table 1 that shows in its upper part the structural equation model e.g. the household health production function, that include drinking water access as an input. Meanwhile, the lower part is presented with the relationships between observable and latent variables. For each of the latent variables a parameter has been set to one (1) in order to calibrate and set the corresponding variable to equal the variable with the parameter of one in the absence of measurement errors. In addition to water access, we include in the equation other factors such as education, the environment and the characteristics of the household, which may have an impact on household health stock.

The results show that almost all observable variables are significantly related to the latent ones, hence the relevance of using several indicators rather than a single indicator to measure both water accessibility and household health status. Additionally, the use of mosquito nets and the knowledge of means of prevention (information collected on the importance of sleeping under a mosquito net, the effectiveness of ACT, application of the treatments, diagnosis of malaria etc.) would have positive effects on the health.

Above all, drinking water access has a positive impact on household health stock. Contaminated water would convey pathogens (bacteria, viruses and microorganisms animals or plants) that may trigger diseases (malaria, cholera, typhoid fever etc.).

Table 1: Accessibility and household health stock

General covariance structure model/SEM	
Variables	Health stock (latent)
# of mosquito net	0.047***
	(0.010)
Use of mesh screens and fly screens	-0.00025
	(0.063)
Smoker in the household	-0.003
	(0.010)
Malaria prevention message	0.067*
	(0.038)
Owner/wealth	0.099**
	(0.043)
Sex of head of household	-0.082*
	(0.047)
Age of household head	0.003**
	(0.001)
# Children sleeping under a mosquito net	0.092***
	(0.017)
Externalizing nets	-0.100**
	(0.045)
Education of the head of household	-0.032
	(0.046)
Water access accessibility (latent)	0.073*
	(0.044)
Confirmatory Factor Analysis / Indicator of drinking water access	
Improved water source	1
	(0)
Max – Time access to water source (min)	8.369***
	(1.209)
Water Conservation	0.165***
	(0.011)
Presence of water in washing hand place	0.230***
	(0.014)

Person who fetches water : no child	0.004
	(0.004)
Drinking water treatment method	1.666***
	(0.014)
Washing hand place	0.256***
	(0.015)
Chlorination	2.207***
	(0.013)
Confirmatory Factor Analysis / Indicator of household health stock	
# members without malaria	1
	(0)
# men without anemia	0.630***
	(0.013)
# children without anemia	0.232***
	(0.005)
# women aged 15-59 without anemia	0.541***
	(0.541)
Disease shock in the past 3 years	0.007*
	(0.004)
Table 3: Accessibility and household health stock (continued)	
Children under 5 years old without diarrhea	0.335***
	(0.016)
Children under 5 years old without fever	0.327***
	(0.017)
Variances [i]	
Water accessibility	0.188
	(0.042)
Household health stock	1.48
	(0.004)
Chi²	15429.37
Log Likelihood	-149905.75
N	5266

Note: variances and covariances are available, but only the values for the latent variables are reported. Standard deviations in parentheses * p <0.10, ** p <0.05, *** p <0.01.
Source: Authors

The proportion of individuals with an access to water is estimated at less than 70% with the composite measurement, while it is estimated at about 78% with the indicator used in the MDGs (EDS-MICS Senegal, 2011). Water access as defined with the commonly used MDG indicator overestimates the proportion of the population with access to safe drinking water. The accessibility classes are consistent with the scores[2] from the latent variable accessibility modeled in the SEM.

4. Conclusion

Water access plays a major role in achieving the MDGs and is a real issue of development. Noting that the classical measurement tool of drinking water access (the common MDG indicator) shows weaknesses that are more or less influential on the quantification and the evaluation of effective water access of populations, the study aimed to explore the multi-dimensional nature of access to water by introducing other dimensions to provide a response to the partial nature of the MDG indicator. The analysis also showed evidence the health issue of water access. Our composite measure was based on the combination of aspects related to water. While integrating the supply source component, which was the commonly used indicator to assess water accessibility, the composite measure take into account the remoteness of drinking water sources (collection time) and drinking water treatment methods made to reduce the risks associated with the contamination of the collected water.

Taking into account the multidimensionality of accessibility allows one to see that the MDG indicator overestimates the proportion of population with access to water. The data indicated a significant difference in the access rate between the composite measure and the MDGs water access indicator. Therefore, considering the composite indicator, there are several people that must be removed from those considered as having access to water when only using the simple statistic of water source type. We could then, based on the MDG indicator, conclude that the MDGs will be achieved with a fast convergence without really meeting the health and the social underlying objectives.

Health issues are shown by the positive impact of accessibility on the household health stock. In fact, the results of the general covariance structure model have established a significant relationship between access to water and household health stock. The availability of water would be one of the prerequisites for achieving the MDGs related to health. This analysis provides a method that would allow policy makers to get a better estimate of drinking water access rate and to effectively identify households that are at the margin. Health issues related to drinking water access indicate that existing interrelations between MDG targets (the link between MDG goal 7 that includes target 10 on water access and MDGs sanitation related targets 4,5 and 6) should be considered for optimal resource allocations. Hence, this framework can be a valuable contribution to the monitoring of drinking water access after 2015 with the post-2015 Development Agenda.

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[2] Method of calculation similar to the "regression scoring", where the means of latent variables are conditional on the observed variables