Accounting for recent trends in the prevalence of diarrhea among under-five children in the Democratic Republic of Congo (DRC)

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Introduction

Diarrheal disease is the second leading cause of death among children under five globally. About 22 percent of childhood deaths in developing countries are attributable to diarrhea [1,2,3]. It kills more young children than AIDS, malaria, and measles combined [3].

Diarrheal diseases are associated with poverty and unhygienic environments [3,4,5]. This probably explains the high prevalence of diarrhea among children whose mothers did not attend school and/or among children living in poorest households particularly in sub-Saharan Africa and South Asia [3].

With about 1 percent of the global population, the Democratic Republic of Congo (DRC) has the third highest diarrheal morbidity among under-five children and the 5th highest under-five mortality rate worldwide [3,6]. About 13 percent of child deaths are diarrhea related, approximately 60,450 deaths due to diarrhea in 2010 [7].

However, recent data from national reports show a decrease in childhood diarrhea prevalence from 2001 to 2010. The prevalence of children with diarrhea decreased from 22 percent in 2001 [8] to around 17 percent in 2007 and 2010 [9,10].

Intuitively, the decrease in prevalence of diarrhea could be explained by: (1) public health improvement globally or selectively among some specific households; and/or (2) increase in the proportion of children living in households with access to water, sanitation and hygiene (wealthy household, living in urban areas, whose mothers have secondary education or higher). The question of substantive interest in this context is: how much of the change is actually due to the improvement of public health suggesting the actual decrease in diarrhea prevalence and how much is due to a compositional change in the population distribution, especially by maternal education, access to clean water and sanitation, household wealth index?

Against this background, this study aims to analyze diarrhea prevalence by maternal education, access to clean water and improved sanitation and household wealth index. The study will also identify the sources of variation of diarrhea prevalence in the DRC, and assess the contribution of each factor in the decline of diarrhea prevalence. To our knowledge, this is the first study of its kind in the DRC as only some descriptive survey reports [11, 8, 9, 10], and few systematic studies have analyzed trends and factors that influence the prevalence of diarrhea among young children in the DRC [12].

Data and Methods

Data

This study uses two successive nationally representative household surveys: the 2001 MICS and the 2007 DHS. During the 2001 Multiple Indicators Cluster Survey (MICS) data collection from May 21 to August 28, 2001, 3 provinces were entirely under the control of the government (Kinshasa, Bas-Congo and Bandundu), 4 were partially administrated by rebels (Equateur, Katanga, Kasai-Oriental and Kasai Occidental), and 4 were entirely controlled by rebels (Oriental, Nord Kivu, Sud Kivu and Maniema). Though the 2007 DHS was carried out after the 2006 elections (February 2 to April 30, 2007 for Kinshasa, and from May 10 to August 31, 2007 for the remaining provinces), some villages and municipalities in the Eastern provinces of Nord-Kivu, Sud-Kivu and Oriental were under armed conflict.

The two datasets have comparable information on household characteristics and child diarrhea at the time of the survey. The sample design and questionnaire are described elsewhere [8, 9]. Consequently, the two surveys offer the opportunity of analyzing change in diarrhea prevalence in the DRC. In total the 2001 MICS database includes information about 8,600 households and 9,748 under-five children, whereas the 2007 DHS database had information about 8,886 households and 7,987 children.

For each child under the age of five, the survey respondent in the household was asked whether the child has had diarrhea in the past two weeks prior to the surveys as indicated in the box below and in French language.

Box 1 – Question on diarrhea among under-five children

1. 2001 MICS: [(*Nom de l'enfant*) a-t-il/elle eu la diarrhée au cours des 2 dernières semaines, c'est-à-dire, depuis (*jour de la semaine*) de l'avant dernière semaine ? in French]. *Has (name of the child) had diarrhea in the last two weeks, that is, since (day of the week) of the week before last*
2. 2007 DHS:[(Nom de l'enfant) a eu la diarrhée au cours des deux dernières semaines? In French] "*Has (name of the child) had diarrhea in the past 2 weeks?*"

Therefore, diarrhea is determined not by medical examination but it is self-reported by the mother or caretaker with symptoms of three or more loose or watery stools per day, or blood in stool.

Variables

Exposure to diarrhea-causing agents is frequently related to the use of contaminated water and to unhygienic practices in food preparation and disposal of excreta. Poor sanitation, lack of access to clean water and inadequate personal hygiene are responsible for an estimated 90 percent of childhood diarrhea [3, 4,5,13].

Exposure variables for this study include maternal education, access to clean water and sanitation, and household wealth index. A large body of empirical work has shown association between these variables and the prevalence of diarrhea among under-five children [3,12, 13, 14,15, 16, 17, 18].

We define clean water or drinking water as water of sufficiently high quality that can be consumed or used with low risk of immediate or long-term harm. It is drawn from an improved drinking water source protected from outside contamination, in particular from contamination with fecal matter including piped water (into residence or plot),

public tap, tube well, protected dug wells and protected springs [19,20]. An improved sanitation facility is defined as one that is likely to hygienically separate human excreta from human contact: public sewer, septic tank, pour-flush latrine, pit latrine with slab, ventilated improved pit and ecological sanitation [19,20]. The MICS and DHS surveys collecting these variables use the same definition and categorization [21,22].

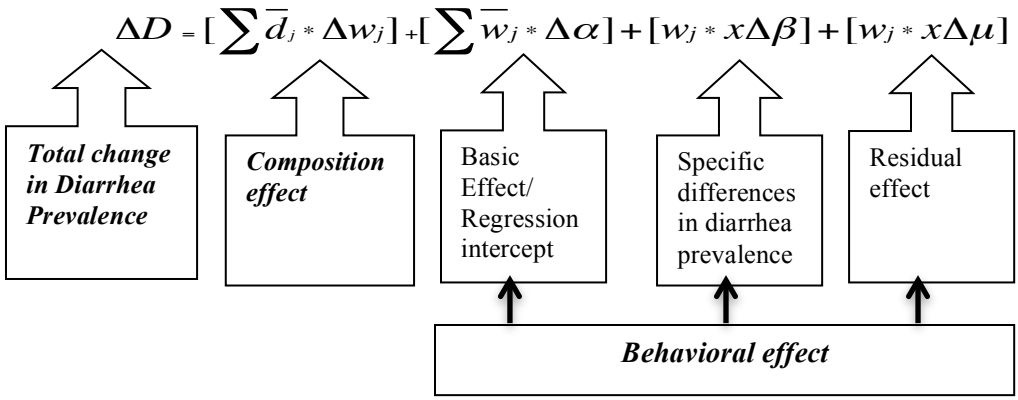
In this study, household wealth index is measured with an asset index and wealth quintile constructed using the statistical Procedure Principal Component Analysis (PCA) developed by Filmer and Pritchett [23]. The index measures economic status based on housing characteristics, household assets and possession of household consumer durables as well as access to clean water and improved sanitation. The 2001 MICS and 2007 DHS have collected these data. Using rank methods, households are classified by quintile of wealth.

Statistical methods

This study uses three complementary methods: trends analysis, decomposition and longitudinal multivariate models (fixed effect regression models). The Stata,"**nptrend**" command performs a non-parametric test of trend for the ranks across ordered groups. The test is an extension of the Wilcoxon rank-sum test [24]. The test provides Z statistics and P-value showing whether the change is statistically significant or not.

The decomposition approach divides the trends in child's diarrhea prevalence into change in population structure and change in health behavior and/or public health over the study period [25,26]. This method assumes that the historical change in child diarrhea prevalence depends on: (1) Trends in distribution of under-five children by access to clean water and improved sanitation facility, household wealth index and maternal education over time (composition effect); (2) actual change in diarrhea prevalence due to change in health behavior or

improvement in public health (the basic effect) that is the regression intercept when x=0 (α); (3) Variation of diarrhea prevalence by exposure variables (β), and the residual effect of other variables not considered as e error term (μ). This change can be presented as follow:



The decomposition analyses are performed at aggregated/ cluster level (the national level by maternal education and household living conditions).

Finally, we use a fixed-effect (FE) regression model to explore the relationship between female education and modern contraceptive use within the country. The equation for the fixed effects model is displayed below:

$$Y_{it} = \beta_1 X_{it} + \alpha_i + \mu i_t$$

Where:

- α_i (i=1...n) is the unknown intercept for each entity (n entity-specific intercepts);
- Y_{it} is the dependent variable (diarrhea prevalence) where i=children and t=time;
- X_{it} represents the independent variable (child' age, province of residence, household living conditions);
- β_1 is the coefficient for the independent variable (maternal education, access to clean water and sanitation, and household wealth index.);
- μ_1 is the error term.

To perform the fixed effect models, we constructed three independent panel datasets (Maternal education, Access to clean water and improved sanitation and household wealth index). Each dataset has multiple observations about each category of the independent

variable considered as individual (number of surveys, 2 in our case). Therefore, the maternal education database contains six observations, while numbers of observations for the access to clean water and improved sanitation and the household wealth index database are respectively estimated at 8 and 10 observations; each database contains the following information proportion of under-five children, year of survey and diarrhea prevalence.

Results

Sample description

Table 1 presents the distribution of under-five children by selected background characteristics in each sample.

Table 1 – Background characteristics of under-five children in DRC (2001 and 2007)

	2001 MICS		2007 DHS	
	Percent	Number	Percent	Number
Child sex				
Male	49.8	4,855	49.5	3,956
Female	50.2	4,893	50.5	4,031
Child age in months				
0-5 months	11.1	1,070	11.5	919
6-11 months	11.3	1,090	10.8	865
12-23 months	22.3	2,162	20.4	1,632
24-35 months	19.2	1,864	19.8	1,582
36-47 months	17.6	1,709	19.0	1,519
48-59 months	18.5	1,792	18.4	1,470
Access to clean water and sanitation				
None	11.8	1,153	13.0	1,039
Water only	6.7	654	1.4	111
Toilet only	41.1	4,008	57.6	4,604
Water and toilet	40.4	3,933	28.0	2,233
Place of residence				
Urban	35.4	3,446	41.1	3,282
Rural	64.6	6,302	58.9	4,705
Province of residence				
Kinshasa	13.9	1,352	10.7	852
Bas-Congo	5.3	515	7.4	590
Bandundu	11.9	1,162	9.2	734
Equateur	11.4	1,107	9.9	789
Orientale	10.0	974	7.1	567
Nord – Kivu	7.3	708	8.7	691
Maniema	6.1	593	9.2	736
Sud-Kivu	2.6	253	8.9	710
Katanga	11.3	1,100	9.6	766
Kasai Oriental	10.9	1,058	10.3	826
Kasai Occidental	9.5	926	9.1	726
Maternal education				
None	27.5	2,680	23.9	1,909
Primary	41.2	4,015	42.2	3,369
Secondary and high	31.3	3,053	33.9	2,709
Household Wealth Index				
Poorest	20.0	1,953	22.0	1,759
Second	19.5	1,903	20.2	1,609
Middle	19.6	1,911	19.5	1,555

Fourth	19.3	1,877	20.9	1,669
Richest	21.6	2,104	17.5	1,395
Total	100.0	9,748	100.0	7,987

Source : 2001DRC- MICS ; 2007 DRC-DHS
Note : Sometime N < Total due to missing values

The database contains information on 9,748 children from the 2001 MICS and 7,987 children from the 2007 DHS. The characteristics of under-five children shown in Table 1, reveal differences in structure across surveys except if one considers child' age and sex. For instance, the proportion of children living in households with access to clean water and to toilets decreased from 40 percent in 2001 to 28 percent in 2007. Moreover, the proportion of under-five children by province of residence varies across surveys. In 2001, the largest proportion of children sample was from Kinshasa (14 percent) and in 2007 a large proportion of children came from Kasai Oriental and Kinshasa.

Trends in diarrhea prevalence in the DRC

Table 2 describes trends in diarrhea prevalence in the DRC from 2001 to 2007.

Table 2 – Prevalence of diarrhea among under-five children in DRC, 2001-2007

	Year		Variation (%)	NPTREND TEST	
Background variables	2001	2007	2001-2007	Z	P-value
	1	2	3		0.000
Maternal education					
None	22.5	15.8	-30.0	-4.24	0.000
Primary	22.9	18.9	-17.4	-5.29	0.000
Secondary &+	20.8	13.9	-33.4	-7.50	0.000
Water and sanitation					
None	25.8	18.2	-29.3	-4.14	0.000
Water alone	23.4	19.5	-16.8	-1.46	0.143
Toilet alone	21.4	16.2	-24.2	-5.96	0.000
Water and toilet	21.6	15.9	-26.7	-6.46	0.000
Household wealth index					
Poorest	20.8	17.0	-18.2	-2.12	0.030
Second	24.9	15.7	-37.0	-6.08	0.000
Middle	23.4	16.2	-30.6	-5.65	0.000
Fourth	23.3	18.3	-21.5	-4.82	0.000
Richest	18.7	14.4	-22.8	-3.99	0.000
Total (DRC)	22.1	16.4	-25.8	-9.74	0.000

Source : 2001DRC- MICS ; 2007 DRC-DHS
Variation (3)=((Prevalence in 2007/ Prevalence in 2001)-(1))*100

There is a decrease in the prevalence of diarrhea. Overall, the prevalence of diarrhea in the DRC declined by 26 percent (Z=-9.7, P-value<0.000) from 22 percent in 2001 to 16 percent in 2007. However, this decrease in diarrhea prevalence is not statistically significant among children who reside in households with water alone without toilet (Z=-1.46, P-value=0.143).

Decomposition of diarrhea prevalence changes in the DRC

We decompose changes in diarrhea prevalence by maternal education, housing living conditions and household wealth index. This may contribute to the understanding on how the observed changes relate to variations in the survey population structure or to changes in public health and/or changes in behavior. Table 3 presents results of the decomposition analysis.

Table 3: Decomposition of trends in diarrhea prevalence in the DRC 2001-2007

	Behavioral effect				Effect of	
	Base	Differentiation	Error	Total	Composition	Contribution
	B1	B2	B3	B	A	C
Maternal education						
None	-1.422	0.000	-0.243	-1.665	-0.764	43.4%
Primary	-2.317	-0.079	0.792	-1.604	0.149	26.0%
Secondary &+	-1.837	-0.125	-0.314	-2.277	0.566	30.6%
Overall	99.7%	3.6%	-4.2%	99.1%	0.9%	100.0
Water and sanitation						
None	-0.732	0.000	-0.349	-1.081	-0.447	27.3%
Water alone	-0.108	0.007	0.087	-0.014	-0.526	9.7%
Toilet alone	-3.201	0.438	-0.580	-3.343	0.945	42.8%
Water and toilet	-1.149	0.236	-0.169	-1.082	-0.050	20.2%
Overall	92.7%	-12.2%	18.0%	98.6%	1.4%	100.0
Household wealth index						
Poorest	-1.425	0.064	0.588	-0.773	0.499	4.9%
Second	-1.340	0.120	-0.605	-1.825	0.226	28.6%
Middle	-1.302	0.176	-0.245	-1.371	-0.038	25.2%
Fourth	-1.337	0.240	0.109	-0.988	0.323	11.9%
Richest	-1.270	0.286	0.185	-0.799	-0.845	29.4%
Overall	119.4%	-15.8%	-0.6%	103.0%	-3%	100.0

Source : 2001DRC- MICS ; 2007 DRC-DHS

In general, decomposition results indicate that changes in actual diarrhea prevalence and/or health behavior are the principal source of decline in diarrhea prevalence between 2001 and 2007 regardless of the exposure variable (Table 3, Column B). The analysis of behavioral

effect (Table 3, columns B1 – B3) suggests that the observed decline in diarrhea prevalence is global (not specific to some socioeconomic characteristics). In other words, the observed changes are due to the general improvement in health behavior in the DRC. The differentiation effect, the error terms and the composition effect are negligible.

Table 3 (column C) shows also the contribution of each socioeconomic category in the overall decrease of diarrhea prevalence in the DRC between 2001 and 2007. Depending on the independent variable, decline in diarrhea prevalence in the following groups have contributed more to the observed changes: Children whose mothers did not attend school (43 percent), among children who live in household with toilet but without access to clean water (43 percent) and among children living in the richest households (29 percent) and children living in the poorer households (29 percent) have contributed more to the diarrhea decrease in the DRC between 2001 and 2007. By contrast, small contributions to the overall changes in diarrhea prevalence are observed from children living in household with "water alone without toilet" (10 percent) and from children who stay in poorest households (5 percent).

Fixed effects of trends in proportion of child's age, province of residence and household's living condition on trends in prevalence of diarrhea in DRC

Table 4 displays results from fixed effects models. Overall there are no significant changes in diarrhea prevalence associated with a variation of the population structure by maternal education, household access to clean water and sanitation as well as by household wealth index.

Table 4– Fixed effect of changes in proportion of children by selected characteristics on changes in diarrhea prevalence in DRC

	β	Constant	Sigma_u	Sigma_e	rho
Change in proportion of children per maternal education	-0.1052	15.626	1.478	5.203	0.070
Change in proportion of children per living condition (access to clean water and sanitation)	-0.008	20.446	1.573	4.699	0.101
Change in proportion of children per household wealth index	-0.1546	22.363	1.691	4.922	0.106

Source : 2001DRC- MICS ; 2007 DRC-DHS
Note : *** p<0.01 ; ** p<0.05 ; * p<0.1

However differences across years explain 7 percent of the variance in the distribution by maternal education, and about 10 percent if one considers under-five children's distribution by access to water and toilet and household wealth index respectively.

Discussion and Conclusion

This study had threefold objective. The first was to describe diarrhea prevalence trends in the DRC, the second was to identify sources of observed changes in diarrhea prevalence, and the last was to assess the contribution of different categories to the observed changes. Exposure variables included maternal education, access to clean water and improved sanitation, and household wealth index. The study used data from the DRC 2001 MICS and 2007 DHS surveys.

Findings from the three complementary statistical methods (trend analysis, decomposition analysis and Fixed Effect regression models) are consistent. The significant decrease in diarrhea prevalence observed in the DRC between 2001 and 2007 is regardless of socioeconomic characteristic and the results from trend analysis corroborate the absence of a composition effect revealed by the decomposition as well as no significant changes in diarrhea prevalence associated with variation of the population structure (results from the

Fixed Effect regression models). Likewise, these results support the decrease in under-five mortality observed in the country since 2001: 213 per thousand live births in 2001 [8] and 158 per thousand live births in 2010 [10].

Furthermore, children of mothers who never attended school, those living in households with toilet alone (without water), and children living in the poorer (second quintile) households as well as those living in the richest households have contributed more than other children to the observed decline in diarrhea prevalence.

However, the decrease in diarrhoea prevalence in the DRC as well as the decline in child mortality contrast with the generalized humanitarian crisis, deterioration in environmental conditions and population poverty observed in the country in the same study period. The country is among the lowest-ranked nations in the 2011 Global Peace Index (148th of 153 countries) [27]. Since 1996, the DRC has been hit by conflict, which has devastated and destabilized the country. People continue to live in crisis conditions in many parts of the country. The eastern provinces (Orientale, Katanga, Maniema, Nord Kivu and Sud Kivu) are afflicted by violence.

Moreover, the DRC's 2010 Human Development Index (HDI) is estimated at 0.239, which gives the country a rank of 168 out of 169 countries with comparable data despite numerous natural resources [28]. Overall, the majority of people do not have access to clean drinking water (54 percent) and improved sanitation (77 percent) [13]. With reference to data used in this study, the proportion of children living in households with access to clean water and improved sanitation diminished from 40 percent in 2001 to 28 percent in 2007.

Two hypotheses could explain the observed discrepancies between the living conditions and changes in diarrhea prevalence in the DRC. Firstly, there may be some real improvement in

health behavior, particularly the use of boiled drinking water and the adequate washing of hands after contact with adult and child stools. However, we cannot test such hypothesis because of lack of data.

Secondly, there may be some issues with data quality. In conflict situations, it might be very difficult to collect reliable data. For instance, during the 2001 MICS, in the Eastern part, often interviewers had to stop their work and resume after several days. Rebels arrested a fieldworker for more than six weeks (MICS2) [8]. Furthermore, diarrhea prevalence is based on self-reporting. Mothers or caregivers can mis-declare diarrhoea prevalence according to her understanding of diarrhea definition in the local language. Also, duration of data collection varies considerably by province (1 month in Kinshasa and about 2 months in Nord-Kivu and Katanga for the 2001 MICS). In addition, the distribution of children by some socioeconomic characteristics varies across survey. This is probably due to the use of an old national sampling frame from the 1984 Census. However, the methods used (decomposition and fixed effect regression models) control for variation in proportion during analyses.

In conclusion, childhood diarrhea remains a public health problem in the DRC despite the observed decline. It is noteworthy that the overall significant decrease in diarrhea prevalence in the DRC contrasts with the poorest living condition observed in the same period. Our study suggests further studies at the district or province levels to validate findings from national household surveys such as DHS and MICS considering the conflict context of the country when these data were collected and the continuing degradation of the country's socioeconomic and transport infrastructure and security. We hope that the next census in preparation will provide a more comprehensive sampling frame. However, improvement in access to clean water and improved sanitation will contribute to accelerate reduction of diarrhea prevalence as well as reduction of child mortality.

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