Disparities in Under-Five Mortality Estimates from Demographic Surveillance and Retrospective Birth Histories

Extended Abstract

Background

Infant and child mortality measurements are central indictors of population health. Measuring infant and child mortality would be straightforward if all countries had complete civil registration and vital statistics systems, however, such is not the case (You et al. 2015). In the region with the highest infant and child mortality rates in the world, sub-Saharan Africa, civil registration is either incomplete or non-existent. Demographic and Health Surveys (DHS) and Health and Demographic Surveillance Systems (HDSS) serve as valuable data sources for much of sub-Saharan Africa.

This research investigates how measurements of infant (1q0) and child (4q1) mortality in HDSS differ from those produced by DHS. The differences between these measurements are tested for associations with contextual and fieldwork attributes which are suspected to affect HDSS or DHS estimates.

DHS are nationally representative cross-sectional cluster surveys containing a birth history questionnaire for women of reproductive age. HDSS cover geographically-defined areas and collect individual-level data on a longitudinal basis; usually through periodic interviews with a household representative. While DHS and HDSS have many methodological differences, they both serve as rich data sources in regions that often lack other high-quality data. Understanding the systematic differences between HDSS and DHS mortality estimates could expand the utility of both data sources and contribute to a better understanding of under-five mortality patterns in sub-Saharan Africa.

The discrepancies in under-five mortality as measured by HDSS and DHS have not been systematically studied. Mortality trends are generally consistent across sources (Byass et al. 2007; Hammer et al. 2004), but HDSS estimates of under-five mortality are usually lower than those of the DHS (Deribew et al. 2016). However, it remains unclear whether the discrepancy can be attributed to methodological differences in data collection and mortality rate estimation, differing areas of geographic coverage, or other factors.

Data

Data from HDSS were obtained from the International Network for the Demographic Evaluation of Populations and their Health (INDEPTH Network) data repository (http://www.indepth-ishare.org). HDSS were selected for inclusion in the study if they were located in sub-Saharan Africa and had an available core dataset for any of the years between 1990 and 2018 as of August 2018. It was also necessary that the HDSS data overlapped with a ten-year period preceding a Demographic and Health Survey of the same country. Demographic and Health Survey data was obtained from the DHS data repository. Data from DHS surveys was included in the study if it pertained to the same country as a selected HDSS and contained retrospective data for the same years as that HDSS.

Table 1: Data included in analysis

Country	HDSS	HDSS data collection dates	DHS region	DHS data collection dates
Burkina Faso	Nanoro	2009 - 2014	Centre-Ouest	2010
	Ougadougou	2009 - 2015	Centre	
Côte d'Ivoire	Taabo	2009 - 2015	Sud sans Abidjan	2012
Ethiopia	Arba Minch	2010 - 2015	SNNPR	2011, 2016
	Dabat	2009 - 2015	Amhara	
	Gilgel Gibe	2006 - 2015	SNNPR	
	Kersa	2008 - 2015	Oromiya	
	Kilite Awlaelo	2010 - 2014	Tigray	
Gambia	Farafenni	1990 - 2015	Kerewan	2013
Ghana	Dodowa	2006 - 2011	Greater Accra	1993, 1998, 2003, 2008, 2014
	Kintampo	2006 - 2014	Brong Ahafo	
	Navrongo	1993 - 2014	Upper East	
Kenya	Kombewa	2011 - 2015	Nyanza	2003, 2008, 2014
	Mbita	2009 - 2015	Nyanza	
	Nairobi	2003 - 2015	Nairobi	
Malawi	Karonga	2003 - 2015	Northern	2004, 2010, 2015
Mozambique	Chokwe	2010 - 2015	Gaza	2011
Senegal	Bandafassi	1990 - 2015	Tambacounda	2005, 2010, 2012, 2014, 2015
	Mlomp	1990 - 2015	Ziguinchor	
	Niakhar	1990 - 2015	Fatick	
South Africa	Agincourt	1993 - 2015	Mpumalanga	1998
	Dikgale	1996 -2015	Northern Province	
Tanzania	Ifakara	1997 - 2014	Morogoro	1996, 1999, 2004, 2010, 2015
	Magu	1994 - 2012	Mwanza	
	Rufiji	1999 - 2014	Pwani	

Methods

Calculation of nqx followed the methods proposed in the R demogsurv package (Eaton 2018). For both the HDSS and DHS data, a standard demographic rate calculation based on observed deaths and person-years within each age group for the given year was used to calculate the cumulative hazard for mortality between the ages 0 to 1, and 1 to 5. This was converted to a survival probability, with standard errors estimated with Taylor linearization. The DHS survival probability was logit-transformed and smoothed with locally weighted scatterplot smoothing using weighted least squares. The smoothing weights were proportional to the inverse of the variance.

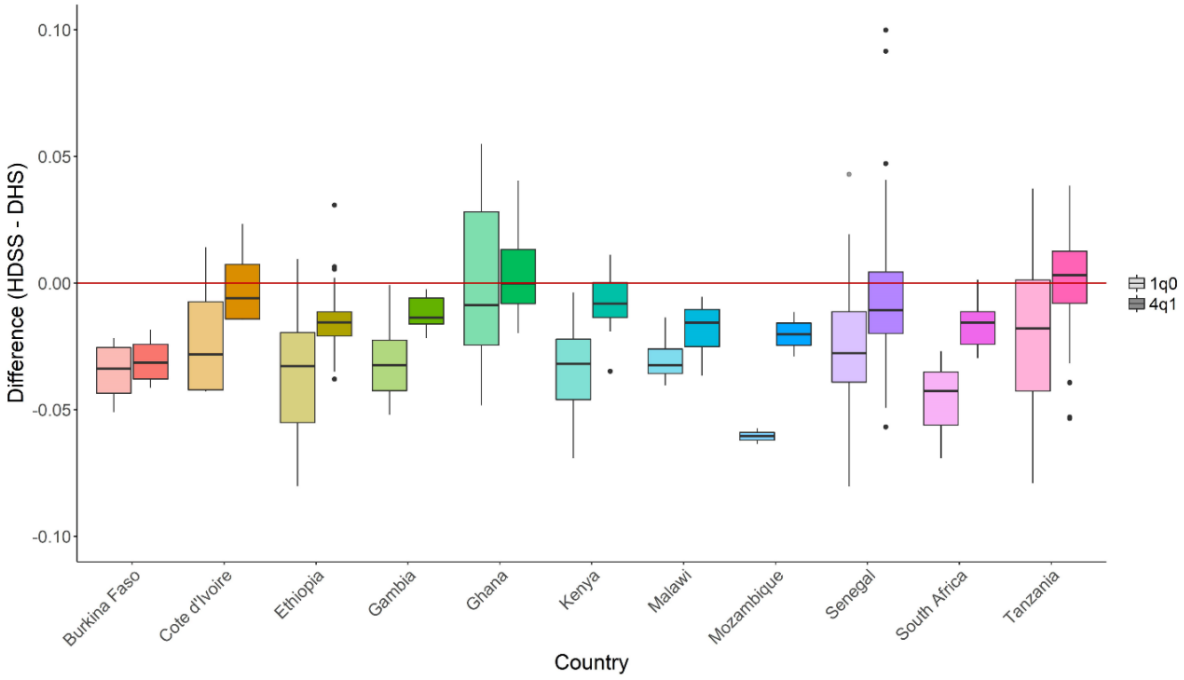
HDSS measurements for 1q0 and 4q1 were compared to the DHS values for the corresponding region. The differences between HDSS and DHS measurements for 1q0 and 4q1 were calculated by subtracting the DHS value from the HDSS value. Using differences in 1q0 and 4q1 as the response variable, linear regression was used to examine associations with certain attributes of interest. Models were run with differences in 1q0 and differences in 4q1 separately. A forward modelling approach was used where covariates were added to the model in order of their strength of association with the dependent variable and retained in the final model if they remained significant at the 0.1 level.

Covariates included HDSS population size, HDSS calendar-day heaping, retrospective DHS period length, length of HDSS census interval, and regional malaria endemicity. The covariate of calendar-day heaping captured whether HDSS report births and deaths as disproportionately occurring on certain days of the month. Kullback-Liebler (KL) Divergence was used to measure calendar-day heaping by quantifying how the observed distributions of days of birth and death differed from the expected distributions. Retrospective DHS period length refers to the calculation of annual estimates of 1q0 and 4q1 from the DHS which was done by extracting information on births and deaths taking place up to ten years prior to a survey. This covariate quantifies the length of the retrospective period for which the mortality estimate was calculated. The HDSS census interval covariate was measured in months and grouped HDSS by those that conduct censuses every 1-4, 5-8, and 9-12 months. Regional malaria endemicity was classified in accordance with the Malaria Atlas Project's global database of plasmodium falciparum endemicity.

Results

HDSS measurements for 1q0 and 4q1 are typically below DHS measurements for the corresponding region, and this difference is greater for infant mortality. In Figure 1, the differences between HDSS and DHS are displayed by country. Positive values on the y-axis imply that the HDSS had a higher mortality that the DHS, while negative values imply that the HDSS measurement was lower than the DHS. HDSS measurements for both 1q0 and 4q1 are usually lower than the corresponding DHS measurements. In general, the differences in 1q0 are more negative than the differences in 4q1.

Figure 1: Differences in U5M estimates between HDSS and DHS, by country



Linear regression was used to investigate the association between HDSS-DHS differences and attributes of interest. For the differences in 1q0, the null model had a constant of -0.025. This is the mean difference between HDSS and DHS values, suggesting that the estimated probability of dying before age 1 is 0.025 points lower in the HDSS than in the corresponding region in the DHS. For the differences in 4q1, the null model had a constant of -0.006. While the HDSS measurements are still below the DHS measurements on average, the difference is smaller than that of 1q0.

HDSS population size and regional malaria endemicity were associated with the size of the difference between HDSS and DHS measurements of 1q0 and 4q1. Larger HDSS populations had 1q0 and 4q1 levels that were closer to the DHS measurements. For 1q0 differences, high regional malaria prevalence was associated with HDSS and DHS measurements that were closer to one another. For 4q1 differences, HDSS census intervals of 5-8 months were associated with lower 4q1 HDSS measurements relative to DHS. The coefficient for HDSS census interval of 9-12 months was not significantly different from the baseline of 1-4 months.

Table 2: Linear regression results for differences in U5M estimates between HDSS and DHS

	Dependent variable: differences in nqx (HDSS – DHS)			
	1q0		4q1	
	(1)	(2)	(1)	(2)
HDSS population size		0.001*** (0.001)		0.001*** (0.001)
HDSS Census interval				
1-4 months (baseline)				0
5-8 months				-0.006** (0.002)
9-12 months				0.005 (0.002)
Malaria endemicity				
0-5% (baseline)		0		
5-40%		0.006 (0.005)		
>40%		0.012* (0.005)		
Constant	-0.025*** (0.002)	-0.041*** (0.005)	-0.006*** (0.001)	-0.015*** (0.002)
Observations	250	250	250	250
R2	0.000	0.096	0.000	0.136
Adjusted R2	0.000	0.085	0.000	0.126
Residual Std. Error	0.026 (df = 249)	0.025 (df = 249)	0.021 (df = 249)	0.019 (df = 245)
F statistic		8.667*** (df = 3; 246)		12.94*** (df = 3; 246)

Note: *p<0.1, **p<0.05, ***p<0.01

Only the results of the null and final models are displayed. Other models with the covariates of HDSS calendar heaping and DHS retrospective period length produced nonsignificant results.

Discussion and future work

HDSS estimates for infant and child mortality are typically below DHS measurements for the corresponding region. The difference is greater for infant mortality, with a mean difference of -0.025 for 1q0 as compared to -0.006 for 4q1. HDSS population size, HDSS census interval, and regional malaria endemicity are associated with the magnitude of the differences between HDSS and DHS.

It is plausible that HDSS underestimate 1q0 due to births and deaths that are entirely missed in cases where both events occur in-between HDSS rounds. Even though many HDSS now collect pregnancy status information which later serves to probe interviewers to record the pregnancy outcome, the pregnancies themselves are likely to be under-reported. This could be for several reasons, including the inhibition to report (early) pregnancies for socio-cultural reasons, and the common use of *proxy respondents*, or, household representative who reports on behalf of his or her entire household (Haws et al. 2010). Pregnancies are perhaps also less likely to be reported if the interviewer is male and the respondent female (Kadobera et al. 2017).

Another explanation could be that HDSS are situated in lower mortality areas relative to the DHS regional average. This does not seem likely, as many HDSS are set up in areas that are known to have high mortality relative to the general population (Sankoh and Byass 2012). For example, the Nairobi HDSS is located in a densely populated urban slum, Agincourt HDSS is in a high HIV prevalence region, and Kisumu HDSS is in a high HIV prevalence and highly malaria endemic region (Deribew 2016). And though HDSS frequently serve as platforms for testing public health interventions and perhaps have higher uptake of health services, there is little evidence that mortality patterns in HDSS are markedly different from populations in similar settings (Sankoh et al. 2006).

By the time of the conference, the regression analysis in this study will be expanded to incorporate additional covariates. One such covariate will be HIV/AIDS mortality level. HIV/AIDS is suspected of causing downward bias in DHS estimates due to the correlation between mother and child mortality and the fact that DHS birth histories are only conducted with surviving mothers. Data quality markers of DHS birth histories will be another covariate of interest. Surveys will be evaluated for displacement and omission of births in accordance with the techniques employed by Schoumaker (2014). Age heaping or age misreporting is a common source of error in retrospective surveys. As this pertains to under-five mortality, deaths occurring under the age of one are often rounded up to one year and transferred from the 1q0 statistic to the 4q1 statistic. The data quality assessment could shed light on whether values of 4q1 are being falsely inflated at the expense of 1q0.

This study will also be extended to examine the ratio between 1q0 and 4q1 in HDSS and DHS, and make comparisons with populations with high quality data. Both HDSS and DHS have been found to display the pattern of abnormally high levels of 4q1 given the level of 1q0 for certain parts of sub-Saharan Africa (Guillot et al. 2012). This phenomenon is likely affected by underreporting of infant deaths and age-at-time-of-death misreporting, though evidence suggests that it is also reflective of the epidemiological environment (Guillot et al. 2012). The existence of this pattern in both sources suggests that the relationship between infant and child mortality in sub-Saharan Africa is truly different from other parts of the world, and not just a result of data quality issues.

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