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METHODOLOGICAL NOTES

# Variations in Under-Five Mortality Estimates in Nigeria: Explanations and Implications for Program Monitoring and Evaluation

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**Abstract** Millennium Development Goal (MDG) 5 aims at reducing under-five mortality by two-thirds between 1990 and 2015. However, monitoring this goal is a challenging task. With an estimated 162 million people in 2011, Nigeria is Africa's most populous country with generally poor maternal and child health indicators. Maternal mortality ratio was estimated at 545 deaths per 100,000 live births in 2008 and recent data show that under-five mortality rates have varied tremendously. This paper provides a synthesis of the data collection and estimation procedures used by the two major sources of child mortality data in Nigeria (the Multiple Indicator Cluster Surveys; and Demographic and Health Surveys) and the importance of reflecting on these dynamics in order to utilize the mortality estimates in program monitoring and evaluation. While efforts to seek explanations for the unstable trends in mortality rates are ongoing, this study calls for stakeholders to seek studies that employ more detailed and robust disaggregation methods that take into account the relative impact of socio-demographic, medical, and public health variables on mortality rates. This will be crucial in assessing the effectiveness of selected interventions in reducing mortality. Further, the study encourages collection, use, and triangulation of health and demographic surveillance system (HDSS) and other available data which could assist in monitoring progress towards achieving MDGs since HDSS as well as census or survey data would provide an opportunity to measure and evaluate interventions through longitudinal follow-up of populations.

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## Background

Millennium Development Goal (MDG) 5 aims at reducing under-five mortality by two-thirds between 1990 and 2015. However, monitoring this goal is a challenging task. With an estimated 162 million people in 2011 (Population Reference Bureau), Nigeria is Africa's most populous country with generally poor maternal and child health (MCH) indicators. Maternal mortality ratio was estimated at 545 deaths per 100,000 live births (LBs) in 2008 [1] and recent data show that under-five mortality rates (U5MRs) have varied tremendously (Fig. 1). The U5MRs have come from survey responses of women of reproductive age.

Figure 1 shows that the Multiple Indicator Cluster Survey (MICS) estimates generally show an increase in infant mortality rate (IMR) over time, specifically between 2007 and 2011 (i.e., from 86 deaths per 1,000 LBs to 105 deaths per 1,000 LBs). Generally, estimates from the closest surveys are very different: IMR from MICS 2007 was estimated at 86 deaths per 1,000 LBs compared with 75 deaths per 1,000 LBs from the 2008 Nigeria Demographic and Health Survey (NDHS). Comparing NDHS and MICS data for consecutive periods shows that between 2003 and 2008, the NDHS registered declines in U5MRs as well as IMRs whereas MICS 2007 and 2011 registered an increase in U5MRs and IMRs.

## Why are Estimates Fluctuating over Time?

Explaining variations in estimates over time requires reflection on data collection and estimation procedures

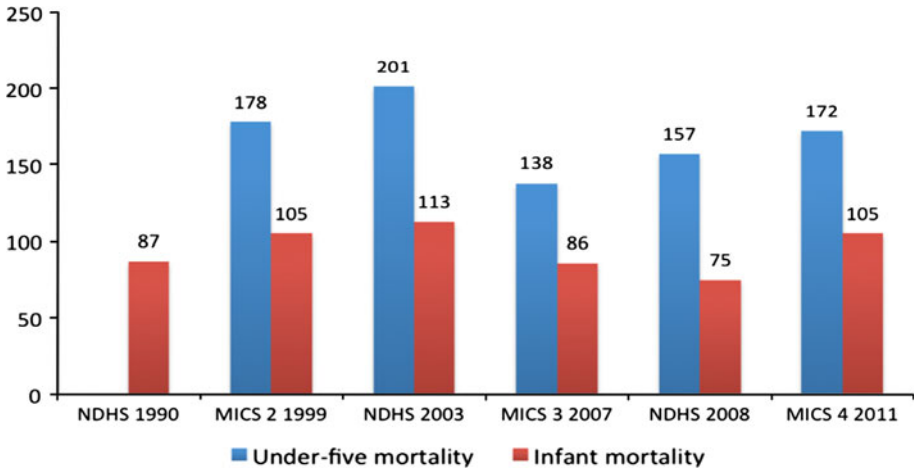


**Fig. 1** Child mortality rates in Nigeria, 1990–2011. *Source*: Reproduced from ([2]; p. 11, Figure CM2)

used by the two major sources of child mortality data in Nigeria, MICS and DHS. Worth noting is that technical experts for MICS and DHS are part of the United Nations Inter-agency Group for Child Mortality Estimation (CME). Formed in 2004, the CME Group shares data on child mortality, consolidates estimates within the United Nations system, improves estimation methods, reports progress towards the MDGs, and enhances country capacity to produce timely and properly assessed estimates of child mortality [3].

Generally, accurate estimates of child mortality cannot be generated from data in many developing countries due to, among other things, the absence of complete vital registration systems. To overcome this, MICS and DHS data have become indispensable in estimating child mortality. Through the CME Group, UNICEF has since 2008 supported about 10 countries to increase capacity in mortality estimation. Part of the variation in DHS and MICS mortality estimates is related to variations in data collection and estimation methods. Further, variations between the surveys exist such as sample size and design as well as data collection and estimation procedures [1–4].

## Sample Size and Design

DHS usually samples 5,000 to ≥30,000 households whereas MICS samples range from 4,000 to 30,000 households. The 2008 NDHS and 2011 MICS had different designs: the primary sampling unit in the NDHS was defined on the basis of the 2006 census enumeration areas (EAs) and the sample was selected using a stratified two-stage cluster design. For MICS, 40 census EAs were selected systematically with equal probability within each state.

## Data and Mortality Estimation

DHS collects birth histories from mothers on the date of birth and, if relevant, the age at death of every live-born child she has had. Using *direct methods*, both IMRs and U5MRs are calculated, dividing deaths for given ages and time periods by exposure to risk in terms of person-years of life lived by the reported children. However, the collection of such information in the DHS is complex and requires high levels of interviewer quality and training. MICS uses *indirect* "*Brass methods*" (by William Brass). Each woman is asked about her age, the total number of children ever born, and the number of those children that have died. For a particular age group of women, the proportion of children dead depends primarily on two things: the level of under-five mortality, and the distribution of the children by how long they have been exposed to the risk of death. The Brass method (and developments of it) adjust the proportions dead by age group of mother for an estimated exposure distribution in order to arrive at pure measures of under-five mortality and of reference dates for these measures. The adjustment process assumes certain patterns of fertility and under-five mortality by age, and results can be quite sensitive to the choices made [1–4].

DHS mortality estimates depend crucially on the quality of data whereas the Brass methods are still the standard for estimating child mortality. Derivation of trends depends crucially on mortality assumptions and current research attempts to derive refinements to the method that compensates some of the weaknesses of the methods but progress has been slow (see 1–4 for details).

A disadvantage, however, of the indirect methods is their inability to locate mortality estimates in time. Indirect methods estimate the probability of a child dying based on women's experience that can extend back as many as 20 years. This approach assumes little or no change in fertility levels and age patterns, and either no change or a linear decline in mortality—which may or may not be true [5]. DHS and MICS estimates are bound to differ because surveys technically differ in terms of: (a) degree of sampling errors which has an implication on the size of the confidence intervals (CIs) thereby making comparison of

survey estimates somewhat problematic; (b) degree of non-sampling errors in part because they are dependent on women's ability to recall events that took place in the distant past; (c) omission and misreporting of births and deaths; and (d) preference for reporting certain ages, which may lead to transfer of deaths across one-year boundary and lead to underestimates of IMRs. Hence, household surveys are considered to produce more robust estimates of U5MRs than IMRs. The U5MRs can also be influenced by variations in women's schooling; proportions of births delivered by skilled attendants; pregnant women receiving tetanus toxoid injections; level of breastfeeding; percent of children receiving all childhood vaccines; and income per capita, among others.

## Understanding Survey Estimates on Mortality

(1) Use of confidence intervals

Confidence intervals provide information on the precision of mortality estimates and it is important to ensure that confidence limits for mortality rates account for the survey design and utilize an acceptable methodology [6]. Nevertheless, mortality estimates provided in large household survey reports lack CIs due to computational demands. As a result, it is problematic to assess whether estimates from two surveys have CIs which overlap. For example, MICS 2007 U5MR was 138 whereas the corresponding rate in the NDHS 2008 was 157. While the 2008 NDHS is higher by 19 points, none of the two sources provided CIs. It is possible that the CIs for the two estimates may overlap. If two statistics have non-overlapping CIs, they are necessarily significantly different *but* if they have overlapping CIs, it is not necessarily true that they are not significantly different. Generally, when comparing two parameter estimates, it is always true that if the CIs do not overlap, then the statistics will be statistically significantly different. However, the converse is not true. Therefore, it is erroneous to determine the statistical significance of the difference between two statistics based on overlapping CIs ([7], p.1).

(2) Understanding trends

Based on the methodological challenges related to surveys and their comparison over time, it is unrealistic to expect the rates to be similar. The magnitude may always be different. Of importance is how estimates are behaving over time or over periods of implementation of MCH interventions. For example, Fig. 1 shows a decline for the DHS in U5MR between 2003 and 2008 whereas MICS shows an increase in the same indicator between 2007 and 2011. Assuming the 2003–2011 data points come from the same source, it would be clear that U5MR declined between 2003 and 2007 and increased thereafter. For the IMR, it is apparent that it declined from 2003 and 2008 and increased in 2011. The trend seems clear between 2007 and 2011, U5MR had increased. Certainly, that is the key message for policy makers and other stakeholders.

(3) Understanding mortality trends using decomposition techniques

Unstable mortality rates compromise interpretation of data and other techniques have to be employed. One of the ways to improve interpretability of IMRs, is to employ transformation methods and assess the strengths of such transformations other than employing the widely used logarithm transformation to account for the curvilinear time trend in IMR [8]. Other methods may also be employed to improve the interpretability of IMRs such as moving averages, time series analysis, and regression.

However, to get a firmer understanding of explanations for unstable rates, public health specialists need to employ disaggregation techniques at the national or sub-regional level (e.g., 9) to examine changes in U5MRs or IMRs. Disaggregation techniques can unravel the effects of factors such as measures of economic development, access to medical care (e.g., skilled delivery), marital fertility, population density, maternal and child welfare clinics on the areal and temporal variation in IMRs or U5MRs. Most of the data are readily available for employing such methods. Thus, any rapid drop or increase in infant and under-five mortality should be viewed as a product of social, economic, demographic, medical, and public health variables [9]. This was also echoed earlier ([10], p. 19) through the eclectic model of mortality for sub Saharan Africa with mortality outcomes being a function of household income; population health coverage indicators; literacy rate, especially for females; exogenous shocks such as famines, wars, epidemics; region- or time-specific factors; and other unobservable factors. Briefly, the eclectic model attempts to capture short- and long-term effects on mortality. As a result, the relative effect of each of the factors included in the model has a significant impact on mortality.

## Unstable Trends in Mortality and Program Planning

Most donors are working in countries with complex socio-economic environments such as Nigeria. Most of their programs include renown and effective interventions yet their deployment usually has less control over some of the factors contained in the eclectic model of mortality [10]. Therefore, donor agencies need to understand that the impact of their interventions may be affected by the national or state socio-economic dynamics. The key is to determine whether any observed unstable mortality

estimates are realistic. In countries where most health metrics are obtained from household surveys—which are prone to a number of methodological challenges and coupled with a complex socio-economic environment—unstable mortality rates may be inevitable. Efforts should be made to commission studies that attempt to disaggregate the observed mortality rates or any other health indicators. Such studies would provide a framework for reference on the progress made by donor programs.

While many low-income countries lack comprehensive data on vital registration systems for systematic assessment of the MDGs, censuses or surveys have become the last resorts to address this gap. However, surveys are limited by their cross-sectional nature which, to a certain extent, limits their ability to provide long-term evaluations of interventions that could track progress towards the MDGs [11]. To address this challenge, Health and Demographic Surveillance System (HDSS) sites such as those spearheaded by the INDEPTH Network (www.indepth-network.org), could play an important role in monitoring progress towards attainment of MDGs. Not only are majority of HDSS sites collecting longitudinal data from rural and disadvantaged areas in selected low-income countries, they provide a core set of components of population change—births, deaths, and migrations, as well as data on marriage. Data collection intervals vary by sites, from one to four times annually with regular updates of educational status of individuals and other socio-economic characteristics (see [11] for details on the potential and dynamics of HDSS data in answering a number of research and policy questions in 45 countries across the world at the time of writing this note).

Although data from INDEPTH member sites provide detailed information than those collected from censuses or surveys they are often located at the district level and some of their results may not be generalized. However, some countries have multiple HDSS locations which may provide more coverage. Since no single data set can provide information across various dimensions, researchers should triangulate the available data sets in order to understand nuances associated with variations in mortality estimates over time.

## Conclusion

Child mortality rates in Nigeria have varied a great deal since the 1990 s. The mortality estimates have come from data generated from household surveys which are prone to sampling and non-sampling errors. Although the sample designs and sizes have been generally consistent across the DHS and MICS, the estimation methods have differed with DHS using more robust direct methods and MICS using standard indirect methods. While efforts to seek explanations for the unstable trends are ongoing, it is imperative for stakeholders to seek studies that employ more detailed and robust disaggregation methods that take into account the relative impact of social, economic, demographic, medical, and public health variables on mortality rates. This will be crucial in assessing the effectiveness of selected interventions in reducing mortality. To sum, unstable (or stable) trends in mortality rates should be interpreted within the context of the behavior of measures of socioeconomics and other determinants of maternal and child health. Further, encouraging collection, use, and triangulation of HDSS and other available data could assist in monitoring progress towards achieving MDGs since HDSS as well as census or survey data would provide an opportunity to measure and evaluate interventions through longitudinal follow-up of populations [11].

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