Evaluating the Consistency of Under-Five Mortality Rate Estimates Using Full Birth Histories and Summary Birth Histories

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Abstract

This paper reviews direct and indirect methods used to estimate child mortality rates when comprehensive vital registration information is unavailable. I present an analysis using data from 115 demographic and health surveys (DHS) in thirty-five countries spanning West Africa, East Africa, Latin America and South and Southeast Asia. This empirical evaluation entails: (i) an examination of the paired difference of direct and indirect estimates using DHS data, (ii) a characterization of these differences based on diagnostic analysis of and adjustment for data errors in the full birth histories and violations of the model assumptions in the indirect method and (iii) a comparison of the Rajaratnam et al. (2010b) indirect method (applied to census data) with corresponding full birth histories from DHS surveys. I conclude with a detailed description of the performance of the methods under different epidemiologic and demographic conditions.

Extended Abstract

The purpose of this paper is to compare the consistency of direct and indirect methods for estimating under-five mortality rates from incomplete and defective data. This analysis is intended to inform discussions about how to evaluate these two estimation methods and make inferences when the resulting estimates from firect and indirect estimation are inconsistent.

The accurate estimation of under-five mortality rates is important for two fundamental reasons:

- Firstly, the under-five mortality rate is an important indicator of population health (Reidpath and Allotey 2003). It is widely used by the international agencies to monitor development progress as part of the Millennium Development Goals and other initiatives to improve population health and human welfare (United Nations Children's Fund 2011).

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- Secondly, the probability of dying before age 5-years old, ${}_5q_0$, is one of the principal input parameters used to develop summary measures such as age-specific mortality rates and life expectancy at birth for developing countries without reliable vital registration(Wilmoth et al. 2009). Thus, errors and biases in estimating child mortality lead to notable inaccuracies in other summary mortality measures.

The accurate estimation of under-five mortality rates is difficult in developing countries that lack comprehensive vital registration systems. In such cases, researchers have to rely on direct and indirect estimation methods based on ad-hoc retrospective survey and census data. Such methods are vulnerable to data errors (inherent in retrospective data collection systems) and errors resulting from simplifying modeling assumptions.

Direct estimation of under five mortality, using either a sample survey or a population census, is derived from full birth histories of women between the ages of 15 and 49 years old.[1] In a full birth history, women are asked to report for each live birth, the date of the birth and, if the child has died, its age at death. With a full birth history, a synthetic cohort life table approach can be used which combines mortality probabilities for small age segments based on actual cohort experience into more common age groups (Rutstein and Rojas 2006).

Indirect estimation of under five mortality rates requires, at the very least, abridged birth histories where women report the total number of children ever born to them and the number who are still alive at the time of the survey. This indirect estimation technique was first proposed by Brass (1964), Brass et al. (1968) and Brass (1971) and builds on the insight that the number of deaths at a given age and the probability of dying in that age group is primarily determined by the age pattern of fertility.

The Brass method and its subsequent variants make adjustments to the proportion of children dead by the mother's age group (or by the mother's marital duration or by the time since first birth) for an estimated exposure distribution so as to estimate under-five mortality and associated reference dates for these rates. The underlying adjustment process of the Brass indirect method is dependent on a number of key underlying assumptions. These include:

- no, or at worst a small, change in fertility levels and age patterns,
- either there is no change or a linear decline in mortality levels,
- the age-specific mortality pattern is consistent with model age patterns represented by the Coale-Demeny Model Life Table system or the United Nations Model Life Table system,
- mortality risks for the mother are independent of those for her child,
- mortality patterns for children are homogenous across all factors except the mother's age (or the time since the mother's first birth or the mother's duration of marriage).

The direct and indirect methods are theoretically supposed to result in unbiased estimates of infant/child mortality rates, despite the methods being based on two different forms of data and notably different assumptions. The indirect method is particularly appropriate when infant/child

[1] In Demographic & Health Surveys, birth histories are usually only collected from women between the ages of 15 and 49 years old. Further, in some cultures, sampled women are restricted to "ever married" women.

mortality data are collected during a population census or when retrospective reporting of ages and dates are known to be unreliable.

The published literature has, up to date, focused mostly on

- the statistical merits of different curve fitting procedures to available mortality estimates (Hill et al. 1999; Murray et al. 2007; Rajaratnam et al. 2010a),and
- a number of pressing data quality issues related to full birth histories that are collected in survey programs such as the Demographic & Health Surveys (eg age heaping (Pullum 2006), birth omissions (Schoumaker 2011), and birth transference (Pullum and Sullivan 2008)) .

Thus, part of the existing literature identifies systematic biases and data problems with full bith histories, while another part of the literature notes the limitations of the Brass indirect estimation method. Recent efforts in synthesiing available child mortality estimates from both direct and indirect estimation methods has narrowly focused mostly on different statistical smoothing techniques such as splines and loess regression. In practice, when analysts synthesize direct and indirect estimates (using statistical curve fitting procedures), they often overlook the relative biases of the underlying point estimates and fail to integrate these underlying data quality issues into the estimation of temporal change in under-five mortality rates.

This paper aims to provide a systematic review of when direct and indirect methods result in different estimates, and how best to evaluate such inconsistencies. The paper seeks to provide a sounder empirical basis for the integration of data quality diagnostics into statistical curve fitting of point estimates. Such an integration is need to ensure that the estimation process better accounts for bias and error in the underlying direct and indirect point estimates.

The empirical analysis of this paper is divided into two parts. The first part is focused on the calculation of absolute and relative differences between direct and indirect estimates of under-five mortality rates using DHS data. These differences are evaluated and then successively re-analyzed after diagnostic analysis of and adjustment for various shortcomings of the classical direct and indirect estimation methods. In particular, I successively carry out diagnostic analysis and re-estimation of rates to account for birth omissions and birth transference in full birth histories used in direct estimation. I also adjust indirect estimates by relaxing the implicit constant fertility assumption that underlies the classical Brass indirect method. After each readjustment of the estimates, I successively review the paired differences between the direct and indirect estimates. In order to charactertize the observed differences, after controlling for potential data errors in the full birth histories and adjusting for violations of assumptions that underly the Brass method, I draw on the categorizations of Garenne and Gakusi (2006). In particular, I classify the inconsistencies between revised direct and indirect estimates according to the nature of health and mortality transitions. These classifications provide a useful framework to identify the magnitude of observed differences in direct and indirect estimates, relative to the type of health and mortality transition experienced. This helps to identify different inconsistencies observed across smooth health transitions, major increases in mortality due to political/economic crises, stalls in mortality decline, and transitions punctuated by periods of excess mortality due to infectious disease outbreaks.

The second part of this paper explores the associated differences between the Rajaratnam et al. (2010b) indirect method and the direct estimation method. The Rajaratnam et al. (2010b) method refines the classic Brass method by providing alternative approximations to the child's length of

exposure to mortality, using cohort and period measures of the proportion of children ever born that have died, and moderling regional and country variation in the age pattern of fertility and mortality. For this evaluation, I compare indirect estimates from available census data and MICS surveys with direct estimates from full birth histories derived from DHS surveys with overlapping reference periods (to the census or MICS). This comparison is important as the Rajaratnam method, when developed, was validated against direct estimates from full birth histories. Thus evaluation of the Rajaratnam et al. (2010b) method by comparing indirect estimates compiled from sources other than DHS surveys provides an important reliability check. This check provides a means to evaluate the consistency of this revised indirect estimation method with direct estimates against the observed consistency between the classical Brass indirect method and direct estimates derived from full birth histories. In line with evaluations in the first part of this paper, I again use the Garenne and Gakusi (2006) characterizations of health and mortality transitions to characterize the types of errors and bias associated with statistically measurable inconsistencies between direct and indirect estimates.

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