

Model Uncertainty in World Wide Estimates of Maternal Mortality*

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Abstract

Background Reducing maternal mortality is a priority for health systems worldwide and the emphasis of Millennium Development Goal 5. Assessing progress requires reliable estimates of both levels and trends in maternal mortality. Recent reports about maternal mortality suggest sustained downward trends in maternal mortality.

Methods We assess the degree of uncertainty in recent estimates of levels and trends in maternal mortality which is due to the missing or only partial available information about maternal mortality in many countries. We develop a method for adjusting the confidence intervals for estimates of the levels of maternal mortality ratios for 2005. We characterize the uncertainty due to the selective nature of countries with missing maternal mortality information as well as the methods which are adopted for including these countries in analyses of worldwide trends in maternal mortality.

Findings Prior reports about maternal mortality understate the uncertainty in estimates of the levels and trends in worldwide maternal mortality. Accounting for missing information about maternal mortality may as much as double the magnitude of confidence intervals for estimates of the level of maternal mortality ratios in 2005.

Interpretation Empirical estimates of maternal mortality for countries with missing or only partial information underestimate the true level of maternal mortality if the uncertainty in data quality is not explicitly incorporated into model estimates.

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1 Introduction

Over the last three years this journal published a series of papers and commentaries concerning the assessment of levels and trends in worldwide maternal mortality—ie, the death of women during pregnancy, childbirth or the 42 days after delivery due to causes associated with pregnancy. Hill et al.¹ present estimates for 171 countries that update prior estimates²⁻⁴ and assess maternal mortality trends over the period 1990-2005. Hogan et al.⁵ incorporate additional data sources and with an alternative set of methods generate estimates for 181 countries over the period 1980-2008. An important achievement of this work is the estimation of world wide trends in maternal mortality as well as the levels and trends of maternal mortality for many countries with limited surveillance of maternal mortality. However, neither study adequately accounts for the uncertainty in the reported estimates resulting from the wide variation in available vital registration and survey data. The large number of countries with incomplete or absent reports of maternal deaths presents a major challenge for generating estimates of maternal mortality. This challenge has been met in both studies with assumptions which we believe result in an underestimation of the uncertainty in the resulting estimates of both the levels and trends of maternal mortality.

The estimates by Hill et al. and those by Hogan et al. share an important feature that is their main virtue yet also a critical weakness: they succeed in producing estimates for most countries in the world including the large number of countries in their samples with little or no information on maternal deaths. The samples of countries in Hill et al. and Hogan et al. include as many as 61 and 21 countries respectively without any indicators of maternal mortality. Far larger numbers of countries in both studies include only infrequent and/or poor indicators of maternal mortality over the time periods under consideration. Yet, the high levels of mortality and of fertility among the countries with missing

information suggest their potentially large contributions to world wide maternal mortality. Hill et al. attribute the countries in their sample which have no indicators of maternal mortality for as much as 25% of total yearly world births. Additional uncertainty in the estimates of maternal mortality for these countries jeopardizes assessing trends for not only the regions where it's highest but also a sizable share of the world wide incidence of maternal mortality.

Many of the exchanges following the release of both Hill et al.'s estimates⁶⁻⁸ and Hogan et al.'s estimates emphasized discrepancies in estimates of country specific levels of maternal mortality⁹⁻¹⁴ and the magnitude of certainty in the reported estimates.^{13, 15, 16} The large divergence in country specific estimates for the year 2005 between the two studies, ranging by factors as large as .36-.45 among the six countries attributed by Hogan et al. with over 50% of global maternal deaths, underscores these concerns. While the strength of both studies' methods lies with generating estimates of trends rather than specific country estimates, it remains in doubt whether the aggregate effects of uncertainty in country specific estimates are adequately reflected in the reported trend estimates.

In this study, we reanalyze Hill et al's data for the year 2005 and demonstrate how the uncertainty in country specific estimates for countries with little or absent indicators of maternal mortality may be large enough to cast doubt on the estimated trends in world wide maternal mortality. (We were not able to obtain access to Hogan et al.'s data.) The larger degree of uncertainty in world wide trends in maternal mortality calls into question inferences suggesting a steady decrease in maternal mortality. Individual country's assessment of goals and long term planning ought to take into account not just the published point estimates and associated confidence intervals but an added level of uncertainty that is completely hidden from view and which may be paramount in measuring progress toward achieving the reduction in world wide maternal mortality declared in Millennium Development Goal 5 of the Millennium Declaration.

2 Results

We present adjusted confidence intervals to account for the uncertainty posed by the unknown distribution of missing maternal mortality information affecting world-wide estimates of mortality trends. Our adjustments demonstrate the potential for sizable underestimates of MMR across countries. Accounting for the range of reasonable distributions which might characterize missing maternal mortality information results in underestimates of PMDF for 36 of the 40 countries we analyzed. These underestimates translate into underestimates of MMR in excess of 44% for more than 20 of the countries. The adjusted confidence intervals also demonstrate large increases in uncertainty across all countries. Although our estimates are defined for 2005, selective availability in maternal mortality indicators occurs in every year of the available series of MMR. Variation in the quality of available information about maternal mortality is further likely to be related to overall levels of economic development and maternal mortality itself.

The large magnitude of errors is particularly troublesome given the restriction of the experimental distributions to a narrow set of distributions for missing PMDF values. Experimental mean and variances for the samples of countries with missing PMDF values were limited to values which preserved the overall sample's observed mean and variance. However, the true global distribution of PMDF including countries with missing information is likely to display a higher mean PMDF.

Our method for measuring uncertainty is easily adaptable to estimating the uncertainty when MMR is directly modeled as by Hogan et al. However, we emphasize PMDF in our analysis since it is less prone to the measurement error introduced by counts of births and deaths and thus more appropriate for identifying the consequences of sample selection bias due to missing maternal mortality information. Any benefits from directly estimating MMRs or from incorporating reports of MMRs from published sources for countries with missing PMDF would be largely outweighed by the substantial increases in uncertainty arising the additional sources of uncertainty in counts of births and deaths.

The higher degree of uncertainty that is implied by our corrected confidence intervals warrants considerable caution in estimating trends in maternal mortality. Our estimates imply uncertainty not only in levels of maternal mortality during the year 2005 but also the in the trendline over the long period from 1990 to 2008. Given the likelihood of overlapping confidence intervals for yearly estimates over much of this period, it becomes difficult to estimate with any confidence trends in maternal mortality over shorter time periods. While our results suggest the possibility of widespread underestimates of maternal mortality levels, such large uncertainty in the model estimates prevents reaching any conclusions about modern trends in maternal mortality.

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