# Estimating Time Trends in Maternal Mortality for all Countries: A Revised Modeling Approach

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**Abstract**

Estimates of the maternal mortality ratio (MMR) are used to track progress in reducing maternal deaths and to evaluate countries' performance related to MDG 5. Given limited data availability and data quality issues for the majority of developing countries, the UN Maternal Mortality Estimation Inter-agency Group obtains estimates for all countries without vital registration systems using a multilevel regression model. While the model works well to assess MMR levels for countries with limited data, it does not provide insights into observed trends in countries where longer time series of observations have become available; estimated trends are covariate-driven and not informed by data-driven trends. In this paper, we propose a revised MMR estimation model, which is a combination of a multilevel regression and a time series model, such that estimates are data-driven for countries with sufficient information. Preliminary results suggest that the revised model provides informative MMR estimates.

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# 1 Introduction

Estimates of the maternal mortality ratio (MMR) are used to track progress in reducing maternal deaths and to evaluate countries' performance related to Millennium Development Goal 5, which calls for a 75% reduction in the MMR between 1990 and 2015. Estimates are constructed and published by the UN Maternal Mortality Estimation Inter-agency Group (MMEIG); the latest set of estimates for 1990–2013 was published in May 2014 (WHO et al. 2014).

Given limited data availability and data quality issues for the majority of developing countries, the MMEIG obtains estimates for all countries without high quality vital registration systems using a multilevel regression model (Wilmoth et al. 2012). While the model has proven to work well to assess MMR levels for countries with limited data, the set-up does not provide insights into observed trends in countries where longer time series of observations have become available; estimated trends are covariate-driven and not informed by data-driven trends.

In this paper, we propose a revised MMR estimation model that provides estimates for all countries by combining a multilevel regression model and a time series model, such that estimates are informed by the data for countries with sufficient information while the regression model is informing the estimates for countries with limited data.

# 2 Summary of the revised estimation approach

The revised MMR estimation model builds upon the current MMEIG estimation approach. The key indicator in this approach is the proportion of non-AIDS maternal deaths among all non-AIDS deaths to women of reproductive ages, referred to as the non-AIDS PM (the AIDS indirect maternal deaths are estimated as well but through a different approach). A multilevel model is used to obtain estimates of the non-AIDS PM for countries without high quality vital registration data, using all available data. The model is given by

$$\begin{aligned} \log(p_{c,t}) &= \beta_0 + \beta_1 x_{1,c,t} + \beta_2 x_{2,c,t} + \beta_3 x_{3,c,t} + \alpha_c^C + \alpha_{r[c]}^R, \qquad (1) \\ \alpha_j^C &\sim N(0, \sigma_{ac}^2), \\ \alpha_k^R &\sim N(0, \sigma_{ar}^2), \end{aligned}$$

where $p_{c,t}$ refers to the non-AIDS PM for country $c$ in period $t$, $x_{k,c,t}$ for $k = 1, 2, 3$ refers to predictors for the non-AIDS PM (given by the log of the general fertility rate, the log of GDP per capita and the proportion of births with a skilled birth attendant), and $\alpha_c^C$ and $\alpha_r^R$ refer to the country and region-specific intercepts (where $r[c]$ refers to the region of country $c$).

The main drawback of the current MMEIG modeling approach is that once the regression coefficients have been estimated in the multilevel model, country-specific trends

are determined by changes in the predictors only and not by the observed trends in the time series of observations.

To be able to capture data-driven trends in MMR estimates, we propose to obtain non-AIDS PM estimates by combining the multilevel model with a time series model:

$$\log(p_{c,t}) \quad = \quad \log(p^*_{c,t}) + \varepsilon_{c,t}, \tag{2}$$

where $\log(p^*_{c,t})$ is given by the multilevel model (left-hand side in Eq. 1) and $\varepsilon_{c,t}$ is modeled with a time series model (an ARMA(1,1) model). Preliminary illustrative results from this model are described in the next section.

Model fitting is carried out in a Bayesian framework. Samples from the posterior distributions are obtained using Markov chain Monte Carlo sampling, implemented in open source software packages `R` (R Development Core Team 2013) and `JAGS` (Just Another Gibbs Sampler, Plummer (2003)).

# 3 Illustrative results

Illustrative results of model (2) are given in Figure 1 for countries A, B and C. Green lines indicate the covariate-driven trend line for the three countries (given by the multilevel model) while the red lines show the MMR estimates. The plots illustrate that the new modeled estimates capture trends in the data well. Uncertainty intervals (illustrated with the red shaded areas) are narrower for years with observations and widen during periods without observations.

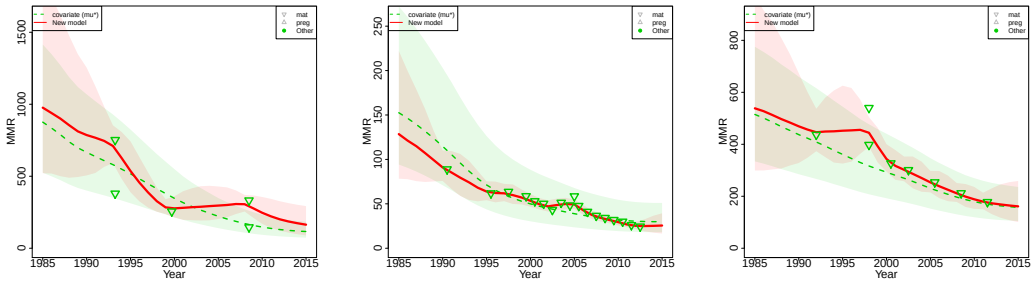


Figure 1: Illustrative results: model-based MMR estimates for countries A, B and C (red). Red shaded areas illustrate the 95% uncertainty intervals. Green lines indicate the covariate-driven trend line.

# References


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