capita (GDP),\(^a\) the general fertility rate, the ratio of live births to the number of reproductive-age women\(^b\) and the proportion of deliveries for which a skilled birth attendant is present.\(^\text{20}\)

Using the proportion of non-AIDS-related deaths among women aged 15–49 that are maternal deaths as the dependent variable, we estimated a multilevel regression model with random effects for both country and region; independent variables were the GDP, the general fertility rate and the proportion of deliveries for which a skilled birth attendant is present.\(^\text{17}\) Predicted values of the regression equation were computed for five-year intervals centered around 1990, 1995, 2000, 2005 and 2008 for each country.

We used the proportion of all deaths among women aged 15–49 that are maternal deaths as the input to our estimation model because it is considered more robust and reliable than either the number of maternal deaths alone or maternal deaths in relation to live births. This decision was based on precedence, as well as on the results of our own analysis of alternative measures.\(^\text{10,21}\) In describing our results, we focus on trends in the MMR, both with and without AIDS-related maternal deaths, because this measure quantifies the risk of maternal death per live birth and thus is an indicator of obstetric risk. Estimates were derived at the country level and then aggregated to the regional and global level. In this paper, most of the results are examined at the regional level using the United Nations MDG regional groupings. The figures reported are rounded (see note in Table 1); however, calculations made using the estimates and reported here are based on the unrounded underlying data.

The process of preparing the data and fitting the model was quite complex and required making several assumptions. Therefore, the point estimates derived from this process are uncertain. This uncertainty comes from many sources: any remaining bias in adjusted values for the proportion of all deaths among women aged 15–49 that are maternal deaths, imprecise knowledge of assumed values for certain model parameters, variability as reflected in the multilevel regression model, errors in data used for the AIDS adjustment or the conversion of the proportion of all deaths among women aged 15–49 that are maternal deaths to MMR estimates (i.e., the “envelope adjustment”\(^\text{22}\)) and alternative specifications of the model (e.g., choice of covariates). With the exception of alternative model specifications, we attempted to account for these various sources in the uncertainty intervals presented here. Further details on the statistical methods are available elsewhere.\(^\text{10}\)

RESULTS

Global Trends in Maternal Mortality

The total number of maternal deaths observed annually fell from 546,000 in 1990 to 358,000 in 2008, a 34% decline over this period (Table 1). Similarly, the global MMR declined from 400 to 260 maternal deaths per 100,000 live births, a decline of 34% over the entire period and an average annual decline of 2.3%. As we will explain in more detail, the rates of decline in maternal deaths and MMR are similar because the global trend in births was essentially flat over the period 1990 to 2008. Although these estimates suggest progress in reducing maternal mortality at the global level, the decline is not rapid enough to achieve the MDG 5 target. Also, there are considerable regional disparities in reduction of maternal mortality.

All results presented here should be viewed with caution, given the considerable uncertainty surrounding these estimates. For example, while the median estimate of the total number of maternal deaths observed in 2008

---


\(^b\) Assuming that observation \(i\) refers to country \(j\) located in region \(k\), PMR is the proportion of non-AIDS related deaths among women aged 15–49 that are maternal deaths, GFR is the general fertility rate and SAB is the proportion of deliveries for which a skilled birth attendant is present, the estimated regression model was as follows:

\[
\log(\text{PMR}) = 2.253 + 0.217\log(\text{GDP}) + 1.272\log(\text{GFR}) + 0.652 \log(\text{SAB}) + a_j + c_k + e_{ijk}
\]

The envelope adjustment estimates the total MMR by multiplying proportion of all deaths among women aged 15–49 that are maternal deaths by the ratio of the estimated number of deaths among all women aged 15–49 to the estimated number of live births.\(^\text{13}\) This figure is then converted into units of maternal deaths per 100,000 live births. The total number of deaths was derived by multiplying UN age-specific estimates of the total number of women and WHO estimates of age-specific death rates (sources: reference 19 and WHO Life tables for WHO member states, 2010, <http://www.who.int/healthinfo/statistics/mortality_life_tables/en/index.html>, accessed July 10, 2010).