Maternal mortality for 181 countries, 1980–2008: a systematic analysis of progress towards Millennium Development Goal 5

Margaret C Hogan, Kyle J Foreman, Mohsen Naghavi, Stephanie Y Ahn, Mengru Wang, Susanna M Makela, Alan D Lopez, Rafael Lozano, Christopher J L Murray

Summary

Background Maternal mortality remains a major challenge to health systems worldwide. Reliable information about the rates and trends in maternal mortality is essential for resource mobilisation, and for planning and assessment of progress towards Millennium Development Goal 5 (MDG 5), the target for which is a 75% reduction in the maternal mortality ratio (MMR) from 1990 to 2015. We assessed levels and trends in maternal mortality for 181 countries.

Methods We constructed a database of 2651 observations of maternal mortality for 181 countries for 1980–2008, from vital registration data, censuses, surveys, and verbal autopsy studies. We used robust analytical methods to generate estimates of maternal deaths and the MMR for each year between 1980 and 2008. We explored the sensitivity of our data to model specification and show the out-of-sample predictive validity of our methods.

Findings We estimated that there were 342 900 (uncertainty interval 302 100–394 300) maternal deaths worldwide in 2008, down from 526 300 (446 400–629 600) in 1980. The global MMR decreased from 422 (358–505) in 1980 to 320 (272–388) in 1990, and was 251 (221–289) per 100 000 livebirths in 2008. The yearly rate of decline of the global MMR since 1990 was 1·3% (1·0–1·5). During 1990–2008, rates of yearly decline in the MMR varied between countries, from 8·8% (8·7–14·1) in the Maldives to an increase of 5·5% (5·2–5·6) in Zimbabwe. More than 50% of all maternal deaths were in only six countries in 2008 (India, Nigeria, Pakistan, Afghanistan, Ethiopia, and the Democratic Republic of the Congo). In the absence of HIV, there would have been 281 500 (243 900–327 900) maternal deaths worldwide in 2008.

Interpretation Substantial, albeit varied, progress has been made towards MDG 5. Although only 23 countries are on track to achieve a 75% decrease in MMR by 2015, countries such as Egypt, China, Ecuador, and Bolivia have been achieving accelerated progress.

Funding Bill & Melinda Gates Foundation.

Introduction

Maternal mortality—the death of women during pregnancy, childbirth, or in the 42 days after delivery—remains a major challenge to health systems worldwide. Global initiatives to intensify policy intervention for maternal mortality began with the Safe Motherhood Initiative in 1987,[1] a response to growing recognition that primary health-care programmes in many developing countries were not adequately focused on maternal health.[2] The 1994 International Conference on Population and Development strengthened international commitment to reproductive health.[3,4] The focus on maternal mortality was sharpened when reduction in maternal mortality became one of eight goals for development in the Millennium Declaration (Millennium Development Goal [MDG] 5).[5] The target for MDG 5 is to reduce the maternal mortality ratio (MMR) by three-quarters from 1990 to 2015.[6] There is a widespread perception that progress in maternal mortality has been slow, and in many places non-existent.[7–9] Acceleration of progress in maternal mortality has received renewed policy attention in the USA through the Obama administration's proposed Global Health Initiative,[10] and high-profile civil society groups such as the White Ribbon Alliance continue to bring further attention.

The need for accurate monitoring of maternal mortality has long been recognised, both to advocate for resources and policy attention and to track progress.[11–13] Maternal mortality, however, is considered very difficult to measure.[14–17] Several efforts have been made over nearly three decades to improve the quality of information about maternal mortality, including the incorporation of sibling history modules in the Demographic and Health Surveys (DHS) and similar surveys;[18,19] the inclusion of questions about whether recent deaths were related to pregnancy in censuses;[20,21] and the use of record linkage or confidential enquiry to identify under-registration of maternal deaths in vital registration systems.[22,23]

Beginning in 1996, WHO sponsored the development of country estimates of maternal mortality for 1990, 1995, 2000, and 2005.[24–27] The most recent assessment of maternal mortality, which was jointly sponsored by WHO, UNICEF, UNFPA, and the World Bank, reported 576 300 maternal deaths globally in 1990, and

1

535 900 maternal deaths in 2005—a 0·48% yearly rate of decline.[7] The corresponding decrease in the global MMR (the number of maternal deaths per 100 000 live-births) was 0·37% per year. As a separate analysis, Hill and colleagues[7] estimated a rate of decline of 2·5% per year for a subset of 125 countries with more than one observation. For the two results to be consistent, a substantial proportion of the countries without multiple observations must have had increases in the MMR.

In view of the continued prominence of maternal mortality as a health and development goal, global rates and trends in maternal mortality need to be reassessed. Recent developments provide an opportunity for substantially improved estimates of maternal mortality. First, the Global Burden of Disease (GBD) study[28] has undertaken a detailed analysis of vital registration data to identify misclassified deaths from causes such as maternal mortality. Second, methodological advances allow for the correction of known biases in survey sibling history data, including whether sibling deaths are from maternal causes.[29] Third, population-based verbal autopsy studies have been done that measure maternal mortality both nationally and subnationally. Fourth, a systematic assessment of data sources for adult female mortality has provided estimates of mortality for women of reproductive age (15–49 years) from 1970 to 2010.[30] Finally, methodological devel-opments in other areas have provided improved methods for estimation. In this study, we used all available data to assess levels and trends in maternal mortality from 1980 to 2008 for 181 countries.

Methods

Definitions

Table 1 classifies, by timing and cause, the types of maternal deaths among pregnant or recently pregnant (up to 1 year) women that can be captured by different data systems. Deaths during pregnancy or less than 42 days after termination of pregnancy were defined as early, and those after 42 days up to 1 year were defined as late. Four groups of causes were identified: direct obstetric causes, causes aggravated by pregnancy (often called indirect), HIV infection, and incidental causes unrelated to pregnancy. Vital registration systems using International Classification of Diseases 10th revision (ICD 10) assign deaths in categories A, B, E, and F to chapter O. The ICD manual[31] and the MDG manual[32] recommend that the maternal mortality rate should include deaths in categories A, B, and C. Late maternal deaths and deaths from incidental causes other than

	Direct	Indirect	HIV	Incidental
Early maternal (<42 weeks)	A	B	C	D
Late maternal (>42 weeks and <1 year)	E	F		

Table 1: Definitions of maternal death and maternal mortality

HIV should not be included in international comparisons of the MMR.

Data sources

We systematically searched for data for maternal mortality from 1980 to the present. Data were divided into four types: vital registration systems; sibling history data from household surveys; data from censuses and surveys for deaths in the household; and published work reporting population-based studies of maternal mortality, both national and subnational.

Vital registration of data for cause of death is the most useful resource to measure maternal mortality. We constructed a dataset based mainly on the WHO mortality database,[33] and supplemented it by an internet search of national statistical offices. Several issues with vital registration data have to be taken into consideration in construction of a time series. First, periodic changes in the ICD rules and codes can lead to discontinuities that are not an indication of true trends. ICD 9 introduced two changes: clear definition of the 42-day period for a maternal death, and the inclusion of indirect causes of maternal death. ICD 10 explicitly added codes for late maternal deaths and made some changes in the coding practice for indirect causes.

Second, maternal deaths can be incorrectly assigned to other causes.[34] Causes that often include misclassified maternal deaths are disseminated intravascular coagulation (D65), peritonitis (K65), septicaemia (A41, A42), pulmonary embolism (I26), acute and chronic renal failure (N18 and N19), acute abdomen (R10), and hypovolaemic shock (R57.1).[23,28,35–37] Additionally, some maternal deaths can be assigned to ill-defined causes of death such as other ill-defined and unspecified causes of mortality (R99), unattended death (R98), and respiratory arrest (R09.2). Naghavi and colleagues[28] have produced a corrected vital registration dataset that provides 2186 country-years for 1980–2008. Correction for mis-classification on average increases maternal deaths in the vital registration country-years by 40% (range 0–260), which is consistent with published work examining under-registration of maternal deaths.[38–40] Care is needed in interpretation of previous studies because some include suicides and late maternal deaths as under-registered deaths, which are not included in the official maternal death definition for the MMR. In this analysis, we counted all deaths coded to the maternal chapter in the ICD as maternal deaths, encompassing codes O00–O99. Importantly, the addition of late maternal deaths in ICD 10[41] could have led to some inconsistencies in time trends, but this effect will mostly be small. On average in ICD-10 datasets, less than 2% of maternal deaths are coded as late maternal, but there are some important exceptions, such as the USA.

We analysed sibling history microdata from the DHS[42] and the US Centers for Disease Control and Prevention (CDC) International Reproductive Health Surveys,[43]

totalling 97 surveys from 53 countries. Sibling histories ask respondents to report for all their siblings, including sex, date of birth, current status (alive or dead), and current age or age at death. For sisters who died between 15 and 49 years of age, questions identify whether the death occurred during pregnancy, childbirth, or within 6 weeks or 2 months after the termination of pregnancy. We pooled surveys together within countries and applied Gakidou-King weights to correct for survivor bias.[29,44] With use of these weights, we estimated the age-specific proportion of maternal deaths in women of reproductive age for 5-year periods starting from the time of the most recent survey in each country, for a maximum of 15 years before the most distant survey in each country.

A further 26 observations were based on survey or census information about deaths in households and whether the death occurred during pregnancy, childbirth, or within 6 weeks of delivery for women of reproductive age. Both the sibling history data and the household death data captured pregnancy-related deaths (categories A, B, C, and D in table 1) and thus could be an overestimate of the proportion of deaths attributable to maternal causes.

We undertook a literature review to identify published estimates of maternal mortality. We searched PubMed for the search terms "maternal mortality" and "country name" for all countries not part of the Organisation for Economic Co-operation and Development (OECD); we excluded OECD countries from this search because most of these countries have high-quality vital registration data. We also reviewed all citations in the WHO publication *Maternal Mortality: a Global Factbook*.[45] This search produced 9659 titles, of which 593 abstracts were identified as potentially relevant. 209 papers were identified from these abstracts, from which 61 studies were extracted and added to the database. We also did a search with the term "verbal autopsy" and identified 1042 titles, yielding a further 22 studies with data for maternal causes. We also searched the Chinese language website Wanfang Data with the search term "maternal mortality surveillance" and identified eight papers. Studies were excluded if they were based in a hospital or clinic, were intervention studies, used the indirect sisterhood method, or were judged to be of low quality. Indirect sisterhood studies were excluded because, at best, they provide a summary assessment of maternal mortality covering a long period before the survey.[46,47]

Before we undertook statistical analysis of the dataset combining all these data sources, implausible values or outliers in the data were identified via qualitative review. 314 of 2651 (11·8%) site-years of data were excluded via expert review with the following criteria: outliers relative to other measurements in the same country, outliers relative to what would be expected on the basis of the model predictions, and outliers relative to MMRs observed in countries with similar levels of development and health-system access. Many of these outliers were from subnational studies with implausibly low rates. These points are plotted on the graphs, but did not contribute to the estimation process.

Statistical analysis

From each of the data sources described above, we extracted the proportion of all female deaths that were attributable to maternal causes for 5-year age-groups in the reproductive age period (15–49 years). These proportions were applied to the new time series of adult female mortality based on a systematic assessment of all adult mortality sources for each country in 1970–2010.[30] For computation of MMRs, we used population and livebirths from the UN Population Division.[48]

We modelled both the count of maternal deaths by use of generalised negative binomial regression and the log of the maternal death rate with ordinary least squares (OLS) and robust regression (the webappendix pp 1 and 7 provides details on the sensitivity analysis). We also tested Poisson regression to model the count, but found its performance to be substantially worse than that with the generalised negative binomial (data not shown). On the basis of tests of predictive validity, we selected the modelling strategy with the best out-of-sample performance. Our modelling strategy was a variant of spatial-temporal regression that has been used in disciplines as disparate as geology, agriculture, and meteorology.[49,50] The basic form of the model is:

$$\ln\left(\mu_{a,i,t}\right) = \beta X_{a,i,t} + M_{a,i,t} + e$$

where μ is the maternal death rate, a is age, i is country, and t is a year. $X_{a,i,t}$ is a vector of covariates that explains variation in maternal mortality rates. Substantial variation in the maternal mortality rate is not explained by these covariates, and the unexplained component $M_{a,i,t}$ varies systematically over time and across countries. Spatial-temporal regression models capture this systematic variation through local regression with weights on time and space.[51] For Loess regression,[52] weighting occurs only in time and not across countries. e is the stochastic error in the maternal mortality rate due to sampling and to unmeasured factors that are not correlated in time and space.

The model was estimated in two stages: we first estimated the linear model $\beta X_{a,i,t}$ and then used spatial-temporal local regression to estimate $M_{a,i,t}$. Our choice for the linear model was dependent on available covariates; included covariates had to be comparable, complete time series for 1980–2008. On the basis of published work and previous theory, we selected the total fertility rate (TFR), gross domestic product (GDP) per head, HIV seroprevalence, neonatal mortality, age-specific female education, and indicators for 5-year age-groups (15–19, 20–24, 25–29, 30–34, 35–39, 40–44, and 45–49 years). We considered including skilled birth

attendance, but found it was collinear with other covariates ($r=0·73$ with neonatal mortality, $r=0·72$ with education, $r=0·67$ with GDP per head) and did not improve model performance (data not shown). We examined the univariate relation of each covariate with the dependent variable and with the model residuals to select the appropriate transformation of each covariate. We used robust regression, which uses Huber and biweights to keep the effect of outliers on the parameter estimates to a minimum.[53]

To estimate $M_{a,i,t}$ we applied spatial-temporal re-gression to the residuals over space and time from this

	Site-years of observation
Vital registration	2186
Sibling histories	204
Surveillance systems	20
Census/survey deaths in household	26
National VA	35
Subnational VA	180
Total	2651

VA=verbal autopsy.

Table 2: **Summary of site-years of observation by source, 1980–2008**

A India

B Mali

Figure 1: **Predicted maternal mortality ratio (MMR) per 100 000 livebirths for India (A) and Mali (B)**
SRS=sample registration system. NFHS=National Family Health Surveys. VA=verbal autopsy. HH=household. DLHS=District Level Household Surveys.

first-stage model. The webappendix p 2 provides details of the space and time weights used for the spatial-temporal local regression. Weights were also included across age-groups so that findings for one age-group were informed by adjacent age-groups. Spatial cor-relation was allowed only within the 21 GBD regions used in this study. If a specific country had both national and subnational data, we assigned a fifth of the weight in the local regression to subnational studies and four-fifths of the weight to national studies to prevent excessive influence from subnational studies. Every local regression was estimated with OLS. We truncated observed residuals to three SDs of the mean of the residuals to reduce the effect of extreme outliers on the spatial-temporal regression.

To validate our modelling approach, we undertook extensive tests of predictive validity. Four different types of predictive validity tests were undertaken: (1) withholding a random sample of 20% of country-years of data; (2) withholding all data from a random sample of 20% of countries; (3) withholding the first 20% of years of data for all countries; and (4) withholding the last 20% of years for all countries. For each of these datasets for which samples of the data had been withheld, we estimated our model including the linear and spatial-temporal local regression components and compared predictions of the MMR to the real data in the 20% of the sample withheld. We repeated these tests 30 times to ensure that our results were not an artifact of a specific random sample of the data being withheld. We also examined the predictive validity of a range of alternative model specifications and model families (webappendix p 8). We present results only for the linear component and the full model for the best performing strategy.

Our uncertainty estimates incorporated four sources of uncertainty: sampling uncertainty in the underlying measurements of the maternal mortality rate from the data sources; parameter uncertainty in both the linear model and the spatial-temporal local regressions;[54] and an estimate of fundamental uncertainty incorporating both the effect of non-sampling variance and systematic variation in the expected value not captured in the model. This conservative approach overestimates uncertainty because we would not want to propagate non-sampling variance into the estimate of uncertainty in the expected value of the maternal death rate. The webappendix pp 3–5 provides further details.

HIV-related maternal deaths were of particular interest. We undertook a counterfactual analysis, exploring the effect on maternal mortality of reducing HIV seroprevalence to zero. We generated counterfactual estimates of HIV-related deaths by use of the final estimated model (including both the linear and $M_{a,i,t}$ components), but set the HIV and HIV-squared covariates to zero. All analyses were done in Stata/MP (version 11.0).
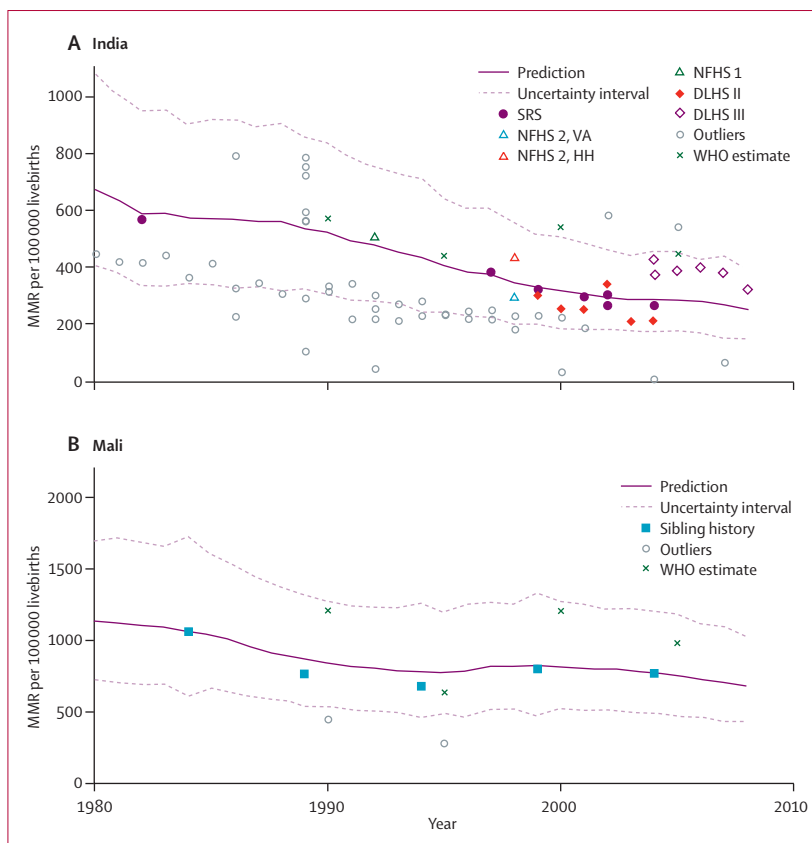
Role of the funding source

The sponsors of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all data in the study and had final responsibility for the decision to submit for publication.

Results

Table 2 shows the source of the 2651 observations included in the dataset. Vital registration data were the dominant source, accounting for 2186 (82%) of the total observations. Other sources contributed 465 observations. 21 countries had no empirical observations during 1980–2008 (webappendix p 10), the largest of which were Angola and Saudi Arabia in terms of births; together these countries accounted for 2·2% of global births. As a region, north Africa and the Middle East was particularly weak in terms of data density, apart from Egypt, Kuwait, and Iran. Because of the availability of sibling history data, many countries in sub-Saharan Africa had more than five observations. Most high-income countries had a nearly complete time series of vital registration data, whereas other low-income settings, such as Bangladesh and Tanzania, had substantial data from surveys and subnational studies.

Figure 1 and webappendix pp 11–12 show four different data scenarios along with our final predictions for the MMR. We had a complete time series of vital registration data from Mexico (webappendix p 11), showing a consistent, downward trend in the MMR from 1980 to 1995, and then a period of little change. The webappendix p 12 shows both vital registration and sibling history data from the Dominican Republic, for which the results of the sibling histories showed higher rates in every year. Our model estimates incorporated both sources of data. India (figure 1A) had the largest number of maternal deaths of any country, and several data sources were available to estimate maternal mortality. Figure 1A shows substantial inconsistencies between sources. In some cases, sources cover only a component of the national population, which could explain these patterns. For example, the Survey of Causes of Death, Rural[55] covers only rural populations and the Medical Certification of Causes of Death covers largely urban populations. We chose to use only national sources with the least apparent bias: the sample registration system,[56] the National Family Health Surveys (NFHS rounds 1 and 2), and the District Level Household Surveys (DLHS rounds 2 and 3). Together, these sources suggested a substantial decrease in maternal mortality, although sources varied substantially for any specific year. The most recent round of the DLHS provided substantially higher estimates than did previous rounds, but was in line with the NFHS 2. Figure 1B shows estimates from Mali, for which we had three DHS including a sibling history module (in 1995, 2001, and 2006). Similar data plots, along with the final

estimates, are available for all countries in the webappendix pp 21–202.

The webappendix p 7 shows the β coefficients from the linear model. TFR showed the strongest relation with maternal mortality of all covariates; greater fertility was associated with increased maternal mortality. Of the covariates included in the model, GDP per head had the next strongest relation, with higher GDP being associated with lower rates of maternal mortality. All covariates were significant in the linear model (p<0·001), and were in the expected direction.

The webappendix p 8 shows predictive validity results for the four out-of-sample tests. All measures of out-of-sample performance showed better performance with the spatial-temporal model than with the linear model. In terms of median relative error, which is resistant to extreme outliers, for improvements relevant to 160 countries with some data, we noted a 61% (uncertainty interval 53–68) reduction in the error rate for prediction of missing country years, a 49% reduction for forecasting, and a 54% reduction for back-casting. Average relative error was higher than were the other measures, but also showed the substantial improvement with spatial-temporal regression methods.

We estimated that there were 342 900 (uncertainty interval 302 100–394 300) maternal deaths worldwide in 2008, down from 526 300 (446 400–629 600) in 1980, which is a yearly rate of decline of 1·5%. In a counterfactual scenario of a global HIV seroprevalence of zero, this number would be 281 500 (243 900–327 900), compared with 526 200 (444 500–633 900) in 1980, which is a rate of decline of 2·2%. Figure 2 shows the trends in the global number of deaths. With the onset of the HIV epidemic in the early 1990s, there was a slowing in the decline of global maternal deaths, with a rate of decline of 1·8% between 1980 and 1990 and 1·4% from 1990 to 2008. The MMR showed a similar consistent decline; we estimated the global MMR to be 251 (221–289) per 100 000 livebirths in 2008, down from 320 (272–388)
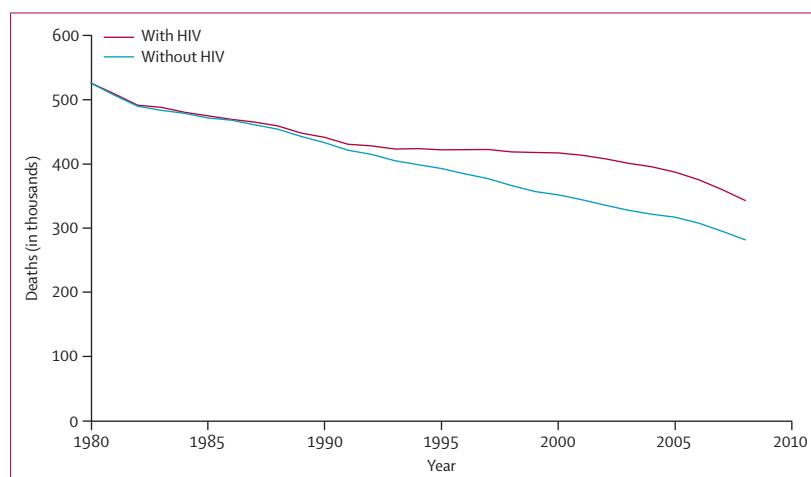

Figure 2: Global maternal deaths, 1980–2008

in 1990 and 422 (358–505) in 1980, which is a yearly rate of decline of 1·8%. For comparison, the MDG target of a 75% reduction from 1990 MMRs by 2015 would need a yearly rate of decline of 5·5%. In the absence of HIV prevalence, we estimated that the global MMR in 2008 would be 206 (179–240).

	1980	1990	2000	2008
Asia-Pacific, high income				
Brunei	77 (47–126)	62 (39–97)	44 (29–66)	37 (25–54)
Japan	20 (17–22)	12 (10–13)	8 (7–9)	7 (6–8)
Singapore	18 (13–23)	12 (9–16)	14 (10–18)	16 (11–21)
South Korea	45 (39–52)	18 (16–21)	14 (13–16)	11 (10–13)
Total	28 (26–31)	14 (13–15)	10 (9–11)	8 (8–9)
Asia, central				
Armenia	31 (24–38)	36 (31–41)	39 (30–49)	30 (21–39)
Azerbaijan	71 (59–83)	39 (33–44)	50 (43–58)	37 (30–45)
Georgia	40 (32–48)	28 (24–33)	27 (21–32)	37 (27–48)
Kazakhstan	62 (54–71)	61 (54–69)	58 (51–66)	44 (38–51)
Kyrgyzstan	71 (60–83)	65 (57–75)	71 (61–83)	69 (58–82)
Mongolia	959 (745–1193)	404 (316–501)	257 (203–320)	207 (163–255)
Tajikistan	128 (110–148)	90 (78–101)	72 (62–84)	46 (38–55)
Turkmenistan	77 (64–90)	67 (58–77)	41 (33–50)	22 (18–26)
Uzbekistan	72 (62–83)	61 (54–69)	49 (43–56)	45 (39–51)
Total	105 (96–115)	72 (68–77)	60 (56–64)	48 (45–52)
Asia, east				
China	165 (144–187)	87 (77–99)	55 (49–62)	40 (35–46)
North Korea	130 (47–298)	68 (27–148)	70 (26–154)	64 (24–143)
Taiwan	38 (23–56)	26 (15–37)	12 (7–16)	14 (8–20)
Total	162 (142–183)	86 (76–98)	55 (48–62)	40 (35–46)
Asia, south				
Afghanistan	1640 (632–3527)	1261 (491–2703)	1957 (729–4356)	1575 (594–3396)
Bangladesh	1329 (800–2105)	724 (420–1196)	574 (344–900)	338 (195–546)
Bhutan	2116 (814–4749)	1145 (437–2539)	481 (186–1063)	255 (100–561)
India	677 (408–1080)	523 (310–835)	318 (190–506)	254 (154–395)
Nepal	865 (536–1351)	471 (290–722)	343 (213–533)	240 (149–370)
Pakistan	746 (411–1267)	541 (327–848)	415 (235–679)	376 (230–587)
Total	788 (568–1099)	560 (391–794)	402 (293–555)	323 (232–444)
Asia, southeast				
Burma	1052 (401–2171)	662 (249–1484)	411 (155–874)	219 (87–495)
Cambodia	499 (324–751)	409 (237–658)	511 (322–786)	266 (171–398)
East Timor	1445 (549–3201)	1016 (402–2184)	953 (363–2081)	929 (374–2077)
Indonesia	423 (274–631)	253 (148–411)	290 (166–477)	229 (133–379)
Laos	1780 (1172–2715)	1215 (796–1816)	630 (377–996)	339 (215–511)
Malaysia	137 (118–160)	76 (66–89)	59 (51–67)	42 (37–49)
Maldives	1057 (405–2277)	366 (145–776)	125 (48–272)	75 (28–167)
Mauritius	122 (100–144)	65 (53–77)	34 (26–43)	28 (21–36)
Philippines	443 (289–661)	174 (112–261)	103 (65–160)	84 (53–130)
Sri Lanka	92 (81–105)	52 (46–60)	40 (36–46)	30 (25–35)
Thailand	115 (101–131)	44 (39–50)	43 (38–48)	47 (42–53)
Vietnam	336 (218–504)	158 (102–233)	84 (55–125)	64 (42–95)
Total	438 (337–573)	248 (187–337)	212 (155–293)	152 (112–212)
Australasia				
Australia	9 (7–10)	6 (5–7)	5 (4–6)	5 (4–6)
New Zealand	12 (9–16)	11 (8–14)	8 (6–10)	8 (6–11)
Total	9 (8–11)	7 (6–8)	6 (5–7)	6 (5–7)
				(Continues on next page)

The webappendix pp 14–15 provides insights into the changing regional composition of maternal deaths. The number of births globally varied between 124 million in 1980 and 136 million in 2008. The regional composition shifted slowly towards sub-Saharan Africa, with the most noticeable change being the reduction in the number of births in east Asia. The proportion of global maternal deaths in sub-Saharan Africa increased from 23% (18–27) in 1980 to 52% (45–59) in 2008, resulting from both the accelerated increase in the number of maternal deaths in the early 1990s and declines in Asia.

The webappendix pp 16–19 shows how trends in the MMR have differed substantially across regions. Five regions had MMRs below 20 per 100000 in 2008: Australasia, western Europe, Asia-Pacific high-income, central Europe, and North America high-income. In these five regions, the largest declines occurred in central Europe, with a decrease of more than two-thirds since 1980. Regions in eastern Europe, east Asia, southern Latin America, central Asia, tropical Latin America, and central Latin America had MMRs less than 60 in 2008. East Asia had a decline greater than three-quarters over

	1980	1990	2000	2008
(Continued from previous page)				
Caribbean				
The Bahamas	120 (81–163)	80 (56–104)	66 (50–86)	59 (45–77)
Barbados	99 (72–133)	86 (65–110)	94 (68–121)	78 (54–104)
Belize	120 (83–168)	88 (65–120)	87 (68–107)	74 (55–94)
Cuba	62 (54–71)	47 (41–54)	51 (45–59)	40 (34–46)
Dominican Republic	127 (78–199)	96 (58–154)	74 (45–116)	66 (40–103)
Grenada	155 (60–341)	99 (38–217)	66 (24–143)	47 (18–102)
Guyana	216 (161–281)	162 (134–192)	164 (139–191)	143 (110–178)
Haiti	1122 (708–1726)	898 (562–1413)	783 (488–1244)	582 (352–902)
Jamaica	82 (69–97)	50 (40–61)	37 (29–47)	34 (27–44)
Saint Lucia	162 (61–369)	92 (33–197)	57 (22–125)	46 (18–99)
Saint Vincent and the Grenadines	174 (64–374)	82 (31–181)	59 (23–130)	45 (17–97)
Suriname	175 (140–216)	106 (82–131)	128 (102–159)	116 (91–145)
Trinidad and Tobago	68 (55–82)	66 (55–78)	52 (40–64)	40 (30–51)
Total	426 (293–613)	348 (234–518)	323 (218–483)	254 (168–372)
Europe, central				
Albania	58 (49–69)	36 (31–43)	12 (9–15)	8 (6–11)
Bosnia and Herzegovina	58 (45–73)	32 (25–40)	20 (15–26)	12 (9–15)
Bulgaria	36 (31–43)	34 (29–39)	36 (30–42)	28 (22–35)
Croatia	21 (15–27)	15 (11–19)	15 (11–19)	14 (11–19)
Czech Republic	20 (16–25)	12 (10–15)	7 (5–9)	7 (5–9)
Hungary	22 (18–26)	16 (14–19)	10 (8–12)	7 (5–9)
Macedonia, the Former Yugoslav Republic of	28 (20–38)	20 (14–27)	19 (13–25)	17 (11–23)
Montenegro	79 (31–178)	33 (13–72)	27 (10–60)	19 (8–41)
Poland	22 (19–25)	21 (19–24)	10 (9–12)	7 (6–9)
Romania	139 (122–157)	92 (80–104)	42 (37–48)	26 (22–31)
Serbia	15 (11–20)	12 (8–16)	10 (8–13)	9 (6–11)
Slovakia	19 (14–25)	13 (9–18)	8 (6–11)	7 (5–9)
Slovenia	30 (20–43)	16 (11–22)	21 (15–29)	19 (13–26)
Total	47 (43–51)	34 (31–37)	18 (17–20)	13 (12–14)
Europe, eastern				
Belarus	30 (24–35)	28 (24–32)	26 (21–31)	19 (15–23)
Estonia	34 (26–46)	28 (22–36)	24 (18–33)	22 (16–33)
Latvia	37 (30–45)	30 (24–36)	24 (18–31)	18 (13–25)
Lithuania	33 (26–40)	22 (18–27)	18 (13–22)	16 (12–21)
Moldova	58 (49–68)	42 (36–48)	31 (25–37)	20 (16–26)
Russian Federation	60 (52–68)	48 (43–55)	45 (39–51)	34 (30–39)
Ukraine	44 (38–50)	35 (31–40)	35 (31–40)	30 (26–34)
Total	54 (49–60)	43 (39–48)	41 (37–45)	32 (29–35)
				(Continues on next page)