MATERNAL MORTALITY IN 2000:
Estimates Developed by WHO, UNICEF and UNFPA

Acknowledgements

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Executive Summary

Reduction of maternal mortality is one of the major goals of several recent international conferences and has been included within the Millennium Development Goals (MDGs). However, because measuring maternal mortality is difficult and complex, reliable estimates of the dimensions of the problem are not generally available and assessing progress towards the goal is difficult. In recent years, new ways of measuring maternal mortality have been developed, with the needs and constraints of developing countries in particular in mind. As a result, there is considerably more information available today than was the case even a few years ago. Nonetheless, problems of underreporting and misclassification are endemic to all methods and estimates that are based on household surveys are subject to wide margins of uncertainty because of sample size issues. For all these reasons, it is difficult to compare the data obtained from different sources and to assess the overall magnitude of the problem.

In response to these challenges and in order to improve the information base, WHO, UNICEF and UNFPA have developed an approach to estimating maternal mortality that seeks both to generate estimates for countries with no data and to correct available data for underreporting and misclassification. A dual strategy is used which involves adjusting available country data and developing a simple model to generate estimates for countries without reliable information. The approach, with some variations, was used to develop estimates for maternal mortality in 1990 and 1995 and has been used again for generating these estimates for the year 2000.

On the basis of the present exercise, the estimated number of maternal deaths in 2000 for the world was 529,000 (Table 1). These deaths were almost equally divided between Africa (251,000) and Asia (253,000), with about 4 per cent (22,000) occurring in Latin America and the Caribbean, and less than one per cent (2,500) in the more developed regions of the world. In terms of the Maternal Mortality Ratio (MMR), the world figure is estimated to be 400 per 100,000 live births. By region, the MMR was highest in Africa (830), followed by Asia (330), Oceania (240), Latin America and the Caribbean (190), and the developed countries (20).

The country with the highest estimated number of maternal deaths is India (136,000), followed by Nigeria (37,000), Pakistan (26,000), Democratic Republic of Congo and Ethiopia (24,000 each), the United Republic of Tanzania (21,000), Afghanistan (20,000), Bangladesh (16,000), Angola, China, Kenya (11,000 each), Indonesia and Uganda (10,000 each). These 13 countries account for 67 per cent of all maternal deaths.

However, the number of maternal deaths is the product of the total number of births and obstetric risk per birth, described by the MMR. On a risk per birth basis, the list looks rather different. With the sole exception of Afghanistan, the countries with the highest MMRs are in Africa. The highest MMRs of 1,000 or greater, are, in rank order, Sierra Leone (2,000), Afghanistan (1,900), Malawi (1,800), Angola (1,700), Niger (1,600), the United Republic of Tanzania (1,500), Rwanda (1,400), Mali (1,200), Somalia, Zimbabwe, Chad, Central African Republic, Guinea Bissau (1,100 each), Kenya, Mozambique, Burkina Faso, Burundi, and Mauritania (1,000 each).

Table 1. 2000 Maternal mortality estimates by United Nations MDG regions

REGION	MATERNAL MORTALITY RATIO (MATERNAL DEATHS PER 100,000 LIVE BIRTHS)	NUMBER OF MATERNAL DEATHS	LIFETIME RISK OF MATERNAL DEATH, 1 IN:
WORLD TOTAL	400	529,000	74
DEVELOPED REGIONS[a]	20	2,500	2,800
Europe	24	1,700	2,400
DEVELOPING REGIONS	440	527,000	61
Africa	830	251,000	20
Northern Africa[b]	130	4,600	210
Sub-Saharan Africa	920	247,000	16
Asia	330	253,000	94
Eastern Asia	55	11,000	840
South-Central Asia	520	207,000	46
South-Eastern Asia	210	25,000	140
Western Asia	190	9,800	120
Latin America & the Caribbean	190	22,000	160
Oceania	240	530	83

The Maternal Mortality Ratio is a measure of the risk of death once a woman has become pregnant (see section 2 below). A more dramatic assessment of risk that takes into account both the probability of becoming pregnant and the probability of dying as a result of that pregnancy cumulated across a woman's reproductive years is the lifetime risk of maternal death. Table 1 shows that the lifetime risk of death is highest in sub-Saharan Africa, with as many as one woman in 16 facing the risk of maternal death in the course of her lifetime, compared with one in 2,800 in developed regions.

The purpose of these estimates is to draw attention to the existence and likely dimensions of the problem of maternal mortality. They are indicative of orders of magnitude and are not intended to serve as precise estimates. In addition, these estimates can serve to stimulate greater awareness of and attention to the challenge of measuring maternal mortality. Following the publication of the 1990 and 1995 estimates, a number of countries have been undertaking special studies to assess the completeness and adequacy of their vital registration and health information systems. For other countries, particularly where the only source of data is from sisterhood surveys, the estimates can serve to draw attention to the potential pitfalls associated with such indirect measurement techniques.

The margins of uncertainty associated with the estimated MMRs are very large and the estimates should not, therefore, be used to monitor trends in the short term. In addition, cross-country comparisons should be treated with considerable circumspection because different strategies are used to derive the estimates for different countries rendering comparisons fraught with difficulty.

[a] Includes Europe, Canada, United States of America, Japan, Australia and New Zealand which are excluded from the regional totals.
[b] Excludes Sudan which is included in sub-Saharan Africa.

Introduction

Background

Reduction of maternal mortality has been endorsed as a key development goal by countries and is included in consensus documents emanating from international conferences such as the World Summit for Children in 1990, the International Conference on Population and Development in 1994 and, the Fourth World Conference on Women in 1995, and their respective five-year follow-up evaluations of progress in 1999 and 2000, the Millennium Declaration in 2000 and the United Nations General Assembly Special Session on Children in 2002.

In order to monitor progress, efforts have to be made to address the lack of reliable data, particularly in settings where maternal mortality is thought to be most serious. The inclusion of maternal mortality reduction in the Millennium Development Goals (MDGs) stimulates increased attention to the issue and creates additional demands for information.[1]The first set of global and national estimates for 1990 was developed in order to strengthen the information base[2]. WHO, UNICEF and UNFPA undertook a second effort to produce global and national estimates for the year 1995.[3] Given that a substantial amount of new data has become available since then, it was decided to repeat the exercise. This document presents estimates of maternal mortality by country and region for the year 2000. It describes the background, rationale and history of estimates of maternal mortality and the methodology used in 2000 compared with the approaches used in previous exercises in 1990 and 1995.

The document opens by summarising the complexity involved in measuring maternal mortality and the reasons why such measurement is subject to uncertainty, particularly when it comes to monitoring progress. Subsequently, the rationale for the development of estimates of maternal mortality is presented along with a description of the process through which this was accomplished for the year 2000. This is followed by an analysis and interpretation of the results, pointing out some of the pitfalls that may be encountered in attempting to use the estimates to draw conclusions about trends.[2,3] The final part of the document presents a summary of the kind of information needed to build a fuller understanding of both the levels and trends in maternal mortality and the interventions needed to achieve sustained reductions in the coming few years.

Maternal mortality: the measurement challenge

Definitions and measures of maternal mortality

Definitions

The Tenth Revision of the International Classification of Diseases (ICD 10) defines a maternal death as the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management but not from accidental or incidental causes.[4]

The 42-day limit is somewhat arbitrary and in recognition of the fact that modern life-sustaining procedures and technologies can prolong dying and delay death, ICD-10 introduced a new category, namely the *late maternal death* which is defined as the *death of a woman from direct or indirect obstetric causes more than 42 days but less than one year after termination of pregnancy*.

According to ICD-10, maternal deaths should be divided into two groups:

Direct obstetric deaths are those resulting from obstetric complications of the pregnant state (pregnancy, labour and the puerperium), from interventions, omissions, incorrect treatment, or from a chain of events resulting from any of the above.

Indirect obstetric deaths are those resulting from previous existing disease or disease that developed during pregnancy and which was not due to direct obstetric causes, but was aggravated by physiologic effects of pregnancy.

The drawback of this definition is that maternal deaths can escape being so classified because the precise cause of death cannot be given even though the fact of the woman having been pregnant is known. Such under-registration is frequent in both developing and developed countries.

Deaths from "accidental or incidental" causes have historically been excluded from maternal mortality. However, in practice, the distinction between incidental and indirect causes of death is difficult to make. To facilitate the identification of maternal deaths under circumstances where cause of death attribution is inadequate, ICD-10 introduced a new category, that of *pregnancy-related death,* which is defined as:

the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the cause of death.

In practical terms then, there are two distinct approaches to identifying maternal deaths, one based on medical cause of death following the ICD definition of maternal death, and the other based on timing of death relative to pregnancy, that is, using the ICD definition of pregnancy-related death. This has important implications for the approaches to measurement described in section 4 below.

Measures of maternal mortality

There are three distinct measures of maternal mortality in widespread use: the maternal mortality ratio, the maternal mortality rate, and the lifetime risk of maternal death. The most commonly used measure is the maternal mortality ratio, that is the number of maternal deaths during a given time period per 100 000 live births during the same time period. This is a measure of the risk of death once a woman has become pregnant. The maternal mortality rate, that is, the number of maternal deaths in a given period per 100 000 women of reproductive age during the same time period, reflects the frequency with which women are exposed to risk through fertility. The lifetime risk of maternal death takes into account both the probability of becoming pregnant and the probability of dying as a result of that pregnancy cumulated across a woman's reproductive years. In theory, the lifetime risk is a cohort measure but it is usually calculated with period measures for practical reasons. It can be approximated by multiplying the maternal mortality rate by the length of the reproductive period (around 35 years). Thus, the lifetime risk is calculated as [1 - (1 - maternal mortality rate)^{35}].

Why maternal mortality is difficult to measure

Maternal mortality is difficult to measure for both conceptual and practical reasons. Maternal deaths are hard to identify precisely because this requires information about deaths among women of reproductive age, pregnancy status at or near the time of death, and the medical cause of death.[4] All three components can be difficult to measure accurately, particularly in settings where deaths are not comprehensively reported through the vital registration system and where there is no medical certification of cause of death. Moreover, even where overall levels of maternal mortality are high, maternal deaths are nonetheless relatively rare events and thus prone to measurement error. As a result, all existing estimates of maternal mortality are subject to greater or lesser degrees of uncertainty.

Broadly speaking, countries fall into one of four categories:

- Those with complete civil registration and good cause of death attribution - though even here, misclassification of maternal deaths can arise, for example, if the pregnancy status of the woman was not known or recorded, or the cause of death was wrongly ascribed to a non-maternal cause.[1]
- Those with relatively complete civil registration in terms of numbers of births and deaths but where cause of death is not adequately classified; cause of death is routinely reported for only 78 countries or areas, covering approximately 35% of the world's population.
- Those with no reliable system of civil registration where maternal deaths - like other vital events - go unrecorded. Currently, this is the case for most countries with high levels of maternal mortality.
- Those with estimates of maternal mortality based on household surveys, usually using the direct or indirect sisterhood methods. These estimates are not only imprecise as a result of sample size considerations, but they are also based on a reference point some time in the past, at a minimum 6 years prior to the survey and in some cases much longer than this (see section 4 below).

WHO, UNICEF and UNFPA have developed estimates of maternal mortality primarily with the information needs of this last group of countries in mind but also as a way of adjusting for under-reporting and misclassification in data for other countries. A dual strategy is used that adjusts existing country information to account for problems of under-reporting and misclassification and uses a simple statistical model to generate estimates for countries without reliable data.

Approaches for measuring maternal mortality

Commonly-used approaches for obtaining data on levels of maternal mortality vary considerably in terms of methodology, source of data and precision of results. The main approaches are described briefly below. As a general rule, maternal deaths are identified by medical certification in the vital registration approach, but generally on the basis of the time of death definition relative to pregnancy in household surveys (including sisterhood surveys), censuses and in Reproductive Age Mortality Studies (RAMOS).

Vital registration

In developed countries, information about maternal mortality derives from the system of vital registration of deaths by cause. Even where coverage is complete and all deaths medically certified, in the absence of active case-finding, maternal deaths are frequently missed or misclassified.[5,6,7,8,9] In many countries, periodic confidential enquiries or surveillance are used to assess the extent of misclassification and under-reporting. A review of the evidence shows that registered maternal

deaths should be adjusted upwards by a factor of 50% on average. Few developing countries have a vital registration system of sufficient coverage and quality to enable it to serve as the basis for the assessment of levels and trends in cause-specific mortality including maternal mortality.

Direct household survey methods

Where vital registration data are not appropriate for the assessment of cause-specific mortality, the use of household surveys provides an alternative. However, household surveys using direct estimation are expensive and complex to implement because large sample sizes are needed to provide a statistically reliable estimate. The most frequently quoted illustration of this problem is the household survey in Addis Ababa, Ethiopia, where it was necessary to interview more than 32,300 households to identify 45 deaths and produce an estimated MMR of 480. At the 95% level of significance this gives a confidence interval of plus or minus about 30%, i.e. the ratio could lie anywhere between 370 and 660.[10] The problem of wide confidence intervals is not simply that such estimates are imprecise. They may also lead to inappropriate interpretation of the figures. For example, using point estimates for maternal mortality may give the impression that the MMR is significantly different in different settings or at different times whereas, in fact, maternal mortality may be rather similar because the confidence intervals overlap.

Indirect sisterhood method

The sisterhood method is a survey-based measurement technique that in high-fertiity populations substantially reduces sample size requirements because it obtains information by interviewing respondents about the survival of all their adult sisters. Although sample size requirements may be reduced, the problem of wide confidence intervals remains. Furthermore, the method provides a retrospective rather than a current estimate, averaging experience over a lengthy time period (some 35 years, with a mid point around 12 years before the survey).[11] For methodological reasons, the indirect method is not appropriate for use in settings where fertility levels are low [(Total Fertility Rate (TFR) <4)] or where there has been substantial migration, civil strife, war or other causes of social dislocation.

Direct sisterhood method

The Demographic and Health Surveys (DHS) use a variant of the sisterhood approach, the “direct” sisterhood method.[12] This relies on fewer assumptions than the original method but it requires larger sample sizes and the information generated is considerably more complex to collect and to analyse. The direct method does not provide a current estimate of maternal mortality but the greater specificity of the information permits the calculation of a ratio for a more recent period of time. Results are typically calculated for a reference period of seven years before the survey, approximating a point estimate some 3 to 4 years before the survey. Because of relatively wide confidence intervals, the direct sisterhood method cannot be used to monitor short-term changes in maternal mortality or to assess the impact of safe motherhood programmes. The Demographic and Health Surveys have published an in-depth review of the results of the DHS sisterhood studies (direct and indirect methods) and have advised against the duplication of surveys at short time-intervals.[13] WHO and UNICEF have issued guidance notes to potential users of sisterhood methodologies, describing the circumstances in which it is or is not appropriate to use the methods and explaining how to interpret the results.[14]

Reproductive Age Mortality Studies

The Reproductive Age Mortality Study - RAMOS - involves identifying and investigating the causes of all deaths of women of reproductive age. This method has been successfully applied in countries with good vital registration systems to calculate the extent of misclassification and in countries without vital registration of deaths.[9,15,16,17,18] Successful studies in countries lacking complete vital registration use multiple and varied sources of information to identify deaths of women of reproductive age; no single source identifies all the deaths. Subsequently, interviews with household members and health care providers and reviews of facility records are used to classify the deaths as maternal or otherwise. Properly conducted, the RAMOS approach is considered to provide the most complete estimation of maternal mortality but can be complex and time-consuming to undertake, particularly on a large scale.

Verbal autopsy

Where medical certification of cause of death is not available, some studies assign cause of death using verbal autopsy techniques.[19] However, the reliability and validity of verbal autopsy for assessing cause of death in general and identifying maternal deaths in particular, has not been established. The method may fail to correctly identify a proportion of maternal deaths, particularly those occurring early in pregnancy (ectopic, abortion-related), those in which the death occurs some time after the termination of pregnancy (sepsis, organ failure), and indirect causes of maternal death (malaria, HIV/AIDS).

Census

There is growing interest in the use of decennial censuses for the generation of data on maternal mortality. A high-quality decennial census could include questions on deaths in the household in a defined reference period, often one or two years, followed by more detailed questions which would permit the identification of maternal deaths on the basis of time of death relative to pregnancy (verbal autopsy). The weaknesses of the verbal autopsy method have already been noted. Nonetheless, the advantages of such an approach are that it would generate both national and subnational figures and that it would be possible to undertake analysis according to the characteristics of the household. Trend analysis would be possible because sampling errors would be eliminated or greatly reduced. However, data obtained from enquiries into recent deaths in the household in a census require careful evaluation, and often adjustment. A number of countries have used the census to generate maternal mortality figures and work is under way to assess the extent to which such approaches may prove of value in measuring maternal mortality.[20]

The development of 2000 estimates of maternal mortality

Process for developing the 2000 estimates

In developing the 2000 estimates, for reasons of comparability, and because of a lack of clear indications that there was a better alternative, WHO, UNICEF and UNFPA followed the broad methodology of the 1990 and 1995 exercises. This involved a dual strategy, adjusting nationally reported data using specific criteria, and generating model-based estimates for countries with no data. A detailed description of the methodology is available elsewhere.[21] The most significant change in 2000 compared with 1995 was the approach used to take account of the impact of HIV-related mortality. The WHO Evidence and Information for Health Policy Cluster (EIP), responsible for the scientific soundness of data and estimates reported by WHO, provided independent review

of the methodology and results and also provided the data on total deaths among women of reproductive age which are used as the outer envelope for the calculation of maternal deaths.

Sources of country data used for the 2000 estimates

Country classifications

Regional and country offices were contacted to obtain the most recent data available on maternal mortality and other key indicators. On the basis of this and other information available in the WHO and UNICEF databases, countries were classified into the following six groups for the purpose of the analysis, as summarised in Table 2 below.

Table 2. Sources of country data used in developing the 2000 estimates

	Source for maternal mortality data	Number of countries	% of countries in each category	% of global births covered
A	Vital registration characterised as complete[a] with good attribution of cause of death	59	34%	13%
B	Vital registration characterised as complete with uncertain or poor attribution of cause of death*	6	3%	1%
C	Direct sisterhood estimates	29	17%	17%
D	RAMOS	13	8%	19%
E	Household survey using direct estimation or census estimates	3	2%	23%
F	No national data on maternal mortality	62	36%	27%
	Total	**172**	**100%**	**60%**

Two groups of countries deserve special mention. Countries in group B are deemed by WHO to have reasonably complete registration of deaths, but questionable cause of death ascertainment. Those in group F have no direct information regarding maternal mortality for the 10 years preceding 2000 (though some of these countries do have estimates for earlier periods). For both these groups of countries, a statistical model is used to estimate the proportion of deaths of women of reproductive age that are due to maternal causes (*PMDF*). This proportion is then applied to an estimate of the number of deaths of women of reproductive age in 2000 as estimated by WHO (for six countries, the number of deaths was obtained either from the WHO Mortality Data Base or from the United Nations Demographic Yearbook for the most recent year available) to estimate maternal deaths. The MMR is then obtained by dividing the estimate of maternal deaths by an estimate of the number of births in 2000 (or the reference date of the deaths) developed by the United Nations Population Division.

The statistical model

Since the dependent variable of the model is a proportion, it is appropriate to model its logit, in

[a] Over 90% of adult deaths are reported according to the United Nations Statistics Division.

order to ensure that predicted values will fall between 0 and 1. Since it is also the objective of the model to predict out of sample, the independent variables must be available for a large majority of the countries for which predicted values are needed. The model was fitted to country observations of *PMDF* and independent variables that can be categorized as:

- *demographic* (a measure of the level of fertility, related to *PMDF* via its effect on the number of risky events);
- *economic* (per capita income in purchasing power parity, whether a member of OECD or not);
- *social* (adult female literacy rate, the ratio of male to female adult literacy, the ratio of male to female secondary gross enrolment ratios and the completeness of registration of adult deaths);
- *health system* (the proportion of pregnancies with antenatal care, the proportion of deliveries assisted by a skilled attendant, WHO's five value categorization of access to essential drugs, the "performance" index from the 2000 World Health Report, and the contraceptive prevalence rate); and
- regional dummy variables.

In a departure from the procedures used in 1990 and 1995, the model was only fitted to observations for non-OECD countries and the *PMDF* was adjusted for HIV-related mortality before fitting the model. The *PMDF* used in the 2000 exercise is thus the proportion maternal of non-AIDS deaths of women of reproductive age. Reverse stepwise regression was used initially to identify the variables that were significantly related to the logit(*PMDF*). Robust regression, performing an initial screening to eliminate gross outliers followed by Huber iterations and biweight iterations[a], was then used to estimate the final model.

Although found to be significant in the model, the WHO overall performance index was not used in the final model because many of the values of this index were themselves estimated from a model using many of the other variables available for our model. In addition, the access to essential drugs indicator was not used in the final model because of concerns about the underlying methodology which relies entirely on informed respondents.

The final data set contained observations for 68 non-OECD countries. Of the 68 countries, however, some had missing values for one or more independent variables, complicating comparisons across models. The final model was

$$\text{logit}(PMDF) = -6.15 + 1.24*\ln(GFR) - 0.014*logit(SA) - 0.26*GDP/PPP + 0.53*LASSAME - 0.62*VRComplete$$

where *GFR* is the General Fertility Rate, *logitSA* is the percentage of births assisted by a skilled attendant, *GDP/PPP* is gross domestic product per capita based on purchasing power parity conversion, *LASSAME* is a dummy variable identifying countries of Latin America, sub-Saharan Africa and the Middle East-North Africa (from Pakistan to Morocco), and *VRComplete* is a dummy variable for countries identified by WHO as having complete death registration.

Annex Figure 1 plots residuals against predicted values. Although the observations appear to cluster somewhat into a high *PMDF* group and a low *PMDF* group, the plot reveals no heteroscedasticity or non-linearity. The same model, fitted with ordinary least squares and with virtually identical parameter values, had an R^2 of 0.91. The model structure was slightly different from the 1995 exercise which included a dummy variable for the former socialist economies but did not include *GDP/PPP* and was fitted to 73 observations including 24 OECD countries. It yielded similar signs and magnitudes of the estimated coefficients and goodness-of-fit statistics, as Table 3 shows.

[a] StataCorp. 2001. *Stat Statistical Software: Release 7.0.* College Station, TX: Stata Corporation.

Table 3. Comparison of 1995 and 2000 statistical models

Model	Constant	ln(*GFR*)	*SA*	*GDP/ PPP*	*HIV*	*FSE*	*LASSAME*	*VRComplete*	R^2
1995	-8.29	+1.39	-0.01	-	-0.02	+0.68	+0.72	-0.68*	0.92
2000	-6.15	+1.24	-0.01	-0.26	-	-	+0.53	-0.62	0.91

* The variable used in the 1995 model was "complete" adult mortality registration, as reported to U.N., as opposed to estimated completeness of adult death registration in the 2000 model.

Producing maternal mortality estimates for each country

The methods for arriving at final values for each country vary according to data availability and type as shown in Table 4.

Table 4. Method of producing the 2000 estimates according to data source and type

Annex Table number	Country data source and type	Method for producing the estimate
A	Complete vital registration[a] with good attribution of cause of death	Maternal mortality estimates are based on the observed value adjusted by a nationally reported adjustment factor if available or by 1.5 if not. In order to reduce the problem of stochastic fluctuation due to small numbers, the average value for the most recent three-year period was used as the basis for the adjustment.
B	Complete vital registration* with uncertain or poor attribution of cause of death	Data on deaths of women of reproductive age were first inflated to adjust for WHO's estimate of under-registration of deaths. The statistical model is used to estimate the value of the PMDF. This is applied to the WHO envelope of non-HIV female deaths to estimate maternal deaths. The MMR is then estimated by dividing by the number of live births reported in the United Nations Demographic Yearbook.
C	Direct sisterhood estimates	The observed PMDF (age standardized and adjusted to refer to non-HIV deaths only) from the sisterhood data is applied to the number of non-HIV female deaths aged 15 to 49 estimated by WHO for the year 2000 to calculate maternal deaths. The MMR was then obtained by dividing total maternal deaths by the UN estimates of live births as reported in the United Nations Demographic Yearbook.
D	RAMOS	The observed MMR is taken with no adjustments. However, estimated numbers of live births for 2000, generally from United Nations estimates, are used to obtain the number of maternal deaths for calculation of global and regional summaries.
E	Other survey or census estimate	The observed MMR is taken with no adjustments. However, estimated numbers of live births for 2000, generally from United Nations estimates, are used to obtain the number of maternal deaths for calculation of global and regional summaries.
F	No national data on maternal mortality	The estimates are developed using the model. For each country, the regression model is used to predict PMDF, and the prediction then applied to WHO estimates of non-HIV deaths of women of reproductive age in 2000 to calculate maternal deaths. The MMR is then obtained by dividing the number of maternal deaths by an estimate of the number of live births in 2000 derived from the United Nations projections (2000 Revision).

[a] As classified by the United Nations Statistics Division and WHO. "Complete" means 90% or more of adult deaths are reported. WHO estimates of the quality of cause of death attribution were used.

Differences between the 2000 methodology compared with 1995

The most significant differences in the approach for the 2000 estimates as compared with those for 1995 can be summarised as follows:

- A careful review of national estimates of maternal mortality was carried out in order to ensure that each country was appropriately classified on the basis of the type, quality and timeliness of available maternal mortality data. The WHO classification of countries according to completeness of vital registration was used rather than that of the United Nations Statistical Division. As a result, the classification of several countries has changed from the 1995 approach. Only adequately documented estimates, backed by clear descriptions of acceptable methodology, were included in the data set on which the model was estimated.
- WHO figures for deaths of women of reproductive age, adjusted to remove HIV-related deaths, were used to calculate maternal deaths from the model-based PMDFs, rather than deaths from the UN projections as was the case for the 1995 estimates. The WHO estimates were recently updated and used to derive a series of life tables for 191 countries.[22]
- Values for the independent variables were carefully reviewed where possible. In particular, estimates of the proportion of deliveries assisted by skilled health care workers were reviewed country by country by WHO and UNICEF.

Analysis and interpretation of 2000 estimates

Maternal mortality estimates for 2000

On the basis of the present exercise, the estimated number of maternal deaths in 2000 for the world was 529,000 (Table 5). These deaths were almost equally divided between Africa (251,000) and Asia (253,000), with about 4 per cent (22,000) occurring in Latin America and the Caribbean, and less than one per cent (2,500) in the more developed regions of the world. In terms of the Maternal Mortality Ratio (MMR), the world figure is estimated to be 400 per 100,000 live births. By region, the MMR was highest in Africa (830), followed by Asia (330), Oceania (240), Latin America and the Caribbean (190), and the developed countries (20).

The country with the highest estimated number of maternal deaths is India (136,000), followed by Nigeria (37,000), Pakistan (26,000), Democratic Republic of Congo (20,000), Ethiopia (24,000), the United Republic of Tanzania (21,000), Afghanistan (20,000), Bangladesh (16,000), Angola, China, Kenya (11,000 each), Indonesia and Uganda (10,000 each). These 13 countries account for 70 per cent of all maternal deaths.

However, in terms of the maternal mortality ratio, which reflects the obstetric risk associated with each pregnancy, the list looks rather different. With the sole exception of Afghanistan, the countries with the highest MMRs are in Africa. The highest MMRs of 1,000 or greater, are, in rank order, Sierra Leone, Afghanistan, Malawi, Angola, Niger, the United Republic of Tanzania, Rwanda, Mali, Somalia, Zimbabwe, Chad, Central African Republic, Guinea Bissau, Kenya, Mozambique, Burkina Faso, Burundi, and Mauritania.

Table 5. 2000 Maternal mortality estimates by United Nations MDG regions

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South-Eastern Asia	210	25,000	140
Western Asia	190	9,800	120
Latin America & the Caribbean	190	22,000	160
Oceania	240	530	83

The maternal mortality ratio is a measure of the risk of death once a woman has become pregnant. An alternative assessment of risk would take into account both the probability of becoming pregnant and the probability of dying as a result of that pregnancy cumulated across a woman's reproductive years - the lifetime risk.[b] This measure is most evocative of the extreme risks that women face during their reproductive lives. Table 5 shows that the lifetime risk of death is highest in sub-Saharan Africa, with as many as one woman in 16 facing the risk of maternal death in the course of her lifetime, compared with one in 2,800 in developed regions.

Annex Tables G, H, I, J and K show estimated maternal mortality ratios, numbers of maternal deaths and lifetime risk for individual countries and for WHO, UNICEF, The State of the World's Children, and UNFPA regions respectively.

[a] Includes Europe, Canada, United States of America, Japan, Australia and New Zealand which are excluded from the regional totals.

[b] In theory, the lifetime risk is a cohort measure but it is usually calculated with period measures for practical reasons. It can be approximated by multiplying the maternal mortality rate by the length of the reproductive period (around 35 years). Thus, the lifetime risk is calculated as $[1 - (1 - \text{maternal mortality rate})^{35}]$.

Differences between 2000 estimates and nationally reported data

The country MMRs derived from this approach differ – in some cases considerably – from nationally-reported figures or from figures from other sources such as vital registration or sisterhood studies. As has been stated, vital registration data have been inflated to account for misclassification of maternal deaths, an endemic phenomenon even in statistically highly-developed settings. In some cases, the inflation factor has been taken from special studies undertaken by national authorities themselves but not all countries have carried out such studies. For these countries, therefore, a standard inflation factor of 1.5 was applied, this figure having been derived from an analysis of the results of studies of under-reporting and misclassification around the world.

Of particular concern to a number of developing countries is the fact that nationally-reported estimates of the Maternal Mortality Ratio derived from sisterhood studies are also adjusted. The adjustment process generally results in considerably higher values for the MMR in countries with sisterhood studies. The main reason for this is the evidence that sisterhood data tend to underestimate overall mortality.[23] This conclusion does not imply anything about the accuracy of sisterhood PMDFs. However, it does imply that, in the absence of counterbalancing errors, the MMRs from sisterhood surveys are likely to be too low. Thus, unless the proportion maternal of sister deaths is substantially over-reported (and the evidence on this point is mixed), the nature of likely biases in the sisterhood data argue for using the data in the form of PMDFs rather than MMRs.[24,25]

There is a further difference in the values for the PMDF that can be drawn from the published Demographic and Health Survey (DHS) results and those used to develop the 1995 and 2000 estimates that is due to a technical problem with using the PMDF. The DHS country reports provide a value for the observed PMDF, calculated as the number of reported deaths of sisters due to maternal causes divided by the number of overall sister deaths. However, the distributions by age of sister deaths, and more generally of sister-years of exposure, are not the same as the corresponding distributions of the actual population.[26] For example, the sisters of reproductive age of respondents aged 15-19 are likely to be on average older than the respondents (they cannot be younger than 15, but they can be 20 or older), whereas the sisters of reproductive age of respondents aged 45-49 are likely to be generally younger. Years of exposure of sisters are thus concentrated in the central ages of the reproductive period at the expense of the extremes. However, it is also in the central ages that most births, and thus most maternal deaths, are likely to occur. Thus, the reported PMDF is likely to be higher than the true PMDF would be for a group of women distributed by age in the same way as the actual population. In order to allow for this effect, age-standardised PMDFs were calculated with the result that the PMDFs in this document differ somewhat from those that can be calculated directly from the published DHS results.

Comparing 2000 estimates with those for 1990 and 1995

The main differences between these 2000 estimates and those for 1995 are slight increases in the absolute numbers of maternal deaths which total 529,000 in 2000 compared with 515,000 in 1995. However, the global MMR remains unchanged at 400 per 100,000 live births. While these figures cannot be interpreted as indicative of trends, it does appear that globally, levels of maternal mortality remained stable between 1995 and 2000.

Table 6. Comparison of 1995 and 2000 regional and global totals

Region	2000		1995	
	Maternal Mortality Ratio	Maternal deaths	Maternal Mortality Ratio	Maternal deaths
WORLD TOTAL	400	529,000	400	515,000
DEVELOPED REGIONS[a]	20	2,500	21	2,800
Europe	28	1,700	28	2,200
DEVELOPING REGIONS	440	527,000	440	512,000
Africa	830	251,000	1,000	273,000
Northern Africa[b]	130	4,600	200	7,200
Sub-Saharan Africa	920	247,000	1,100	265,000
Asia	330	253,000	280	217,000
Eastern Asia	55	11,000	55	13,000
South-Central Asia	520	207,000	410	158,000
South-Eastern Asia	210	25,000	300	35,000
Western Asia	190	9,800	230	11,000
Latin America & the Caribbean	190	22,000	190	22,000
Oceania	240	530	260	600

The main regional differences between the 1995 and 2000 estimates are a decline in the levels in Africa and an increase in South-Central Asia.

Using the 2000 maternal mortality estimates

What can the 2000 estimates be used for?

The purpose of these estimates is to draw attention to the existence and likely dimensions of the problem of maternal mortality. They are indicative of orders of magnitude and are not intended to serve as precise estimates. In addition, these estimates can serve to stimulate greater awareness of and attention to the challenge of measuring maternal mortality. Following the publication of the 1990 estimates, a number of countries undertook special studies to assess the completeness and adequacy of their vital registration and health information systems. For other countries, particularly where the only source of data is from sisterhood surveys, the estimates can serve to draw attention to the potential pitfalls associated with such indirect measurement techniques.

What should they NOT be used for?

The margins of uncertainty associated with the estimated MMRs are very large and the estimates should not, therefore, be used to monitor trends in the short term. In addition, cross-country comparisons should be treated with considerable circumspection because different strategies have been used to derive the estimates for different countries rendering comparisons fraught with difficulty. The extent to which such comparisons are appropriate will depend critically on the strategy used to develop the estimate for each country. For example, whereas it is reasonable to

[a] Includes Europe, Canada, United States of America, Japan, Australia and New Zealand which are excluded from the regional averages.
[b] Excludes Sudan which is included in sub-Saharan Africa.

compare countries whose estimates are developed using a similar approach – for example, all countries with vital registration data – it would not be appropriate to compare countries with estimates derived from, say, sisterhood studies with those derived using RAMOS approaches or vital registration.

Why can the 2000 estimates NOT be used to analyse trends?

The 2000 estimates cannot be used to analyse trends because of the wide margins of uncertainty associated with the estimates. These margins of uncertainty derive from several sources:

- For countries with highly developed statistical systems, MMRs are thought to be underestimated by a substantial margin, and have been inflated by 50 per cent in developing these estimates. While there is increasing evidence that such an adjustment factor is by no means exaggerated, the true figure could be higher, or it could be lower, and it could change over time.
- For countries with maternal mortality data derived from direct or indirect household surveys, the margins of error derive largely from sampling error but uncertainty also arises as the result of recall problems and the resultant need to impute missing data.
- For countries with data derived using RAMOS approaches, the margins of uncertainty result from sampling errors but may also arise because of errors in calculating the numbers of live births.
- For countries with modelled PMDFs, the margins of uncertainty are the result of prediction errors.

Attempts have been made to arrive at uncertainty boundaries around the estimated value within which the true figure is likely to lie. These are not confidence intervals in the statistical sense, because there are errors involved that cannot be quantified in a rigorous probabilistic manner. However, they do give a sense of the magnitude of the possible errors involved.

The uncertainty bounds are extremely wide (Annex Tables G, H, I, J and K). At the global level, the lower uncertainty bound is for a MMR of 210 per 100,000 live births, and an annual total of 277,000 maternal deaths, and the upper uncertainty bound is for a ratio of 620 per 100,000 live births, and an annual total of 817,000 maternal deaths. Country comparisons need to be made very cautiously, taking into account the very large range of uncertainty around the point estimates.

In addition to these very wide margins of uncertainty, there are other reasons why it would be inappropriate to compare the 2000 estimates with those for 1990 and 1995 and draw conclusions about trends. As has already been pointed out, a number of modifications were introduced into the approach for developing the 2000 estimates in order to address the concerns voiced by countries and technical experts. In particular, a number of countries have been classified differently in the 2000 exercise. While the basic structure of the modelling strategy is unchanged, a number of changes have been incorporated which further add to the inappropriateness of comparing the three sets of estimates.

Next steps

Generate better information

The interest in having timely, reliable and comparable national-level data on maternal mortality is laudable and understandable. After all, a maternal death is the ultimate and clearest adverse health outcome and one that must remain at the heart of efforts to improve the health of women and of newborn infants. Furthermore, the MMR implies a lot about the performance and functioning of the

health care system. There is now a broad consensus that reduction in MMRs cannot be achieved in the absence of increased use of high-quality health care services. Where MMRs are high, one must conclude that the health care system is dysfunctional, either in terms of providing adequate access to care or in the quality of care provided or, as is most likely, a combination of the two.

As we have seen, measuring maternal mortality is difficult not so much because of the lack of measurement tools - several alternatives are now available - but because the resource requirements needed for accurate measurement are too great. There is an inevitable trade-off that has to be made between a method that provides an accurate and complete estimate of maternal mortality and one that is affordable and feasible in resource-constrained settings. In an effort to reconcile this apparent conflict, the use of proxy or process indicators is advocated. We have focused on one such indicator, the percentage of births with a skilled health care worker. This indicator, while easier to generate than maternal mortality, has problems of its own, particularly in relation to definitions, but also regarding its precise relationship to the primary variable of interest, that is maternal mortality. We know that the two indicators are related. We cannot say with certainty that the relationship is one of cause and effect.

There is increasing interest in directing a larger share of limited resources into efforts to understand **why** the problem of maternal mortality persists. Answering this question is vital for programme planners and for service providers. Such information is often qualitative rather than quantitative and will usually be specific to a particular place and time. More countries are now seeking to enhance quantitative information on levels of maternal mortality by the in-depth analysis of cases of maternal death through facility-based audits and national-level confidential enquiries. Different strategies and tools have been developed to support this kind of in-depth investigation and have been described elsewhere.[27]

In-depth investigations can offer a range of benefits, including:

- creating awareness among health care providers and among communities that maternal deaths are avoidable;
- forging stronger linkages between the health care facility and the community;
- providing actionable data for improving quality of care;
- rationalising routine statistics gathering and reporting;
- stimulating the development of reporting systems that are responsive to changing needs in the health service; and
- strengthening linkages between users and collectors of data.

But most important of all, such in-depth investigations can provide answers to the question “Why do maternal deaths occur and what can be done to prevent them?”

In the final analysis, answering this question is more important than, though related to, knowing the precise value of the MMR. This should not be taken to imply that efforts to measure levels and trends should be abandoned. Knowing the level of maternal mortality and how it changes over time is an important goal, but given currently available measurement methods one that cannot readily be achieved with available resources. Further research is needed to identify cost-effective and reliable ways of measuring maternal mortality in the absence of comprehensive and sustainable systems of vital registration. In the meantime, a combination of direct and indirect population-based measurement approaches, model-based estimates, process indicators and qualitative investigations can help guide policy-makers and programme managers.

Annex Table A
Maternal mortality data derived from vital registration: Countries with good death registration and good attribution of cause of death

	Year[a]	Reported maternal mortality ratio (maternal deaths per 100,000 live births)	National adjustment factor[b]	Adjusted maternal mortality ratio (maternal deaths per 100,000 live births)
Argentina	2000	43	1.9*	82
Australia	2000	5	1.5	8
Austria	2000	3	1.5	4
Bahrain	2000	19	1.5	28
Barbados	2000	64	1.5	95
Belarus	2000	23	1.5	35
Belgium	2000	7	1.5	10
Bosnia and Herzegovina	2000	21	1.5	31
Bulgaria	2000	21	1.5	32
Canada	2000	4	1.5	6
Chile	2000	21	1.5	31
Costa Rica	2000	36	1.2*	43
Croatia	2000	5	1.5	8
Cyprus	2000	31	1.5	47
Czech Republic	2000	6	1.5	9
Denmark	2000	3	1.5	5
Estonia	2000	42	1.5	63
Finland	2000	6	1.03*	6
France	2000	8	2*	17
Germany	2000	5	1.5	8
Greece	2000	6	1.5	9
Hungary	2000	11	1.5	16
Iceland	2000	0	1.5	0
Ireland	2000	4	1.5	5
Israel	2000	11	1.5	17
Italy	2000	4	1.5	5
Japan	2000	7	1.5	10
Kuwait	2000	3	1.5	5
Latvia	2000	28	1.5	42
Lithuania	2000	9	1.5	13
Luxembourg	2000	18	1.5	28
Macedonia, The former Yugoslav Republic of	2000	15	1.5	23
Malta	2000	14	1.5	21
Mauritius	2000	16	1.5	24
Mexico	2000	60	1.4*	83
Moldova, Republic of	2000	24	1.5	36
Mongolia	2000	75	1.5	110

[a] Based on vital registration data available at WHO.
[b] Adjustment factors from national studies were applied to the reported vital registration based figures, where available. In all other cases, the adjustment factor was 1.5.

	Year[a]	Reported maternal mortality ratio (maternal deaths per 100,000 live births)	National adjustment factor[b]	Adjusted maternal mortality ratio (maternal deaths per 100,000 live births)
Netherlands	2000	11	1.4*	16
New Zealand	2000	7	1*	7
Norway	2000	11	1.5	16
Panama	2000	108	1.5	160
Poland	2000	9	1.5	13
Portugal	2000	4	1.5	5
Puerto Rico	1999	16	1.5	25
Qatar	2000	5	1.5	7
Romania	2000	33	1.5	49
Russian Federation	2000	45	1.5	67
Serbia and Montenegro	2000	7	1.5	11
Singapore	2000	20	1.5	30
Slovakia	2000	2	1.5	3
Slovenia	2000	12	1.5	17
Spain	2000	3	1.5	4
Sweden	2000	1	1.5	2
Switzerland	2000	4	1.5	7
Trinidad and Tobago	2000	103	1.5	160
Ukraine	2000	23	1.5	35
United Kingdom	2000	7	1.7*	13
United States	2000	11	1.5	17
Uruguay	2000	18	1.5	27
Venezuela	2000	64	1.5	96

Annex Table B
Maternal mortality data derived from vital registration:
Countries with good death registration but uncertain attribution of cause of death

	Year[a]	Adjusted maternal mortality ratio (maternal deaths per 100,000 live births)
Brunei Darussalam	1992	37
Colombia	1995	130
Ecuador	1997	130
Guyana	1996	170
Paraguay	1994	170
Tunisia	1995	120

Data on deaths of women of reproductive age were first inflated to adjust for WHO's estimate of under-registration of deaths. The statistical model is used to estimate the value of the PMDF. This is applied to the WHO envelope of non-HIV female deaths to estimate maternal deaths. The MMR is then estimated by dividing by the number of live births reported in the United Nations Demographic Yearbook.

[a] Reference year for female deaths of reproductive age and live births.

Annex Table C
Maternal mortality data derived from the direct sisterhood method:
Reported and adjusted estimates

	Year	DHS-reported maternal mortality ratio (maternal deaths per 100,000 live births)	Adjusted maternal mortality ratio (maternal deaths per 100,000 live births)
Benin	1989-1996	498	850
Brazil	1983-1996	161	260
Burkina Faso	1994-1998	484	1000
Cambodia	1994-2000	437	450
Cameroon	1989-1998	430	730
Central African Republic	1989-1995	1132	1100
Chad	1991-1997	827	1100
Eritrea	1986-1995	998	630
Ethiopia	1994-2000	871	850
Gabon	1994-2000	519	420
Guatemala	1990-1995	190	240
Guinea	1992-1999	528	740
Haiti	1995-2000	523	680
Kenya	1992-1998	590	1000
Madagascar	1990-1997	488	550
Malawi	1994-2000	1120	1800
Mali	1989-1996	577	1200
Mauritania	1995-2001	747	1000
Morocco	1992-1997	228	220
Nepal	1990-1996	539	740
Peru	1994-2000	185	410
Philippines	1991-1997	172	200
Rwanda	1996-2000	1071	1400
Tanzania, United Republic of	1987-1996	529	1500
Togo	1993-1998	478	570
Uganda	1992-2001	505	880
Yemen	1988-1997	351	570
Zambia	1990-1996	649	750
Zimbabwe	1995-1999	695	1100

The observed PMDF (age standardized and adjusted to refer to non-HIV deaths only) from the sisterhood data is applied to the number of non-HIV female deaths aged 15 to 49 estimated by WHO for the year 2000 to calculate maternal deaths. The MMR was then obtained by dividing total maternal deaths by the UN estimates of live births as reported in the United Nations Demographic Yearbook.

Annex Table D
Maternal mortality data derived from RAMOS

	Year	Reported RAMOS maternal mortality ratio (maternal deaths per 100,000 live births)
Belize	1995	140
China[a]	1998	56
Cuba	2000	33
Egypt	2000	84
Honduras	1997	110
Jamaica	1993-1995	87
Jordan	1995-1996	41
Korea, Republic of	1995-1996	20
Malaysia	1996	41
Saudi Arabia	1997	23
Sri Lanka	1996	92
Suriname	1990-1995	110
Thailand	1995-1996	44

For countries with maternal mortality estimates from RAMOS-type surveys, the observed MMR is taken with no adjustments. However, estimated numbers of live births for 2000, generally from United Nations estimates, are used to obtain the number of maternal deaths for calculation of global and regional summaries.

[a] Including Macao and Hong Kong.

Annex Table E
Countries with data from household surveys or census

	Year	Reported maternal mortality ratio (maternal deaths per 100,000 live births)
Bangladesh	1998-2001	380[a]
India	1997-1998	540[b]
Iran (Islamic Republic of)	1995-1996	76[c]

The observed MMR is taken with no adjustments. However, estimated numbers of live births for 2000, generally from United Nations estimates, are used to obtain the number of maternal deaths for calculation of regional summaries.

[a] Bangladesh Maternal Health Services and Maternal Mortality Survey 2001.
[b] National Family Health Survey 1998-1999. The report does not give enough information to evaluate the resulting MMR in detail, but the information in general appears to be of good quality and the estimated MMR as reported has been used.
[c] Iran carried out a national census in 1996 that included questions on household deaths in the year before interview. Evaluation of the information on deaths suggested substantial omission, but the proportion maternal among female deaths was assumed to be of good quality. Thus, the reported PMDF from the census was applied to United Nations estimate of deaths of women of reproductive age in 1995 to arrive at an estimate of maternal deaths, and the MMR was then estimated by dividing this number by the United Nations estimate of the number of live births in 1995.

Annex Table F
Maternal mortality estimates derived from the model

	Year	Model-based maternal mortality ratio (maternal deaths per 100,000 live births)
Afghanistan	2000	1900
Albania	2000	55
Algeria	2000	140
Angola	2000	1700
Armenia	2000	55
Azerbaijan	2000	94
Bahamas	2000	60
Bhutan	2000	420
Bolivia	2000	420
Botswana	2000	100
Burundi	2000	1000
Cape Verde	2000	150
Comoros	2000	480
Congo	2000	510
Congo, Democratic Republic of	2000	990
Côte d'Ivoire	2000	690
Djibouti	2000	730
Dominican Republic	2000	150
El Salvador	2000	150
Equatorial Guinea	2000	880
Fiji	2000	75
Gambia	2000	540
Georgia	2000	32
Ghana	2000	540
Guinea-Bissau	2000	1100
Indonesia	2000	230
Iraq	2000	250
Kazakhstan	2000	210
Korea, Democratic People's Republic of	2000	67
Kyrgyzstan	2000	110
Lao People's Democratic Republic	2000	650
Lebanon	2000	150
Lesotho	2000	550
Liberia	2000	760
Libyan Arab Jamahiriya	2000	97
Maldives	2000	110
Mozambique	2000	1000
Myanmar	2000	360

	Year	Model-based maternal mortality ratio (maternal deaths per 100,000 live births)
Namibia	2000	300
Nicaragua	2000	230
Niger	2000	1600
Nigeria	2000	800
Occupied Palestinian Territory	2000	100
Oman	2000	87
Pakistan	2000	500
Papua New Guinea	2000	300
Reunion	2000	41
Senegal	2000	690
Sierra Leone	2000	2000
Solomon Islands	2000	130
Somalia	2000	1100
South Africa	2000	230
Sudan	2000	590
Swaziland	2000	370
Syrian Arab Republic	2000	160
Tajikistan	2000	100
Timor-Leste	2000	660
Turkey	2000	70
Turkmenistan	2000	31
United Arab Emirates	2000	54
Uzbekistan	2000	24
Viet Nam	2000	130

For countries lacking complete vital registration or other acceptable national estimate of maternal mortality, the estimates are developed using the model. For each country, the regression model was used to predict PMDF, and the prediction was then applied to the WHO estimated envelope of HIV-adjusted deaths of women of reproductive age in 2000 to estimate maternal deaths. The MMR was then obtained by dividing the number of maternal deaths by an estimate of the number of births in 2000.

Annex Table G
Country estimates of number of maternal deaths, lifetime risk, maternal mortality ratio, and range of uncertainty (2000)

	Annex Table	PMDF from model ** (%)	Number of maternal deaths	Lifetime risk of maternal death: 1 in:	Maternal mortality ratio* (maternal deaths per 100,000 live births)	Range of uncertainty on MMR estimates	
						Lower estimate	Upper estimate
Afghanistan	F	46	20,000	6	1,900	470	3500
Albania	F	3	35	610	55	23	92
Algeria	F	9	1,000	190	140	35	260
Angola	F	40	11,000	7	1,700	420	3100
Argentina	A		590	410	82	54	110
Armenia	F	2	20	1,200	55	23	91
Australia	A		20	5,800	8	5	10
Austria	A		3	16,000	4	3	5
Azerbaijan	F	3	100	520	94	40	150
Bahamas	F	2	4	580	60	25	98
Bahrain	A		3	1,200	28	19	38
Bangladesh	E	24	16,000	59	380	320	450
Barbados	A		3	590	95	64	130
Belarus	A		30	1,800	35	23	46
Belgium	A		10	5,600	10	7	13
Belize	D		10	190	140	70	280
Benin	C	34	2,200	17	850	490	1200
Bhutan	F	21	310	37	420	110	780
Bolivia	F	18	1,100	47	420	110	790
Bosnia and Herzegovina	A		10	1,900	31	21	42
Botswana	F	9	50	200	100	25	190
Brazil	C	12	8,700	140	260	160	370
Brunei Darussalam	B	2	2	830	37	22	53
Bulgaria	A		20	2,400	32	21	42
Burkina Faso	C	37	5,400	12	1,000	630	1500
Burundi	F	40	2,800	12	1,000	260	1900
Cambodia	C	18	2,100	36	450	260	620
Cameroon	C	29	4,000	23	730	430	1100
Canada	A		20	8,700	6	4	8
Cape Verde	F	11	20	160	150	37	280
Central African Republic	C	37	1,600	15	1,100	670	1600
Chad	C	46	4,200	11	1,100	620	1500
Chile	A		90	1,100	31	21	42

	Annex Table	PMDF from model ** (%)	Number of maternal deaths	Lifetime risk of maternal death: 1 in:	Maternal mortality ratio* (maternal deaths per 100,000 live births)	Range of uncertainty on MMR estimates	
						Lower estimate	Upper estimate
China	D		11,000	830	56	28	110
Colombia	B	8	1,300	240	130	83	180
Comoros	F	26	130	33	480	120	890
Congo	F	32	690	26	510	130	960
Congo, Democratic Republic of	F	36	24,000	13	990	250	1800
Costa Rica	A		40	690	43	28	57
Côte d'Ivoire	F	24	3,900	25	690	170	1300
Croatia	A		4	6,100	8	5	11
Cuba	D		45	1,600	33	16	66
Cyprus	A		5	890	47	31	63
Czech Republic	A		10	7,700	9	6	11
Denmark	A		3	9,800	5	3	6
Djibouti	F	23	180	19	730	190	1400
Dominican Republic	F	7	300	200	150	37	280
Ecuador	B	7	400	210	130	53	200
Egypt	D		1,400	310	84	42	170
El Salvador	F	10	250	180	150	37	270
Equatorial Guinea	F	38	180	16	880	220	1600
Eritrea	C	33	930	24	630	380	890
Estonia	A		5	1,100	63	42	84
Ethiopia	C	33	24,000	14	850	500	1200
Fiji	F	4	15	360	75	19	140
Finland	A		3	8,200	6	4	8
France	A		120	2,700	17	11	22
French Polynesia***			1	1,700	20		
Gabon	C	23	200	37	420	240	600
Gambia	F	27	270	31	540	140	1000
Georgia	F	2	20	1,700	32	12	53
Germany	A		55	8,000	8	5	11
Ghana	F	23	3,500	35	540	140	1000
Greece	A		10	7,100	9	6	12
Guadeloupe***			0	8,300	5		
Guam***			1	1,700	12		
Guatemala	C	21	970	74	240	140	350
Guinea	C	30	2,700	18	740	420	1100
Guinea-Bissau	F	35	590	13	1,100	280	2100

	Annex Table	PMDF from model ** (%)	Number of maternal deaths	Lifetime risk of maternal death: 1 in:	Maternal mortality ratio* (maternal deaths per 100,000 live births)	Range of uncertainty on MMR estimates	
						Lower estimate	Upper estimate
Guyana	B	7	30	200	170	110	240
Haiti	C	17	1,700	29	680	400	970
Honduras	D		220	190	110	54	220
Hungary	A		15	4,000	16	11	22
Iceland	A			0	0	0	0
India	E		136,000	48	540	430	650
Indonesia	F	6	10,000	150	230	58	440
Iran (Islamic Republic of)	E	5	1,200	370	76	38	150
Iraq	F	16	2,000	65	250	62	460
Ireland	A		3	8,300	5	4	7
Israel	A		20	1,800	17	11	22
Italy	A		25	13,900	5	4	7
Jamaica	D		45	380	87	44	170
Japan	A		120	6,000	10	7	13
Jordan	D		70	450	41	21	82
Kazakhstan	F	2	560	190	210	120	299
Kenya	C	49	11,000	19	1,000	580	1400
Korea, Democratic People's Republic of	F	2	260	590	67	17	130
Korea, Republic of	D		120	2,800	20	10	40
Kuwait	A		2	6,000	5	3	6
Kyrgyzstan	F	4	110	290	110	48	180
Lao People's Democratic Republic	F	19	1,300	25	650	160	1200
Latvia	A		10	1,800	42	28	56
Lebanon	F	6	100	240	150	38	290
Lesotho	F	22	380	32	550	140	1000
Liberia	F	33	1,200	16	760	190	1400
Libyan Arab Jamahiriya	F	8	140	240	97	24	180
Lithuania	A		4	4,900	13	9	18
Luxembourg	A		2	1,700	28	18	37
Macedonia, The former Yugoslav Republic of	A		5	2,100	23	15	30
Madagascar	C	23	3,800	26	550	310	780
Malawi	C	54	9,300	7	1,800	1100	2600
Malaysia	D		220	660	41	20	81
Maldives	F	11	10	140	110	28	220
Mali	C	39	6,800	10	1,200	680	1700

	Annex Table	PMDF from model ** (%)	Number of maternal deaths	Lifetime risk of maternal death: 1 in:	Maternal mortality ratio* (maternal deaths per 100,000 live births)	Range of uncertainty on MMR estimates	
						Lower estimate	Upper estimate
Malta***	A		1	2,100	21	10	42
Martinique***			0	12,300	4		
Mauritania	C	37	1,200	14	1,000	630	1500
Mauritius	A		5	1,700	24	16	32
Mexico	A		1,900	370	83	56	110
Moldova, Republic of	A		20	1,500	36	24	48
Mongolia	A		65	300	110	75	150
Morocco	C	19	1,700	120	220	120	310
Mozambique	F	35	7,900	14	1,000	260	2000
Myanmar	F	9	4,300	75	360	91	660
Namibia	F	17	190	54	300	74	550
Nepal	C	24	6,000	24	740	440	1100
Netherlands	A		30	3,500	16	10	21
Netherlands Antilles***			1	2,000	20		
New Caledonia***			0	3,300	10		
New Zealand	A		4	6,000	7	5	10
Nicaragua	F	19	400	88	230	58	420
Niger	F	50	9,700	7	1,600	420	3100
Nigeria	F	32	37,000	18	800	210	1500
Norway	A		10	2,900	16	11	22
Occupied Palestinian Territory	F	13	130	140	100	25	190
Oman	F	29	80	170	87	22	160
Pakistan	F	16	26,000	31	500	130	940
Panama	A		100	210	160	110	220
Papua New Guinea	F	11	470	62	300	77	570
Paraguay	B	14	280	120	170	72	270
Peru	C	20	2,500	73	410	230	590
Philippines	C	12	4,100	120	200	120	280
Poland	A		50	4,600	13	9	18
Portugal	A		5	11,100	5	4	7
Puerto Rico	A		15	1,800	25	16	33
Qatar	A		1	3,400	7	3	14
Reunion	F	3	5	970	41	10	79
Romania	A		110	1,300	49	33	66
Russian Federation	A		830	1,000	67	45	90
Rwanda	C	49	4,200	10	1,400	790	2000

	Annex Table	PMDF from model ** (%)	Number of maternal deaths	Lifetime risk of maternal death: 1 in:	Maternal mortality ratio* (maternal deaths per 100,000 live births)	Range of uncertainty on MMR estimates	
						Lower estimate	Upper estimate
Samoa***			5	150	130		
Saudi Arabia	D		160	610	23	12	46
Senegal	F	27	2,500	22	690	180	1300
Serbia and Montenegro	A		15	4,500	11	7	15
Sierra Leone	F	39	4,500	6	2,000	510	3800
Singapore	A		15	1,700	30	20	41
Slovakia	A		2	19,800	3	2	4
Slovenia	A		3	4,100	17	12	23
Solomon Islands	F	12	25	120	130	33	240
Somalia	F	43	5,100	10	1,100	270	2000
South Africa	F	9	2,600	120	230	58	430
Spain	A		15	17,400	4	3	6
Sri Lanka	D		300	430	92	46	180
Sudan	F	23	6,400	30	590	150	1100
Suriname	D		10	340	110	56	220
Swaziland	F	17	120	49	370	94	700
Sweden	A		2	29,800	2	1	3
Switzerland	A		5	7,900	7	4	9
Syrian Arab Republic	F	14	780	130	160	41	310
Tajikistan	F	10	160	250	100	43	170
Tanzania, United Republic of	C	46	21,000	10	1,500	910	2200
Thailand	D		520	900	44	22	88
Timor-Leste	F	10	140	30	660	170	1200
Togo	C	25	1,000	26	570	340	810
Trinidad and Tobago	A		30	330	160	100	210
Tunisia	B	5	210	320	120	49	190
Turkey	F	5	1,000	480	70	18	130
Turkmenistan	F	6	40	790	31	12	53
Uganda	C	37	10,000	13	880	510	1200
Ukraine	A		140	2,000	35	23	47
United Arab Emirates	F	4	20	500	54	14	100
United Kingdom	A		85	3,800	13	8	17
United States	A		660	2,500	17	11	22
Uruguay	A		15	1,300	27	18	35
Uzbekistan	F	5	130	1,300	24	9	41
Vanuatu***			10	140	130		

	Annex Table	PMDF from model ** (%)	Number of maternal deaths	Lifetime risk of maternal death: 1 in:	Maternal mortality ratio* (maternal deaths per 100,000 live births)	Range of uncertainty on MMR estimates	
						Lower estimate	Upper estimate
Venezuela	A		550	300	96	64	130
Viet Nam	F	6	2,000	270	130	32	240
Western Sahara***			70	26	850		
Yemen	C	38	5,300	19	570	330	810
Zambia	C	34	3,300	19	750	430	1100
Zimbabwe	C	44	5,000	16	1,100	620	1500

* The MMRs have been rounded according to the following scheme: < 100 : no rounding; ≥ 1000 rounded to nearest 100.

** The proportion maternal among deaths of females of reproductive age (PMDF) is the dependent variable used in the model for calculating maternal mortality estimates. For countries in categories A and D, the estimates are taken directly from vital registration and mortality survey data, no modelling required.

*** For countries with less than 300,000 population or no data, estimates from the 1995 report were used.

Annex Table H
Estimates of maternal mortality ratios, number of maternal deaths, and lifetime risk by WHO Regions (2000)

	Maternal mortality ratio (maternal deaths per 100,000 live births)	Number of maternal deaths	Lifetime risk of maternal death: 1 in:	Range of uncertainty on MMR estimates	
WHO Regional Office for Africa	910	236,000	17	390	1,500
WHO Regional Office for the Americas	140	22,000	240	82	210
WHO Regional Office for the Eastern Mediterranean	460	71,000	41	130	830
WHO Regional Office for Europe	39	3,900	1,300	19	61
WHO Regional Office for South-East Asia	460	174,000	58	340	590
WHO Regional Office for the Western Pacific	81	21,000	540	39	140
Non-member states	120	210	180	18	140
WORLD*	**400**	**529,000**	**74**	**210**	**620**

Annex Table I
Estimates of Maternal Mortality Ratios, Number of Maternal Deaths, and Lifetime Risk by UNICEF Regions (2000)

	Maternal mortality ratio (maternal deaths per 100,000 live births)	Number of maternal deaths *	Lifetime risk of maternal death: 1 in:	Range of uncertainty on MMR estimates	
				Lower	Upper
Sub-Saharan Africa	940	240,000	16	400	1,500
ESARO	980	123,000	15	490	1,500
WCARO	900	118,000	16	310	1,600
Middle East and North Africa	220	21,000	100	85	380
South Asia	560	205,000	43	370	760
East Asia and Pacific	110	37,000	360	44	210
Latin America and Caribbean	190	22,000	160	110	280
CEE/CIS and Baltic States	64	3,400	770	29	100
Industrialized countries	13	1,300	4,000	8	17
Developing countries	440	527,000	61	230	680
Least developed countries	890	236,000	17	410	1,400
World	400	529,000	74	210	620

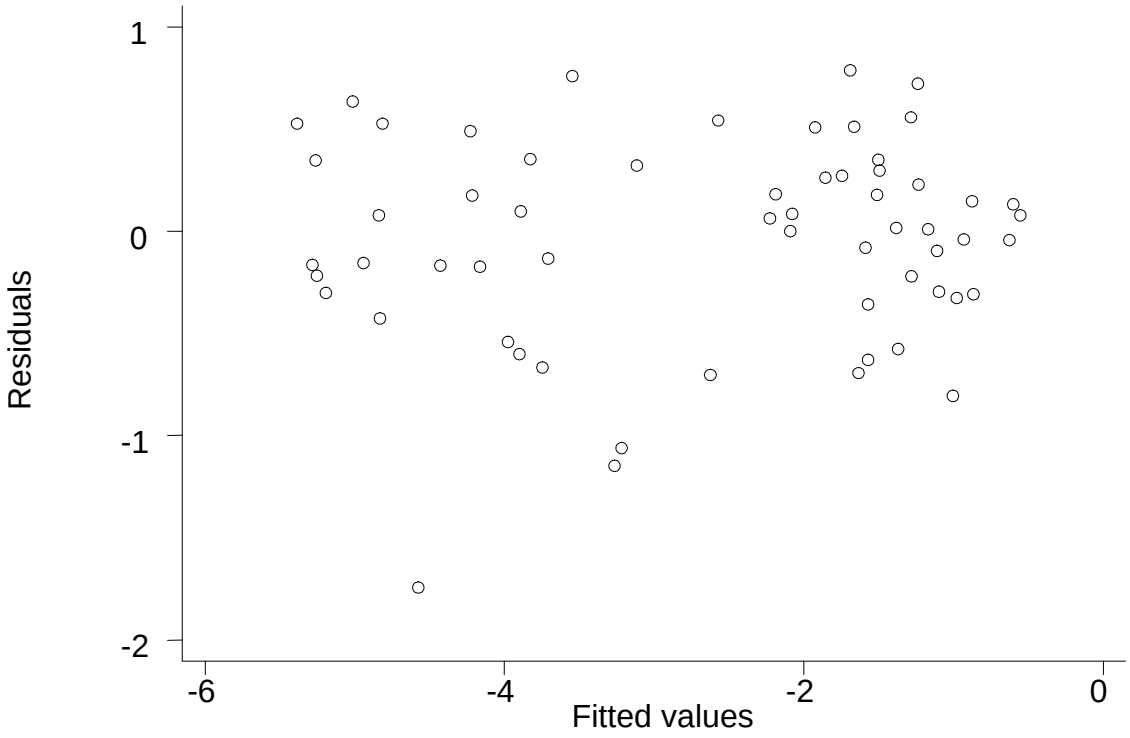
Annex Table J
Estimates of maternal mortality ratios, number of maternal deaths, and lifetime risk by State of the World's Children Regions (2000)

Region	Maternal mortality ratio	Maternal deaths	Lifetime risk 1 in:
Sub-Saharan Africa	1,100	252,000	13
Middle East and North Africa	360	33,000	55
South Asia	430	155,000	54
East Asia and Pacific	140	49,000	283
Latin America and the Caribbean	190	22,000	157
CEE/CIS and Baltic States	55	3,500	797
Industrialised countries	12	1,200	4,085
Developing countries	440	511,000	61
Least developed countries	1,000	230,000	16
Total	**400**	**529,000**	**75**

Annex Table K
Estimates of maternal mortality ratios, number of maternal deaths, and lifetime risk by UNFPA regions (2000)

UNFPA region	Maternal mortality ratio (maternal deaths per 100,000 live births)	Number of maternal deaths *	Lifetime risk of maternal deaths: 1 in:	Range of uncertainty on MMR estimates	
				Lower	Upper
Africa (46 countries)	**940**	235,000	16	**400**	**1,500**
Arab States/ Europe (50 countries)	**200**	28,000	170	**73**	**340**
Asia/ Pacific (40 countries)	**340**	243,000	93	**220**	**490**
Latin America/ Caribbean (41 countries)	**190**	22,000	160	**110**	**280**
NOTE: Figures may not add to total due to rounding.					
World -in UNFPA list - (177 countries)	**430**	528,000	66	**230**	**670**
Non-UNFPA list - (32 countries)	**13**	1,300	3,600	**8**	**17**
World - (all countries)	**400**	529,000	74	**210**	**620**

Figure 1. Plot of Residuals against Fitted Values



References

[1] Fifty-fifth session of the United Nations General Assembly. Agenda item 60(b). Resolution adopted by the General Assembly. *United Nations Millenium Declaration*. (A/RES/55/2).

[2] WHO/UNICEF. *Revised 1990 estimates of maternal mortality: a new approach by WHO and UNICEF*, 1996. WHO/FRH/MSM/96.11 and UNICEF/PLN/96.1. Geneva, World Health Organization, 1996.

[3] WHO/UNICEF/UNFPA. *Maternal mortality in 1995: estimates developed by WHO, UNICEF, UNFPA.* WHO/RHR01.9. Geneva, World Health Organization, 2001.

[4] World Health Organization. *International Statistical Classification of Diseases and Related Health Problems. Tenth Revision*. Geneva, World Health Organization, 1992.

[5] Bouvier-Colle MH et al. Reasons for the underreporting of maternal mortality in France, as indicated by a survey of all deaths among women of childbearing age. *International Journal of Epidemiology, 1991;**20**:717-21*.

[6] Hibbard BM et al. C*onfidential enquiries into maternal deaths in the United Kingdom, 1988-1990*. London, HMSO, 1994.

[7] Smith JC et al. An assessment of the incidence of maternal mortality in the United States. *American Journal of Public Health*, 1984;**74**:780-3.

[8] Thonneau et al. Risk factors for maternal mortality : results of a case-control study conducted in Conakry (Guinea). *International Journal of Gynecology and Obstetrics*, 1992;**39**:87-92.

[9] Child Survival Project, in cooperation with USAID, Egypt. *National maternal mortality study: findings and conclusions. Egypt, 1992-1993.* Ministry of Health, Egypt, 1994.

[10] Kwast B et al. Epidemiology of maternal mortality in Addis Ababa : a community-based study. *Ethiopian Medical Journal*, 1985;**23**:7-16.

[11] Graham W, Brass W, Snow RW. Indirect estimation of maternal mortality: the sisterhood method. *Studies in Family Planning*, 1989;**20**:125-35.

[12] Rutenberg N, Sullivan JM. *Direct and indirect estimates of maternal mortality from the sisterhood method.* Washington DC, IRD/Macro International Inc.,1991.

[13] Stanton C, Abderrahim N, Hill K. *DHS maternal mortality indicators : an assessment of data quality and implications for data use*. Demographic and Health Surveys Analytical Report No 4. Calverton (MD), Macro International Inc., 1997.

[14] WHO/UNICEF. *The sisterhood method for estimating maternal mortality: guidance notes for potential users.* WHO/RHT/97.28 and UNICEF/EPP/97.1. Geneva, World Health Organization, 1997.

[15] World Health Organization. *Studying maternal mortality in developing countries: a guidebook.* WHO/FHE/87.7. Geneva, World Health Organization, 1987.

[16] Castellanos M et al. *Mortalidad materna : investigación sobre mortalidad de mujeres en edad reproductiva con énfasis en mortalidad materna.* Universidad Nacional Autónoma de Honduras, Honduras, 1990.

[17] Walker GJ et al. Maternal mortality in Jamaica. *Lancet*, 1986; 1(**8479**):486-8.

[18] Walker GJA et al. Identifying deaths in developing countries. Experiences from Jamaica. *International Journal of Epidemiology*, 1990;**19**:599-605.

[19] World Health Organization. *Verbal autopsies for maternal deaths.* WHO/FHE/MSM/95.15. Geneva, World Health Organization, 1995.

[20] Stanton C et al. Every death counts: measurement of maternal mortality via a census. *Bulletin of the World Health Organization*, 2001;79(**7**):657-64.

[21] Hill K, AbouZahr C, Wardlaw T. Estimates of maternal mortality for 1995. *Bulletin of the World Health Organization*, 2001;79(**3**):182-93.

[22] Lopez AD et al. *World mortality in 2000: life tables for 191 countries.* Geneva, World Health Organization, 2002.

[23] Stanton C, Abderrahim N, Hill K. An assessment of DHS maternal mortality indicators. *Studies in Family Planning*, 2000; 31:111-23.

[24] Stecklov G. Maternal mortality estimation: separating pregnancy-related and non-pregnancy related risks. *Studies in Family Planning*, 1995;**26**:33-8.

[25] Shahidullah M. The sisterhood method of estimating maternal mortality: the Matlab experience. *Studies in Family Planning*, 1995;**26**:101-6.

[26] Hakkert, personal communication.

[27] World Health Organization. *Beyond the numbers. Reviewing maternal deaths and complications to make pregnancy safer.* (Forthcoming).