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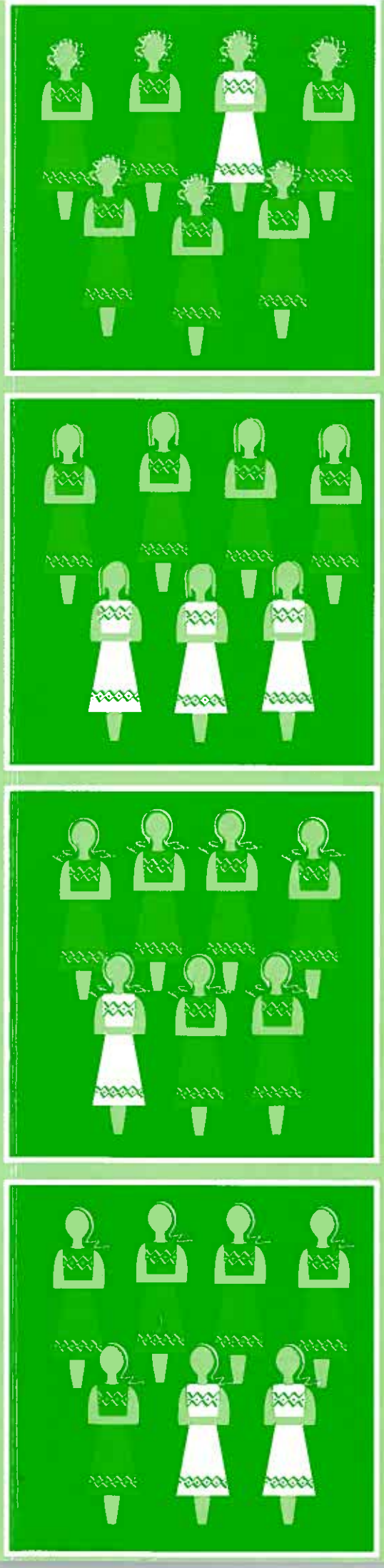

Maternal Mortality in 1995:

Estimates developed by WHO, UNICEF, UNFPA

World Health Organization, Geneva
RHR Reproductive Health and Research

United Nations Children's Fund

United Nations Population Fund

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Abbreviations

CEE/CIS	Central and Eastern Europe/Commonwealth of Independent States
DHS	Demographic and Health Surveys
EIP	WHO Cluster on Evidence and Information for Policy
FSE	Former Socialist Economies
GFR	General fertility rate
ICPD	International Conference on Population and Development
LASAME	Countries in Latin America and Caribbean, sub-Saharan Africa and the Middle East
MMR	Maternal mortality ratio
PMDF	Proportion maternal among deaths of women of reproductive age
RAMOS	Reproductive age mortality study
TFR	Total fertility rate
TRATT	Proportion of deliveries with a skilled health care worker
UN	United Nations
UNAIDS	Joint United Nations Programme on HIV/AIDS
UNFPA	United Nations Population Fund
UNICEF	United Nations Children's Fund
WHO	World Health Organization

Contents

Tables

Figures

Annex Tables

Appendices

Reduction of maternal mortality is one of the major goals of several recent international conferences. 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 using this outcome indicator. 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, the methods available differ considerably so that it is difficult to compare the data obtained from different sources. Moreover, problems of underreporting and misclassification of maternal deaths are endemic to all methods.

In order to strengthen the information base, WHO and UNICEF, with the participation of 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 was first used to develop estimates for 1990 maternal mortality, the baseline data stipulated in a series of internationally agreed goals and targets, including those of the World Summit for Children in 1990 and the International Conference on Population and Development in 1994. The results were published in 1996 and generated widespread interest and comment. A number of criticisms levelled at the approach have been taken into account in the current development of estimates for 1995.

On the basis of the present exercise, the estimated number of maternal deaths in 1995 for the world was 515,000 (Table 1). Of these deaths, over half (273,000) occurred in Africa, about 42% (217,000) occurred in Asia, about 4% (22,000) in Latin America and the Caribbean, and less than 1% (2,800) 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 (1,000), followed by Asia (280), Oceania (260), Latin America and the Caribbean (190), Europe (28) and Northern America (11).

The country with the highest estimated number of maternal deaths is India (110,000), followed by Ethiopia (46,000), Nigeria (45,000), Indonesia (22,000), Bangladesh (20,000), Democratic Republic of Congo (20,000), China (13,000), Kenya (13,000), Sudan (13,000), United Republic of Tanzania (13,000), Pakistan (10,000) and Uganda (10,000). These 12 countries account for 65 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. The countries with the highest MMRs are all in Africa; the top eleven, with MMRs of 1,300 or greater, are, in rank order, Rwanda, Sierra Leone, Burundi, Ethiopia, Somalia, Chad, Sudan, Burkina Faso, Equatorial Guinea, Angola and Kenya. In all, there are 22 countries in sub-Saharan Africa with MMRs of 1,000 or higher. Only one other country - Haiti - has a value in excess of 1,000.

Table 1: WHO/UNICEF/UNFPA estimates of maternal mortality by United Nations regions (1995)

UN 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**	**515,000**	**75**
More developed countries*	21	2,800	2,500
Less developed countries*	440	512,000	60
Least developed countries*	1,000	230,000	16
Africa	1,000	273,000	16
Eastern Africa	1,300	122,000	11
Middle Africa	1,000	39,000	13
Northern Africa	450	20,000	49
Southern Africa	360	4,500	65
Western Africa	1,100	87,000	13
Asia**	280	217,000	110
Eastern Asia	55	13,000	840
South-central Asia	410	158,000	55
South-eastern Asia	300	35,000	95
Western Asia	230	11,000	95
Europe	28	2,200	2,000
Eastern Europe	50	1,600	1,100
Northern Europe	12	140	3,900
Southern Europe	12	170	5,000
Western Europe	14	280	4,000
Latin America and the Caribbean	190	22,000	160
Caribbean	400	3,100	85
Central America	110	3,800	240
South America	200	15,000	150
Northern America	11	490	3,500
Oceania**	260	560	260
Australia/New Zealand	8	25	5,500
Melanesia	310	560	60
Micronesia	-	-	-
Polynesia	33	5	700

* See Appendix I for listing of countries within UN regions.

** Japan and Australia/New Zealand have been excluded from the regional averages and totals but are included in the average and total for more developed countries.

Figures may not add to totals due to rounding.

The MMR is a measure of the risk of death once a woman has become pregnant. But a more realistic 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. This measure is becoming increasingly popular. 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 MMR by the length of the reproductive period (around 35 years). Thus, the lifetime risk is calculated as 1–(1–maternal mortality rate)[35]. The lifetime risk can also be approximated by the product of the total fertility rate (TFR) and the MMR. An adjustment factor of 1.2 is included in order to compensate for pregnancy loss, i.e. pregnancies that do not result in a live birth. Thus, the lifetime risk is 1/(1.2*TFR*MMR).[7] Table 1 shows that the lifetime risk of death is highest in Eastern Africa, with as many as one woman in 11 facing the risk of maternal death in the course of her lifetime, compared with one in 4,000 in Western Europe and one in 3,500 in Northern America.

As was the case for the 1990 estimates, these 1995 estimates are primarily intended to be of use in countries with no estimates of maternal mortality or where there is concern about the adequacy of officially reported data. 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 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.

Because of the difficulties associated with the use of the MMR there is increasing agreement on the need to use intermediary or process or proxy indicators for monitoring progress towards the reduction of maternal mortality. A number of such indicators have been proposed but the indicator with which there is the most experience is the percentage of all births attended by skilled health workers - and this is also the process indicator recommended by the Special Session of the United Nations General Assembly in July 1999 in its report on the five-year review and appraisal of the Programme of Action of the International Conference on Population and Development (Cairo, 1994).

1. Background

This document summarizes the process used for the development of 1995 estimates of maternal mortality in all countries in the world. It represents the culmination of a series of interagency and interregional discussions, bringing together technical experts from various countries, agencies and academic institutions, to generate a broad consensus around the most appropriate way of developing such global estimates. This inclusive and open process helped to generate increased understanding around the challenges of measuring maternal mortality, monitoring trends, and interpreting results derived from different measurement strategies and information sources.

The document opens by summarizing 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 1995 estimates of maternal mortality is presented along with a description of the process through which this was accomplished. This is followed by an analysis and interpretation of the results, comparing them to the 1990 estimates developed by WHO and UNICEF and describing some of the difficulties that such comparisons involve. This section points out some of the pitfalls that may be encountered in attempting to use the estimates to draw conclusions about trends. The final parts of the document present a review of progress in maternal mortality reduction accomplished over the past few years followed by 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.

2. Why is maternal mortality difficult to measure?

Maternal mortality is notoriously difficult to measure for both conceptual and practical reasons. Maternal deaths are hard to identify precisely. The definition in the Tenth Revision of the International Classification of Diseases includes deaths due to both direct obstetric causes and to conditions aggravated by pregnancy or delivery.[1] In statistically-developed countries, the conventional source of information about maternal mortality is the civil registration system, recording deaths by cause as well as live births on a continuing basis. Even in such settings, however, maternal deaths are invariably found to be underrecorded in official statistics as a result of misclassification of cause.[2,3,4,5,6] In countries that are less statistically-developed, errors in both numbers of deaths and attribution of cause may result in biased measures of maternal mortality derived from vital registration.

Broadly speaking, countries fall into one of three categories:

- Those with complete civil registration and good cause of death attribution though even here, misclassification of maternal deaths can arise for a variety of reasons.[7]

- 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.[8]
- Those with no reliable system of civil registration where maternal deaths - like other vital events - go unrecorded.

Most of the developing countries of the world - and all of those where levels of maternal mortality are very high - fall into this last category. In these settings, it is necessary to use survey techniques to develop estimates of the levels of maternal mortality. But even where overall levels of maternal mortality are high, maternal deaths are relatively rare events, limiting the applicability of sample survey methods to their measurement. The most commonly used measure, the maternal mortality ratio (MMR), expresses maternal deaths per 100,000 live births, yet MMRs rarely exceed 1,000, or one per hundred live births. Even with large sample sizes, the standard errors of the MMR will inevitably be large. 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 sampling error of about 30%, i.e. the ratio could lie anywhere between 370 and 660.[9] 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.

In general, high maternal mortality countries have neither adequate systems of civil registration nor the resources to rely on large-scale surveys as an alternative. Indirect or event-history methods of estimating mortality, including maternal mortality, have been developed with the needs of these countries in mind. However, they remain subject to wide margins of error and have the additional disadvantage of averaging experience over a lengthy time period (some 35 years, with a midpoint around 12 years before the survey) and hence do not provide a current estimate. These methods and some of the problems associated with them are described in more detail in what follows.

Because of these difficulties, few developing countries have reliable national estimates of maternal mortality. In the absence of data, it becomes difficult to make the policy case for addressing the problem, often described as the 'measurement trap'.[7]

3. How can maternal mortality be measured?

Knowledge of the different methods available to measure maternal mortality at the national level is important for understanding the approach developed by WHO and UNICEF to generate global estimates. There are several commonly-used approaches for obtaining data on levels of maternal mortality which vary considerably in terms of methodology, source of data and precision of results. The main approaches are described briefly below.

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. In many countries, periodic confidential inquiries or surveillance are used to assess the extent of misclassification and underreporting. A review of the evidence shows that maternal deaths are underreported by a factor of some 50% on average.[10] 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, in the case of maternal mortality in particular, in view of the relatively small absolute number of maternal deaths, household surveys using direct estimation are expensive and complex to implement because large sample sizes are needed to provide a statistically reliable estimate. Because of the wide confidence intervals, the results cannot be used for monitoring trends other than in the very long term. A further problem is that such imprecise estimates may be interpreted inappropriately.

Indirect sisterhood method

The sisterhood method is a survey-based measurement technique that substantially reduces sample size requirements because it obtains information by interviewing respondents about the survival of all their adult sisters. For methodological reasons, the indirect method is not appropriate for use in settings where fertility levels are low [total fertility rate (TFR) <3] or where there has been substantial migration, civil strife, war or other causes of social dislocation. Although sample size requirements are reduced, the problem of wide confidence intervals remains and the technique is not appropriate for monitoring. Furthermore, the method provides a retrospective rather than a current estimate, usually centred around 10-12 years before the survey.[11]

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 larger sample sizes permit the calculation of a ratio for a more recent period of time. The reference point for a survey based on a reference period of 0-7 years would be 3-4 years prior to the data collection. Like the indirect method, the direct sisterhood method cannot be used to monitor changes in maternal mortality or to assess the impact of safe motherhood programmes in the short term.[13]

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.[14,15,16,17,18] All successful studies use multiple and varied sources of information; 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. RAMOS studies are considered to be the 'gold standard' for estimating maternal mortality but they 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, studies assign cause of death using verbal autopsy techniques.[19] However, the reliability of verbal autopsy for identifying maternal deaths 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 (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, many researchers remain unconvinced that the approach would prove of value in practice. The existing literature on direct and indirect estimation of overall adult mortality via a census in the developing world suggests that data obtained from enquiries into recent deaths in the household in a census require careful evaluation, and often adjustment. Nonetheless, 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] At present, reliable census data are available only for a few countries.

4. What were the sources of country data used for the 1995 estimates?

A general conclusion that emerges from a study of the different measurement methods is that problems with correct classification and complete ascertainment of maternal deaths are common to all methods. Determination of best estimates of maternal mortality accordingly implies adjusting data derived from different sources. In 1995, nationally reported data on maternal mortality were available from a variety of sources as summarized in Table 2 below.

Table 2: Sources of country data used in developing the 1995 estimates

Source for maternal mortality data	Number of countries	Global births covered	Annex Table
Vital registration characterized as complete* with good attribution of cause of death	49	13%	A
Vital registration characterized as complete* with uncertain or poor attribution of cause of death	18	2%	B
Direct sisterhood estimates	29	18%	C
Reproductive Age Mortality Studies	19	42%	D
No national data on maternal mortality	55	26%	E

* As classified by the UN Statistics Division. Complete means 90% or more of adult deaths are reported.

Percentages do not add to 100% due to rounding.

WHO and UNICEF, with the participation of 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 underreporting and misclassification in current data sources.

5. Why estimate maternal mortality for 1995?

During the 1990s there were increasing demands for reliable information on levels of maternal mortality. These demands were stimulated by a series of international conferences, including the Nairobi Safe Motherhood Conference in 1987, the World Summit for Children in 1990, the International Conference on Population and Development (ICPD) in 1994 and the Fourth World Conference on Women in 1995. During the review and appraisal of the implementation of the ICPD Programme of Action in 1999, the goal of reducing maternal mortality was reiterated as high priority and countries agreed to further strengthen information systems to permit regular monitoring of the implementation of the Conference goals.[21]

A common goal for these conferences was the reduction of maternal mortality by half of the 1990 levels by the year 2000. WHO and UNICEF have maintained databases on this indicator and issued the results periodically.[22] However, such monitoring has had to confront the lack of reliable data, particularly in the settings where maternal mortality is thought to be most serious. Notwithstanding the wording of the goal, which specifies a 1990 baseline, for the overwhelming majority of developing countries there were no reliable data on the levels of maternal mortality in 1990. This impeded an accurate assessment of the likely dimensions of the problem and its geographic spread. It was this that led to the development of the WHO/UNICEF 1990 estimates, published in 1996.[23] The estimates generated widespread interest and created a new momentum around the issue of maternal mortality, seen to represent a major public health threat with implications for the health and development of many millions of women, children and families around the world.

However, the estimates also generated a number of concerns among national authorities and experts working on maternal mortality. These included questions about the relationship between the estimates and available, nationally-reported data; lack of a common understanding about the rationale for the adjustments or for the use of modelling approaches; and worries about the implications of the adjusted estimates for data collection methodologies such as the sisterhood method.

These reactions must be seen in the context of generally poor knowledge about the dimensions and causes of adult mortality in general and relatively weak understanding of the complexities of reliably measuring maternal mortality.[24] Methodological and conceptual advances, and the publication of guidelines and explanatory materials, have since led to a much improved understanding of the strengths and weaknesses of different measurement methods and to a more sophisticated analysis of the results of different methodological approaches.

Moreover, the publication of the 1990 estimates had a number of positive results that have become increasingly clear with the passage of time. Following the publication of the 1990 estimates there has been increased attention to and understanding of definitional and methodological issues and the inevitable constraints these bring to reliable measurement of maternal mortality. There is also a better understanding of limits of different methodologies, in particular the sisterhood method. In this connection, there have been important conceptual and methodological advances in the understanding of the strengths and weaknesses of the two variants of the method. The Demographic and Health Surveys (DHS) 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.[25] In addition, following a meeting of technical experts, WHO and UNICEF 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.[26] A further welcome development is increased agreement on the need to use process indicators for monitoring progress.[27] UNICEF, WHO and UNFPA have jointly issued guidance on a short series of process indicators and these are now being used in a range of settings in South Asia, Africa, and Latin America.

As a result of the interest aroused by the publication of the 1990 estimates, WHO and UNICEF, joined by UNFPA, undertook to carry out a review of both the methodology and results and to develop a new set of estimates for the year 1995. This work was undertaken in close collaboration with countries and involved UN system agencies, interested non-governmental organizations and academic experts.

6. What was the process for developing the 1995 estimates?

In embarking upon the process for developing the 1995 estimates, WHO, UNICEF and UNFPA were anxious to fulfil the commitments made to countries that the concerns they had expressed in relation to the 1990 estimates would be addressed. While this inevitably would result in a longer process of developing the estimates, it would help generate a broader consensus around the process and its results. Thus, the development of the 1995 estimates has been made up of several distinct stages, including a systematic compilation of country concerns, analysis of responses to questionnaires sent to countries, interregional and interagency consultations, investigation of potential alternative modelling strategies, and peer review.

Compilation of comments received

A systematic review and analysis of country concerns in relation to the 1990 estimates was undertaken. Comments received during discussions with country experts were compiled and served both to improve the basic data set upon which the estimates were based and to stimulate attention to ways of improving the approach.

Dissemination of questionnaires

A questionnaire was developed in order to obtain the most recent nationally reported data. During 1997-1998, questionnaires were sent to WHO and UNICEF regional and country offices soliciting their inputs and requesting the most recent data available on maternal mortality and other key indicators.

Interregional consultations

A series of interregional and interagency consultations was organized. These brought together country and technical experts to discuss issues related to the measurement and monitoring of maternal mortality, as well as the details of the strategy used in the development of the 1990 estimates. Three such consultations were organized, covering Latin America (Washington, D.C., April 1998),[28] Asia (Bangkok, June 1998)[29] and Africa (Geneva, July 1999).[30] The consultations provided a forum for discussion around the concerns expressed by countries and technical experts, including:

- the need to report country-generated data alongside adjusted estimates;
- the classification of countries on the basis of nationally available data;
- adjustments made to nationally reported data;
- the modelling strategy used to generate estimates for countries without data;
- the use of the UN Population Division estimates of deaths of women of reproductive age which were felt to be insufficiently precise to be appropriate for this purpose;
- the values of the independent variables used in the model, in particular, the proportion of deliveries attended by a skilled health care worker.

Review of alternative modelling strategies

Alternative strategies for developing model-based estimates, including several developed by UNFPA, were reviewed during 1998-1999.[31] All involved modelling the MMR directly and using a variety of independent variables such as female life expectancy and female education. Model-based estimates were developed for all countries whatever the source and type of available country information. These alternatives were submitted to technical experts at a peer review meeting in May 1999 (see below).

Peer review meeting

A meeting of technical experts was convened to review the WHO/UNICEF approach and the UNFPA alternatives and to provide further ideas for improvement.[32] The peer review group was composed of independent technical experts and responsible staff from WHO, UNICEF, UNFPA, the UN Population Division and the World Bank (Appendix II). A full report of the peer review meeting is available.[33]

The majority of reviewers expressed a preference for the strategy in which the dependent variable is the proportion maternal among deaths of females of reproductive age (PMDF), and the major independent variables are the general fertility rate (GFR) and the proportion of deliveries attended by a skilled health care worker (TRATT). These independent variables were considered particularly crucial because they are closely associated with the reduction of maternal mortality. Another important perceived strength of this approach was that modelling is used to develop estimates only for a minority of countries (55 in all), the remainder being estimated using a variety of methods to adjust nationally reported data.

The overall conclusion of the peer review group was that the effort of the agencies to develop estimates was a valuable means of ensuring that estimates of maternal mortality were firmly based on objective, scientific and transparent approaches. However, the group stressed that the purpose of estimates of maternal mortality should not be for monitoring but for drawing attention to the existence and likely dimensions of the problem. The MMR, whether estimated or measured empirically, should not (other than in limited circumstances) be considered suitable for regular monitoring and evaluating of programmes for which more attention should be paid to process indicators. The group advised that the margins of uncertainty around values of the MMR should be published. Given current data collection methods, they would inevitably be wide whether the data are empirically derived or developed using mathematical models. The peer review group also recommended that UN Population Division estimates for data on live births and total deaths of reproductive-age women should be used in preference to other sources. The group also advised that when using UN estimates of deaths of women of reproductive age, the effect of AIDS deaths should be taken into account.

Review by WHO's Cluster on Evidence and Information for Policy

The final stage in the process consisted of an independent review of both the WHO/UNICEF and the UNFPA strategies by the Cluster on Evidence and Information for Policy (EIP), responsible for the scientific soundness of data and estimates reported by WHO. A preference was expressed for modelling the PMDF rather than modelling the MMR directly because the former approach has the advantage that it uses independent variables of public health significance, such as general fertility rate, rather than demographic variables, such as female life expectancy. EIP laid particular emphasis on the importance of acknowledging uncertainty in both empirical and estimated data and advised that uncertainty levels should be published for both empirical and estimated data.

7. What methods were used for the 1995 estimates?

The 1995 estimates were developed in a similar way to that used for the 1990 estimates. This involved using a dual strategy of adjusting nationally reported data using specific criteria and generating model-based estimates for countries with no data. On the basis of the information received from the responses to the question-

naires and information available in the WHO and UNICEF databases, countries were classified into the following groups for the purpose of the analysis:

- Countries with accurate death registration and good cause of death data.
- Countries with good death registration (reported to the UN as 'complete') and with numbers of deaths by age and sex for a recent year available in the UN Demographic Yearbook but with questionable data on cause of death.
- Countries with direct sisterhood estimates of maternal mortality.
- Countries with maternal mortality estimates from RAMOS-type studies.
- Countries with no reliable national estimates.

In the light of the inputs received from countries following the publication of the 1990 estimates, through the questionnaires, the interregional meetings, and the peer review, modifications were introduced to the strategy for generating 1995 estimates of maternal mortality. A detailed description of the methodology is available elsewhere.[34] As in the 1990 estimates, the dependent variable in the model was not the MMR itself, but the PMDF. The major independent variables were the general fertility rate and the proportion of deliveries attended by a skilled health care worker.

In all, the model was fitted to 73 contemporary observations, 30 of which were for developed countries or countries of formerly socialist Europe. The final model (shown in Box 1) included:

Box 1. Final model for the 1995 estimation process

The final model, fitted using a robust regression approach that eliminates gross outliers and underweights observations with large residuals, was:

$$ln\{PMDF/(1-PMDF)\} = -8.289 - 0.0141*TRATT + 1.386*lnGFR + 0.682*FSE + 0.719*LASSAME - 0.684*goodVR - 0.0197*HIV/AIDS$$
$$(-4.54)\ (-2.96)\qquad (3.91)\qquad (3.19)\qquad (2.93)\qquad (-3.16)\qquad (-1.36)$$

where :

PMDF	= proportion maternal among deaths of females of reproductive age
TRATT	= proportion of deliveries with a skilled health care worker
GFR	= general fertility rate
FSE	= former socialist economies
LASSAME	= countries in Latin America and the Caribbean, sub-Saharan Africa and the Middle East
goodVR	= degree of completeness of vital registration
HIV/AIDS	= indicator of HIV prevalence in adults.

Values in parentheses under the coefficients show the t-values, all except the HIV/AIDS variable being significant at the 1% level or better. The robust regression does not provide a direct R^2 for this model, but Ordinary Least Squares gave very similar parameter estimates with an R^2 of 0.911 and a Root Mean Square Error of 0.51. A plot of predicted values of PMDF against observed values (not shown) does not indicate heteroscedasticity or specification problems.

- one fertility variable (the natural logarithm of the GFR);
- one health sector variable (the proportion of deliveries assisted by skilled health care workers);
- two regional dummy variables (one for countries of formerly socialist Europe, and one for all countries in Latin America and the Caribbean, sub-Saharan Africa and the Middle East);
- one indicator of a country's level of statistical development [whether the country reports to the UN that registration of deaths is complete or otherwise (including not reporting)]; and
- an indicator of HIV prevalence (a national estimate from UNAIDS - the Joint United Nations Programme on HIV/AIDS).

The methods for arriving at final values for each country vary according to data availability and type as shown in Table 3.

Table 3: Methods of producing the 1995 estimates according to data source and type

Country data source and type	Method for producing the estimate	Annex Table
Complete vital registration* 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.	A
Complete vital registration* with uncertain or poor attribution of cause of death	The PMDF is estimated from the model, and applied to the nationally reported envelope of female deaths to estimate maternal deaths. The MMR is then estimated by dividing by the registered number of live births.	B
Direct sisterhood estimates	The observed PMDF (age standardized) from the sisterhood data is applied to the number of female deaths aged 15 to 49 implied by the UN population estimates and projections (1998 Revision) for the year 1995.	C
Reproductive Age Mortality Studies	The observed MMR is taken with no adjustments. However, estimated numbers of live births for 1995, generally from UN estimates, are used to obtain the number of maternal deaths for calculation of regional summaries.	D
No national data on maternal mortality	The estimates are developed using the model. For each country, the regression model was used to predict the PMDF, and the prediction was then applied to an envelope of deaths of females of reproductive age in 1995 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 1995. In almost all cases, the deaths envelope was obtained from the UN population projections (1998 Revision).	E

* As classified by the UN Statistics Division. Complete means 90% or more of adult deaths are reported.

8. How does the 1995 methodology differ from that used for the 1990 estimates?

The most significant differences in the approach for the 1995 estimates as compared with those for 1990 can be summarized 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 and quality of available maternal mortality data. As a result, the classification of several countries differs in the 1995 approach from the 1990 one. Only adequately documented estimates, backed by clear descriptions of acceptable methodology, were included in the data set on which the model was estimated.
- For the purpose of classifying countries, the distinction between developing and developed countries was dropped.
- For countries with documented assessments of completeness of recording of maternal deaths through the vital registers, the resulting estimate of coverage was used to adjust observed values. PMDFs for other countries with registration-based estimates were adjusted by a uniform factor of 1.5; the justification for this adjustment has been described in detail elsewhere but is based on the well-documented evidence of misclassification of maternal deaths even in settings with sophisticated health information and vital registration systems.[10]
- Estimates of PMDF derived from direct sisterhood surveys were age-standardized.
- 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.[34]
- Historical observations and the dummy variable denoting them were dropped.
- The most substantive change relates to the strategy for dealing with the impact of the HIV/AIDS epidemic on levels of adult female mortality. A major increase in female adult mortality resulting from the AIDS epidemic would tend to reduce the PMDF by increasing other causes of death (and perhaps by reducing fertility). Failure to take the epidemic into account would thus result in a model that would overestimate the PMDF in countries badly affected by the epidemic, and would tend to underestimate the PMDF elsewhere. Country-specific estimates of HIV prevalence for 1995 from UNAIDS were therefore used to adjust the PMDF in countries severely affected by the HIV/AIDS epidemic.[35]
- Particular measures were taken to deal with two countries, Rwanda and Liberia, affected in the early 1990s by civil strife. This civil strife inflated the estimated number of deaths for the period 1990-1995. By 1995, mortality levels had returned to more normal levels, so applying an estimated PMDF for 1995 to the 1990-1995/1995-2000 average would have overestimated total, and thus maternal, deaths (maternal deaths might have been only slightly inflated by the civil strife). For these two countries, the model-estimated PMDF was applied to an estimate of deaths in the absence of strife. For both Rwanda and Liberia, deaths in the absence of strife for 1995 were estimated as the average annual deaths between 1995 and 2000.

9. What are the results?

On the basis of this exercise, the estimated number of maternal deaths in 1995 for the world was 515,000 (Table 1). Of these deaths, over half (273,000) occurred in Africa, about 42% (217,000) occurred in Asia, about 4% (22,000) in Latin America and the Caribbean, and less than 1% (2,800) in the more developed regions. In terms of the MMR, the world figure is estimated to be 400 per 100,000 live births. By region, the MMR was highest in Africa (1,000), followed by Asia (280), Oceania (260), Latin America and the Caribbean (190), Europe (28) and Northern America (11).

The country with the highest estimated number of maternal deaths is India (110,000), followed by Ethiopia (46,000), Nigeria (45,000), Indonesia (22,000), Bangladesh (20,000), Democratic Republic of Congo (20,000), China (13,000), Kenya (13,000), Sudan (13,000), United Republic of Tanzania (13,000), Pakistan (10,000) and Uganda (10,000). These twelve countries account for nearly two thirds 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. The countries with the highest MMRs are all in Africa; the top eleven, with MMRs of 1,300 or greater are, in rank order, Rwanda, Sierra Leone, Burundi, Ethiopia, Somalia, Chad, Sudan, Burkina Faso, Equatorial Guinea, Angola and Kenya. In all, there are 22 countries in sub-Saharan Africa with MMRs estimated to be 1,000 or higher. Only one other country - Haiti - has a value in excess of 1,000.

The MMR is a measure of the risk of death once a woman has become pregnant. But a more realistic 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. This measure is becoming increasingly popular. 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 MMR by the length of the reproductive period (around 35 years). Thus, the lifetime risk is calculated as $[1–(1–MMR)^{35}]$.[7] The lifetime risk can also be approximated by the product of the total fertility rate (TFR) and the MMR. An adjustment factor of 1.2 is included in order to compensate for pregnancy loss, i.e. pregnancies that do not result in a live birth. Thus, the lifetime risk is [1/(1.2*TFR*MMR)].[7] Table 1 shows that the lifetime risk of death is highest in Eastern Africa, with as many as one woman in 11 facing the risk of maternal death in the course of her lifetime, compared with one in 4,000 in Western Europe and one in 3,500 in Northern America.

Annex Tables G, H and I show estimated MMRs, numbers of maternal deaths and lifetime risk for the WHO and UNICEF regions respectively.

10. How do these estimates differ from nationally reported estimates?

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 adjusted to account for misclassification of maternal deaths, an endemic phenomenon even in statistically highly-developed settings. In some cases, the adjustment 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 adjustment factor of 1.5 was applied, this figure having been derived from an analysis of the results of studies of underreporting and misclassification around the world.

Of particular concern to a number of developing countries is the fact that nationally reported estimates of maternal mortality 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.[36] 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 overreported (and the evidence on this point is mixed), the nature of likely biases in the sisterhood data argues for using the data in the form of PMDFs rather than MMRs.[37,38]

There is a further difference in the values for the PMDF that can be drawn from the published DHS results and those used to develop the 1995 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.[39] 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 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-standardized 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.

11. How do these estimates differ from the WHO/UNICEF 1990 estimates?

The main difference between these 1995 estimates and those for 1990 are in the absolute numbers of maternal deaths which total 515,000 in 1995 compared with 585,000 in 1990, a 12% difference, as shown in Table 4. However, the differences between the global MMRs are less pronounced. In 1990 the global ratio was 430 per 100,000 live births compared with 400 per 100,000 in 1995, a 7% difference. Part of the difference can be explained by the fact that global estimates of numbers of live births in 1995 are some 5% lower than those for 1990 as calculated by the UN population projections.

There are substantial regional differences between the 1990 and 1995 estimates. In general, the 1995 estimates for Asia and Central America are lower compared with 1990 whereas the 1995 estimates for Africa are substantially higher. Whereas in 1990 Africa accounted for 40% of the global total of maternal deaths, the 1995 estimates indicate that Africa accounts for some 53% of the total. By contrast, whereas in 1990, Asia contributed 55% of total maternal deaths, in 1995 it contributes 42%.

12. What can the 1995 estimates be used for?

As was the case for the 1990 estimates, these 1995 estimates are primarily intended to be of use in countries with no estimates of maternal mortality or where there is concern about the adequacy of officially reported data. 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 and relatively small changes to the model specification could have resulted in markedly different country level 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 sisterhood surveys, the estimates can serve to draw attention to the potential pitfalls associated with such indirect measurement techniques.

13. What should the estimates 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

Table 4: New regional estimates for 1995 compared with previous estimates for 1990

UN region	1990 Maternal mortality ratio (maternal deaths per 100,000 live births)	1990 Number of maternal deaths	1995 Maternal mortality ratio (maternal deaths per 100,000 live births)	1995 Number of maternal deaths
World total	430	585,000	400	515,000
More developed countries*	27	4,000	21	2,800
Less developed countries*	480	582,000	440	512,000
Least developed countries*	-	-	1,000	230,000
Africa	870	235,000	1,000	273,000
Eastern Africa	1,060	97,000	1,300	122,000
Middle Africa	950	31,000	1,000	39,000
Northern Africa	340	16,000	450	20,000
Southern Africa	260	3,600	360	4,500
Western Africa	1,020	87,000	1,100	87,000
Asia**	390	323,000	280	217,000
Eastern Asia	95	24,000	55	13,000
South-central Asia	560	227,000	410	158,000
South-eastern Asia	440	56,000	300	35,000
Western Asia	320	16,000	230	11,000
Europe	36	3,200	28	2,200
Latin America and Caribbean	190	23,000	190	22,000
Caribbean	400	3,200	400	3,100
Central America	140	4,700	110	3,800
South America	200	15,000	200	15,000
Northern America	11	500	11	500
Oceania**	680	1,400	260	600

* See Appendix I for listing of countries within UN regions.

** Japan and Australia/New Zealand have been excluded from the regional averages and totals but are included in the average and total for more developed countries.

Figures may not add to totals due to rounding.

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 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.

14. Why can the 1995 estimates NOT be used to analyse trends?

The 1995 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 adjusted by 50% 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 Table F). At the global level, the lower uncertainty bound is for a MMR of 230 per 100,000 live births, and an annual total of 303,000 maternal deaths, and the upper uncertainty bound is for a ratio of 635 per 100,000 live births, and an annual total of 822,000 maternal deaths. For countries with high point estimates derived from the model, the spread between the low and the high bounds is very wide. Countries with low point estimates derived from the model have an even wider relative range. 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 1995 estimates with those for 1990 and draw conclusions about trends. As has already been pointed out, a number of modifications were introduced into the approach for developing the 1995 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 1995 exercise. While the basic structure of the modelling strategy is unchanged, a number of changes have been incorporated which further add to the unsuitability of comparing the two sets of estimates. Specifically, dummy variables used in the 1990 model have been dropped and new ones introduced.

15. What available evidence is there to assess trends in the maternal mortality ratio?

This document has stressed the difficulties inherent in using the MMR for monitoring purposes when it is estimated using survey techniques that have wide margins of uncertainty. However, where comprehensive systems of vital registration are in place it is possible to use the MMR for monitoring trends. Such is the case for the developed countries as well as for some developing countries, mostly in Latin America, and countries of the former Soviet Union and some of the CEE/CIS (Central and Eastern Europe/Commonwealth of Independent States) and Baltic States. Where the absolute numbers of maternal deaths are small, there are likely to be random fluctuations in the levels of maternal mortality. In such cases, it is advisable to use moving averages when analysing trends.

It is also important to bear in mind the limitations of these data. As has been stressed repeatedly in this document, evidence indicates significant underreporting and misclassification of maternal deaths even in sophisticated vital registration systems. Much depends on the capacity of the vital statistics system to classify maternal deaths as such. The kinds of deaths most often missed in routine reporting include:

- those associated with abortion (especially where it is illegal),
- early pregnancy deaths (ectopic or molar pregnancy) where the fact of pregnancy may have been unknown to the woman and her family,
- indirect maternal deaths (malaria, anaemia, tuberculosis, hepatitis, cardiovascular disease, etc.) which are frequently miscoded to other categories, and
- deaths that occur some time after the termination of the pregnancy, especially when the death takes place on a non-obstetric hospital ward, for example, in an intensive care or specialized unit.[4,40,41,42]

Addressing the issue of under-ascertainment of maternal deaths in civil registration systems requires an ongoing effort of data quality control through, for example, systematic investigation of deaths of reproductive-age women and confidential enquiries. Nonetheless, the information available through the vital statistics system, albeit partial and incomplete, can serve to illustrate trends. In this report we

have assumed that the overall proportion of maternal deaths missed in routine reporting is likely to remain relatively stable unless active efforts are undertaken to improve case-finding.

Figures 1 and 2 show maternal mortality trends derived from civil registration in developing countries in Asia and Latin America respectively. The UN has classified these countries as having complete vital registration and they have trend data on maternal mortality derived from vital registration. The countries are Azerbaijan, Kazakhstan, Kyrgyzstan, Republic of Korea, Singapore, Tajikistan, Turkmenistan and Uzbekistan in Asia, and Argentina, Chile, Costa Rica, Cuba, Mexico and Venezuela in Latin America. We have not included vital registration data from the only African country classified by the UN as having complete coverage, namely Mauritius, because the absolute numbers are very small.

Figure 1 also includes trend data for China, where RAMOS studies have been used to estimate maternal mortality since 1989. Malaysia, Sri Lanka and Thailand also have time-series data on maternal mortality derived from routine reporting coupled, in recent years, with various methods of triangulation in order to reduce misclassification of maternal deaths and improve the completeness of reporting. We have not included trend data for these three countries in this analysis because improved case ascertainment in the more recent data renders any trend analysis problematic. Apparent increases in levels of maternal mortality in the recent past, notably in Malaysia and Thailand, reflect improved data collection as a result of the triangulation rather than a real upward trend.

In this analysis, we have assumed that the overall proportion of maternal deaths missed in routine reporting has remained relatively stable given the absence of efforts to improve case-finding. This seems a reasonable enough assumption though there is no evidence either way and it is conceivable that the quality of vital registration has improved or deteriorated over the period in question. These trend data cannot be assumed to fully capture true levels of maternal mortality because of the problems of underreporting and misclassification. In Argentina and Mexico, for example, small-scale studies in major urban areas have concluded that officially reported levels of maternal mortality may be underreported by as much as 50%.[28]

Bearing all these caveats in mind, it would seem that significant reductions in registered maternal mortality have occurred. However, most of the decline took place prior to 1990 (the vertical line in Figures 1, 2 and 3), the baseline date from which progress towards the attainment of the international development goals is to be measured. Only Argentina, Chile, China, Costa Rica and Uzbekistan are able to demonstrate unequivocal reductions in maternal mortality over the past decade. Elsewhere, there appears to have been a relative stagnation in maternal mortality since 1990, albeit at relatively low levels.

It is important to stress that these countries cannot be considered representative of trends in developing countries as a whole. All have levels of maternal mortality

that are low by developing country standards, at less than 100 per 100,000 live births. Taken as a whole, they account for only 24% of births in the world.

Figure 3 shows trends in maternal mortality in some countries of Eastern Europe, which are thought to have relatively efficient systems of vital registration. The apparent transient increases in some countries (for instance, Latvia) may be the result of random fluctuations due to the small numbers involved or, alternatively, due to improved case-reporting. In Romania, the precipitous fall in maternal mortality observed in 1989-1990 reflects the liberalization of the law regarding availability of safe abortion. Prior to 1989, strongly pronatalist policies, lack of reliable contraception, prohibition of abortion, and economic difficulties for ordinary people, combined to result in extremely high levels of abortion-related mortality.[43] Although the situation appears to have stabilized somewhat since 1990, differentials in levels of maternal mortality in countries of Eastern Europe and those of the European Union (data not shown) are marked.

16. How can we assess progress?

As has already been emphasized, where high-quality vital registration is not available - as in the majority of developing countries - measurement of maternal mortality has to rely on direct or indirect survey techniques, which are subject to wide margins of error because maternal deaths are relatively rare events. Because of problems such as these, the use of the MMR as the sole monitoring indicator is not considered appropriate in such settings. So what does that imply for monitoring progress towards the universally accepted goal of reducing levels of maternal mortality? It implies that intermediary or process or proxy indicators will be needed for regular monitoring of progress.

A good process indicator is one that is closely correlated with the outcome of interest, in this case, maternal mortality, but is simpler to measure on a regular basis. Process indicators have a number of advantages over outcome indicators. They are generally easier and cheaper to collect and are more sensitive to change, and are thus very useful for regular and short-term monitoring of progress.

Skilled attendant at delivery

A number of process indicators have been proposed for monitoring progress towards the reduction of maternal mortality, but the indicator with which there is the most experience in terms of data collection and analysis is the percentage of all births attended by skilled health workers. This indicator is highly correlated with maternal mortality and readily measurable using survey techniques; and it meets key criteria in terms of scientific soundness and accessibility. Moreover, data are widely available up to and including 1998.

However, correlation does not necessarily imply causation. Although there are sound clinical reasons for supposing that survival is higher among women who

deliver with the assistance of a person who can recognize and manage pregnancy-related complications, unequivocal epidemiological evidence is lacking. Moreover, the apparent simplicity of the indicator tends to obscure the complex reality of care during childbirth. Skilled attendants comprise doctors, midwives and nurses, yet the range of skills that these categories represent is vast. The difference between a normal and a complicated delivery implies a huge range in the skills, equipment and supplies required for appropriate care and management. Analytical work by Graham and colleagues has shown that the correlation between maternal mortality and skilled attendant appears to be stronger for doctors than for nurses/midwives.[44] Bi-variate and multi-variate analyses suggest some intriguing findings with regard to the mix of doctors and midwives/nurses that is most likely to result in reduced maternal mortality. Although the issue is too complex to address here, it is important to bear it in mind and considerable caution is warranted in interpreting what follows.

In recognition of the potential of the skilled attendant indicator to serve as a proxy for monitoring progress in maternal mortality, a report of the Special Session of the United Nations General Assembly in July 1999 on the review and appraisal of the ICPD Programme of Action recommended the following:[45]

> *In order to monitor progress towards the achievement of the Conference's goals for maternal mortality, countries should use the proportion of births assisted by skilled attendants as a benchmark indicator.*

WHO and UNICEF have monitored several indicators for coverage of maternity care - use of prenatal care, institutional deliveries, and skilled attendant at delivery - for many years in the context of monitoring progress towards Health For All and the World Summit for Children goals. While efforts are made to standardize definitions of skilled birth attendant, there is doubt about the comparability of some of the results across countries and within countries at different time periods. One source of potential confusion is the differing interpretations as to who is or is not a skilled attendant. Problems arise particularly in settings where traditional birth attendants have been trained and where many of them work within a health setting. The precise competencies of health care providers under the various titles of *partera, comadrona, dai,* etc. can be clarified only at the local level. This issue is particularly complex in Latin America where there appear to be discrepancies in the definition of the health workers included under the term 'skilled attendant'. Moreover, the definitions have, in some cases, changed from one DHS to another, particularly with regard to the categorization of *parteras*. In order to avoid these problems, for countries in Latin America we have used the proportion of births taking place in a health care facility, for which the definitions are consistent from one survey to the next, rather than the less clearly defined term 'skilled attendant'. For all other countries, we have followed the survey definition but included in our analysis only birth attendants described as doctors, nurses or nurse-midwives. This should not be taken to imply any recommendation as to the place of delivery; the decision is based on statistical considerations alone.

Apart from problems of definitions, there are other issues related to the way data on skilled attendants at delivery are collected. Concerns include:

- the extent to which respondents can accurately report the levels of skills of the birth attendant; and
- potential bias introduced by the fact that most household surveys report on live births in the past five years, thus missing many adverse health outcomes which are disproportionately concentrated among women experiencing adverse outcomes such as stillbirths or miscarriages.

Estimates as of end 2000 indicate that, globally, only around 56% of births are assisted by a skilled person. In developing countries, the lowest levels are in south Asia (29%) and sub-Saharan Africa (37%) with the highest levels in Latin America and the Caribbean (83%). Trend data on skilled attendants are not available for all countries. The information presented here represents only the subset of 53 countries that have a minimum of two data points derived from sources using similar estimation methods, generally DHS surveys. Overall, these 53 countries account for around three quarters of the developing world's live births, although this figure varies considerably by region. Table 5 shows the annual rate of change in the skilled attendant at delivery indicator for major regional groupings. Because data are available for different years and cover a different time period for each country, we have adjusted trends to a common ten-year period 1989-1999. The observed rate of change was used to project data for the end points in 1989 and 1999. The regional averages are weighted by the numbers of live births.

Table 5: Annual average rate of change in skilled attendant at delivery indicator for 53 countries over the period 1989-1999

UN region	Number of countries with trend data	% of total regional births	% of births attended by skilled health personnel		Annual average rate of change (%)*
	1999	1999	1989	1999	1989-1999
Sub-Saharan Africa	17	59	44	44	0.1
Middle East and North Africa	9	56	49	63	2.5
Asia	7	89	39	49	2.2
Latin America and Caribbean	18	74	74	81	0.9
Total	**53 ****	**76 *****	**44**	**52**	**1.7**

* Average of individual country data weighted by number of births.

** Includes an additional three countries from Central and Eastern Europe and the Commonwealth of Independent States as well as the developing countries included in the regions listed.

*** Data coverage for the developing world.

Given the imprecision of the data collection methodologies used to derive this indicator, it would be inappropriate to read too much into the apparent changes in coverage of care discernible in the figures currently available. Nonetheless, some tentative conclusions can be drawn. In general, only modest improvements in coverage of care at delivery have occurred, with an average annual increase of around 1.7% over the period 1989-1999.

In sub-Saharan Africa, the annual average rate of change over the period was unchanged, with no overall improvement over the decade despite improvements in some countries, notably Niger and Togo. Of the seventeen sub-Saharan countries for which trend data are available, only six - Ghana, Guinea, Niger, Nigeria, Senegal, and Togo - have significantly 0increased levels of coverage since 1988. In Bolivia, Egypt, Indonesia and Morocco - all countries characterized in recent years by a determined and high-level commitment to address maternal mortality - there have been significant improvements in coverage over a relatively short period of time. In Egypt, for example, coverage by skilled attendants at delivery increased from 35% to 61% over the period 1988 to 2000. In Indonesia, coverage by skilled attendants increased from 36% in 1987 to 56% in 1999. In Morocco, coverage increased from 24% in 1984 to 40% in 1995. In Honduras, institutional deliveries increased from 41% in 1987 to 54% in 1996. Similar increases are observed in other countries such as Argentina, Ecuador and Mexico.

17. What can we conclude about progress in reducing maternal mortality in the past decade?

Only two indicators are commonly available to permit an examination of progress achieved in reducing maternal mortality over the past decade: one direct indicator, namely maternal mortality data for countries with comprehensive vital registration systems; and one process indicator, namely data on skilled attendant at delivery. Where maternal mortality is high, data systems are generally too weak to permit trend analysis. Trends in MMRs relate almost entirely to those countries where levels of maternal mortality are already relatively low. In these countries, there are some signs of progress despite some apparently temporary setbacks in certain CEE/CIS and Baltic States. However, only a few countries have been able to demonstrate sustained reductions in levels of maternal mortality between 1990 and 2000.

Currently available data do not permit us to establish clear and unequivocal linkages between trends in skilled attendant at delivery and maternal mortality. Like any other indicator, the proportion of deliveries with a skilled attendant represents a summary measure of a complex reality. Much more detailed information is needed both on how the indicator is measured, and also, perhaps more importantly, precisely what it means in different settings with regard to the level of care available to women with normal and complicated deliveries. However, if the association between the two indicators holds, the data currently available suggest that there may be grounds for optimism with regard to maternal mortality trends in

parts of the Middle East and North Africa, Latin America and in Asia. By contrast, the situation in large parts of sub-Saharan Africa is disquieting, with stagnant or declining levels of coverage of skilled care for women during the crucial period of childbirth. This is a particular cause for concern in settings with high prevalence of HIV/AIDS where the need for skilled care during labour and childbirth is critical. Further information on these trends is available elsewhere.[46]

18. How can countries generate better maternal mortality 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 provision 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 attended by 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.[47]

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;
- rationalizing 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 as important as knowing the precise value of the MMR if not more so. 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.

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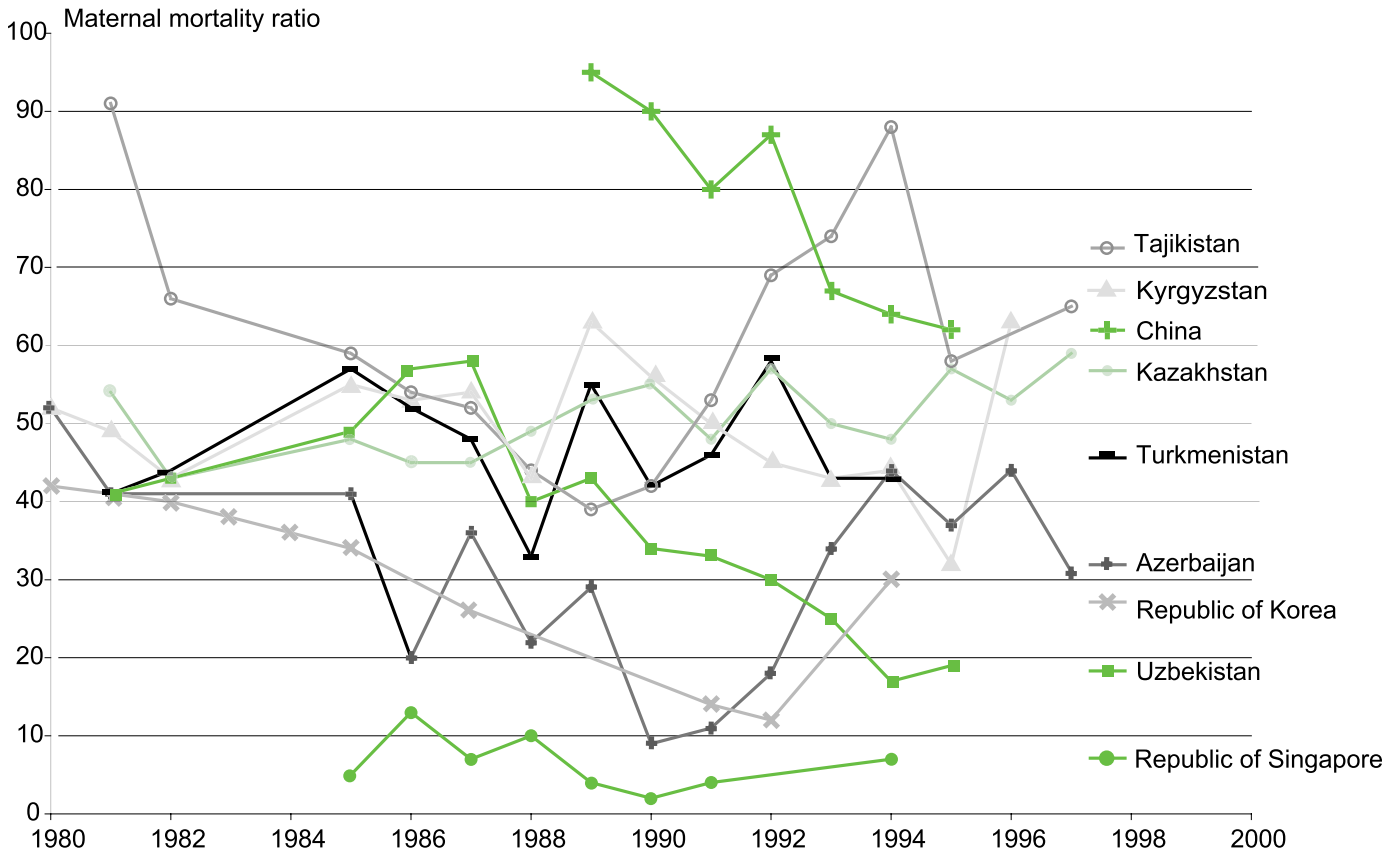
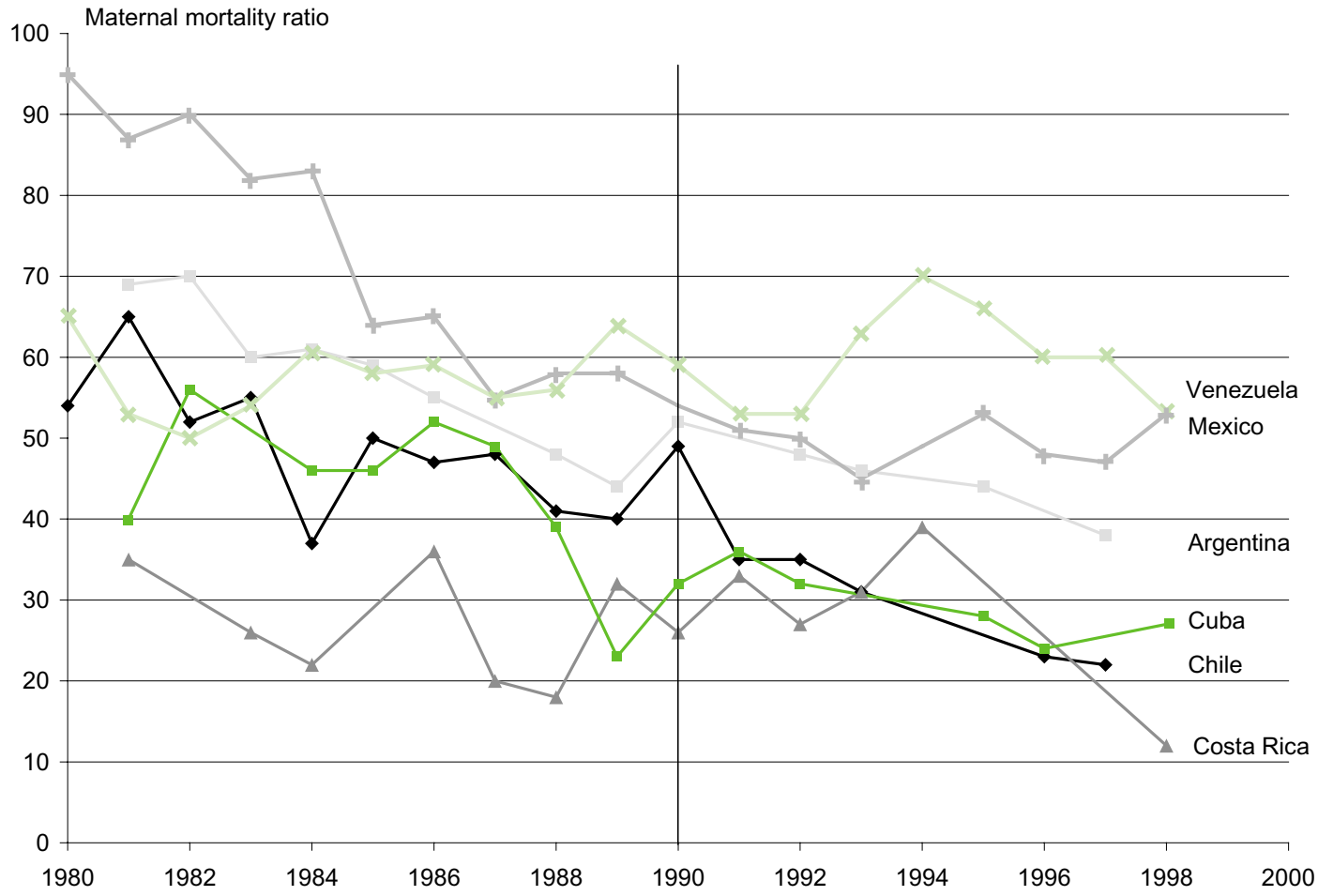
Figure 1: Trends in maternal mortality, 1980-1997, selected countries with vital registration in Asia, unadjusted figures



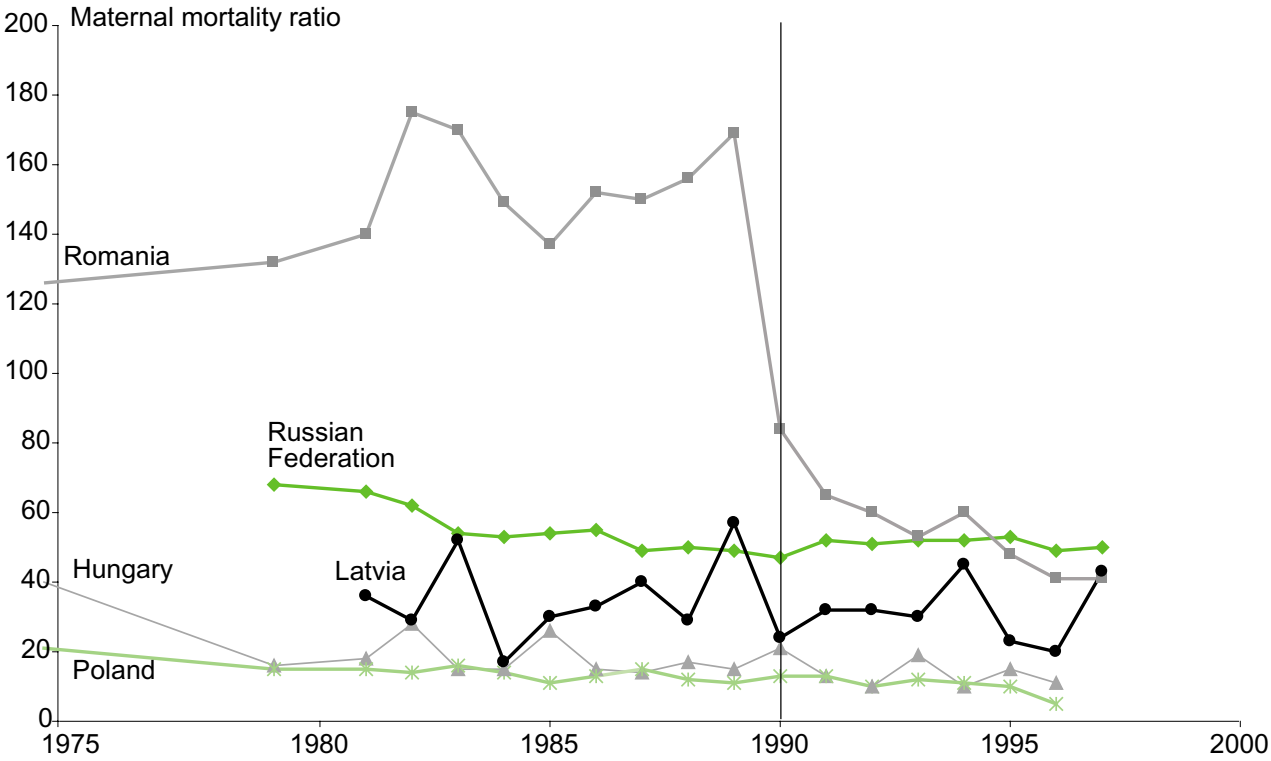
Source: WHO and UNICEF maternal mortality databases.

Figure 2: Trends in maternal mortality, 1980-1998, selected countries with vital registration in Latin America, unadjusted figures



Source: WHO and UNICEF maternal mortality databases.

Figure 3: Trends in maternal mortality, 1974-1997, selected countries with vital registration in Eastern Europe, unadjusted figures



Source: UNICEF and WHO maternal mortality databases.

ANNEX TABLES

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

	Year	Reported maternal mortality ratio (maternal deaths per 100,000 live births)	National adjustment factor	Adjusted maternal mortality ratio (maternal deaths per 100,000 live births)
Argentina	1995	44	1.9*	84
Australia	1993	4	1.5	6
Austria	1995	7	1.5	11
Belarus	1996	22	1.5	33
Belgium	1989	5	1.5	8
Bosnia/Herzegovina	1990	10	1.5	15
Bulgaria	1992-94	15	1.5	23
Canada	1993	4	1.5	6
Costa Rica	1994	29	1.2*	35
Croatia	1995	12	1.5	18
Cyprus	1993	0	1.5	0
Czech Republic	1995	9	1.5	14
Denmark	1995	10	1.5	15
Estonia	1995	52	1.5	78
Finland	1993-95	6	1.03*	6
France	1992-94	10	2.0*	20
Germany	1994-95	8	1.5	12
Greece	1993-95	1	1.5	2
Hungary	1995	15	1.5	23
Ireland	1990-92	6	1.5	9
Israel	1992-95	5	1.5	8
Italy	1990-92	7	1.5	11
Japan	1992-94	8	1.5	12
Latvia	1994	45	1.5	68
Lithuania	1996	18	1.5	27
Luxembourg	1994	0	1.5	0
Macedonia, TFYR	1995-96	11	1.5	17
Malta	1994	0	1.5	0
Mauritius	1996	30	1.5	45
Mexico	1995	48	1.4*	67
Moldova	1996	42	1.5	63
Netherlands	1993-95	7	1.4*	10
New Zealand	1994	15	1.0*	15

	Year	Reported maternal mortality ratio (maternal deaths per 100,000 live births)	National adjustment factor	Adjusted maternal mortality ratio (maternal deaths per 100,000 live births)
Norway	1991-93	6	1.5	9
Poland	1994-96	8	1.5	12
Portugal	1993-95	8	1.5	12
Puerto Rico	1991	20	1.5	30
Romania	1997	41	1.5	62
Russian Federation	1996	49	1.5	74
Singapore	1993-95	6	1.5	9
Slovakia	1995	9	1.5	14
Slovenia	1995-96	11	1.5	17
Spain	1990-92	5	1.5	8
Sweden	1993-95	5	1.5	8
Switzerland	1993-94	5	1.5	8
Ukraine	1996	30	1.5	45
United Kingdom	1992-95	7	1.4*	10
United States of America	1990-95	8	1.5	12
Yugoslavia	1995-96	10	1.5	15

* Adjustment factors from national studies, when available, were applied to the reported figures from vital registration. In all other cases, the adjustment factor was 1.5.

Methodological note

Maternal mortality rates are supplied here in their original unrounded form. Annex Table F follows the standard practice of rounding to the nearest 5 those rates that fall between 50 and 99 per 100,000.

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

	Year *	Adjusted maternal mortality ratio (maternal deaths per 100,000 live births)
Albania	1991/96	31
Armenia	1994	29
Barbados	1991/95	33
Brunei Darussalam	1992/96	22
Cape Verde	1991/92	190
Chile	1995	33
Fiji	1995/94	20
Georgia	1996/95	22
Kazakhstan	1996/95	80
Kuwait	1994/95	25
Kyrgyzstan	1995	80
Panama	1995	100
Qatar	1994	41
Tajikistan	1994	120
Trinidad/Tobago	1995	65
Uruguay	1993/95	50
Uzbekistan	1994	60
Venezuela	1991/95	43

* Reference year of deaths and births: where two years are given, the first is for deaths, the second for births.

Methodological note

For countries with good death registration (reported to the UN as 'complete') and with numbers of deaths by age and sex for a recent year available in the UN Demographic Yearbook, but with questionable data on cause of death, the proportion maternal among deaths of females of reproductive age (PMDF) is estimated from the model, and applied to the appropriate envelope of female deaths to estimate maternal deaths. The MMR is then estimated by dividing by the registered number of live births.

Annex Table C: Maternal mortality estimates derived from the 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	1989-96	498	880
Bolivia	1989-96	390	550
Brazil	1983-96	161	260
Cameroon	1989-98	430	720
Central African Republic	1989-95	1,451 *	1,200
Chad	1991-97	827	1,500
Côte d'Ivoire	1989-95	597	1,200
Ecuador	1988-94	159	210
Eritrea	1986-95	998	1,100
Guatemala	1990-95	190	270
Indonesia	1988-94	454 *	470
Kenya	1992-98	590	1,300
Madagascar	1990-97	488	580
Malawi	1986-92	752 *	580
Mali	1989-96	577	630
Morocco	1998	228	390
Namibia	1983-92	395 *	370
Nepal	1990-96	539	830
Niger	1986-92	672 *	920
Peru	1990-96	265	240
Philippines	1987-93	208 *	240
Senegal	1986-92	566 *	1,200
Sudan	1983-89	569 *	1,500
Tanzania, United Republic of	1987-96	529	1,100
Togo	1993-98	478	980
Uganda	1986-95	506	1,100
Yemen	1988-97	351	850
Zambia	1990-96	649	870
Zimbabwe	1988-94	393 *	610

* Where indicated, from 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 4*. Macro International Inc. Calverton, MD, 1997. Otherwise from DHS country reports.

Methodological note

For countries with direct sisterhood estimates of maternal mortality the observed PMDF (age standardized) from the sisterhood data is applied to the number of female deaths aged 15 to 49 implied by the UN population estimates and projections (1998 Revision) for the year 1995. For Morocco, the 1998 PAPCHILD survey included questions on deaths in the household in the year before the survey and questions on time of death relative to pregnancy for deaths of women of reproductive age. Detailed data from the survey have not been published but the estimated level of overall female adult mortality appears surprisingly low. Therefore, the reported PMDF has been applied to the UN estimates of deaths in 1995.

Annex Table D: Maternal mortality estimates derived from Reproductive Age Mortality Studies (RAMOS)

	Year	Reported RAMOS maternal mortality ratio (maternal deaths per 100,000 live births)
Belize	1995	140
China	1995	60
Cuba	1996	24
Egypt	1992-93	170
Guinea-Bissau	1989-90	910
Honduras	1989-90	220
India*	1992-93	440
Iran**	1996	130
Jamaica	1986-87	120
Jordan	1995-96	41
Korea, Republic of	1995-96	20
Lao People's Democratic Republic	1989-91	650
Malaysia	1994	39
Maldives	1992-94	390
Saudi Arabia	1997	23
Sri Lanka	1996	60
Suriname	1991-93	230
Thailand	1995-96	44
Tunisia	1994	70

* India carried out a major household survey, the National Family Health Survey, in 1992-1993 in collaboration with the Demographic and Health Surveys (DHS) programme. 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.

** The Islamic Republic of 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 deaths of females of reproductive age (PMDF) was assumed to be of good quality. Thus, the reported PMDF from the census was applied to the UN 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 UN estimate of the number of live births in 1995.

Methodological note

For countries with maternal mortality estimates from RAMOS-type surveys, the observed MMR is generally taken without adjustments.

Annex Table E: Maternal mortality estimates derived from the model (1995)

	Year	Model-based maternal mortality ratio (maternal deaths per per 100,000 live births)
Afghanistan	1995	820
Algeria	1995	150
Angola	1995	1,300
Azerbaijan	1995	37
Bahrain	1995	38
Bangladesh	1995	600
Bhutan	1995	500
Botswana	1995	480
Burkina Faso	1995	1,400
Burundi	1995	1,900
Cambodia	1995	590
Colombia	1995	120
Comoros	1995	570
Congo	1995	1,100
Congo, Democratic Republic of	1995	940
Djibouti	1995	520
Dominican Republic	1995	110
East Timor	1995	850
El Salvador	1995	180
Equatorial Guinea	1995	1,400
Ethiopia	1995	1,800
Gabon	1995	620
Gambia	1995	1,100
Ghana	1995	590
Guinea	1995	1,200
Guyana	1995	150
Haiti	1995	1,100
Iraq	1995	370
Korea, Democratic Republic of	1995	35
Lebanon	1995	130
Lesotho	1995	530
Liberia	1995	1,000
Libya	1995	120
Mauritania	1995	870

	Year	Model-based maternal mortality ratio (maternal deaths per per 100,000 live births)
Mongolia	1995	65
Mozambique	1995	980
Myanmar	1995	170
Nicaragua	1995	250
Nigeria	1995	1,100
Oman	1995	120
Pakistan	1995	200
Papua New Guinea	1995	390
Paraguay	1995	170
Réunion	1995	39
Rwanda	1995	2,300
Sierra Leone	1995	2,100
Solomon Islands	1995	60
Somalia	1995	1,600
South Africa	1995	340
Swaziland	1995	370
Syria	1995	200
Turkey	1995	55
Turkmenistan	1995	65
United Arab Emirates	1995	30
Viet Nam	1995	95

Methodological note

For countries lacking complete vital registration or other acceptable national estimates of maternal mortality, the estimates are developed using the model. For each country, the regression model was used to predict the proportion maternal among deaths of females of reproductive age (PMDF), and the prediction was then applied to an envelope of deaths of women of reproductive age in 1995 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 1995. In almost all cases, the deaths envelope was obtained from the UN population projections (1998 Revision).

Annex Table F: Country estimates of numbers of maternal deaths, lifetime risk, maternal mortality and ranges of uncertainty (1995)

	Annex Table	PMDF from model 1** (%)	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 estimate* Lower estimate	Upper estimate
Afghanistan	E	27	7,900	15	820	300	1,700
Albania	B	3	20	1,000	31	9	95
Algeria	E	12	1,200	140	150	55	360
Angola	E	42	7,100	9	1,300	600	2,100
Argentina	A		550	370	85	44	90
Armenia	B	2	15	1,500	29	9	85
Australia	A		15	7,700	6	4	8
Austria	A		10	5,400	11	7	15
Azerbaijan	E	2	55	980	37	12	110
Bahamas ***			5	3,200	10	5	20
Bahrain	E	4	5	690	38	13	110
Bangladesh	E	14	20,000	42	600	200	1,500
Barbados	B	1	5	1,600	33	10	110
Belarus	A		35	1,700	33	22	44
Belgium	A		10	6,500	8	5	11
Belize	D		10	150	140	70	280
Benin	C	32	2,000	15	880	560	1,200
Bhutan	E	21	360	30	500	180	1,100
Bolivia	C	21	1,400	33	550	370	740
Bosnia/Herzegovina	A		5	4,000	15	10	20
Botswana	E	9	250	38	480	150	1,400
Brazil	C	11	8,800	130	260	190	340
Brunei Darussalam	B	3	5	1,300	22	7	65
Bulgaria	A		15	2,600	23	15	31
Burkina Faso	E	30	6,700	9	1,400	570	2,600
Burundi	E	31	5,100	7	1,900	780	3,500
Cambodia	E	14	2,100	29	590	200	1,400
Cameroon	C	23	3,800	21	720	490	960
Canada	A		25	8,700	6	4	8
Cape Verde	B	18	20	120	190	70	420
Central African Republic	C	24	1,500	14	1,200	870	1,600
Chad	C	39	4,500	9	1,500	1,100	1,900
Chile	B	3	90	1,000	33	11	95
China	D		13,000	710	60	31	120

	Annex Table	PMDF from model 1** (%)	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 estimate* Lower estimate	Upper estimate
Colombia	E	8	1,200	240	120	40	320
Comoros	E	22	130	29	570	220	1,200
Congo	E	24	1,300	12	1,100	440	2,200
Congo, Democratic Republic of	E	29	20,000	13	940	390	1,800
Costa Rica	A		30	820	35	29	60
Côte d'Ivoire	C	25	6,000	13	1,200	860	1,500
Croatia	A		10	2,900	18	12	24
Cuba	D		35	2,200	24	12	48
Cyprus	A		-	0	0	0	0
Czech Republic	A		15	4,300	14	9	19
Denmark	A		10	3,300	15	10	20
Djibouti	E	13	120	29	520	190	1,300
Dominican Republic	E	7	220	250	110	37	300
East Timor	E	15	230	21	850	300	2,000
Ecuador	C	12	640	120	210	150	270
Egypt	D		3,000	130	170	160	190
El Salvador	E	9	300	130	180	65	470
Equatorial Guinea	E	40	240	10	1,400	610	2,400
Eritrea	C	33	1,600	12	1,100	830	1,400
Estonia	A		10	760	80	50	100
Ethiopia	E	39	46,000	7	1,800	790	3,200
Fiji	B	2	5	1,400	20	6	60
Finland	A		5	7,700	6	6	12
France	A		150	2,500	20	10	20
French Polynesia ***			5	1,400	20	10	40
Gabon	E	15	250	25	620	220	1,400
Gambia	E	25	500	14	1,100	430	2,100
Gaza Strip ***			50	90	120	60	240
Georgia	B	1	10	1,900	22	7	65
Germany	A		90	5,300	12	8	16
Ghana	E	24	4,000	26	590	230	1,200
Greece	A		5	32,100	2	1	3
Guadeloupe ***			-	8,300	5	3	10
Guam ***			-	2,000	12	6	24
Guatemala	C	15	1,000	60	270	130	420
Guinea	E	31	3,600	12	1,200	510	2,300

	Annex Table	PMDF from model 1** (%)	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 estimate* Lower estimate	Upper estimate
Guinea-Bissau	D		420	15	910	650	1,200
Guyana	E	6	30	230	150	50	430
Haiti	E	24	2,800	16	1,100	420	2,300
Honduras	D		440	80	220	200	240
Hungary	A		25	2,300	23	15	31
Iceland ***			5	2,400	16	11	22
India	D		110,000	55	440	330	540
Indonesia	C	15	22,000	65	470	370	580
Iran, Islamic Republic of	D	7	2,100	180	130	100	160
Iraq	E	22	2,800	41	370	140	770
Ireland	A		5	4,900	9	6	12
Israel	A		10	3,700	8	5	11
Italy	A		60	6,300	11	7	15
Jamaica	D		65	280	120	60	230
Japan	A		140	4,600	12	8	16
Jordan	D		85	390	41	31	50
Kazakhstan	B	2	220	450	80	25	240
Kenya	C	29	13,000	13	1,300	1,000	1,700
Korea, Democratic Republic of	E	2	170	1,100	35	11	110
Korea, Republic of	D		140	2,500	20	18	22
Kuwait	B	5	10	1,100	25	8	70
Kyrgyzstan	B	4	95	310	80	23	250
Lao People's Democratic Republic	D		1,300	21	650	530	790
Latvia	A		15	880	70	45	90
Lebanon	E	7	95	230	130	43	350
Lesotho	E	18	370	32	530	200	1,200
Liberia	E	24	1,100	12	1,000	400	2,100
Libya	E	10	170	180	120	40	300
Lithuania	A		10	1,900	27	18	36
Luxembourg	A		-	0	0	0	0
Macau ***			5	2,800	20	10	40
Macedonia, TFYR	A		5	2,300	17	11	23
Madagascar	C	22	3,400	25	580	430	740
Malawi	C	20	2,800	21	580	410	750
Malaysia	D		210	630	39	29	50

	Annex Table	PMDF from model 1** (%)	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 estimate*	
						Lower estimate	Upper estimate
Maldives	D		30	38	390	230	610
Mali	C	32	3,000	19	630	450	810
Malta	A		-	0	0	0	0
Martinique ***			-	11,600	4	2	10
Mauritania	E	28	850	17	870	360	1,700
Mauritius	A		10	880	45	30	60
Mexico	A		1,600	430	65	34	130
Moldova	A		35	660	65	42	85
Mongolia	E	4	40	440	65	19	190
Morocco	C	19	2,600	70	390	310	490
Mozambique	E	24	7,400	13	980	380	2,000
Myanmar	E	4	1,500	190	170	55	470
Namibia	C	15	210	44	370	250	490
Nepal	C	23	6,300	21	830	580	1,100
Netherlands	A		20	5,200	10	7	14
Netherlands Antilles ***			5	1,900	20	10	40
New Caledonia ***			-	3,000	10	5	20
New Zealand	A		10	2,600	15	15	30
Nicaragua	E	19	410	70	250	95	540
Niger	C	31	4,300	13	920	710	1,100
Nigeria	E	28	45,000	14	1,100	460	2,200
Norway	A		5	4,900	9	6	12
Oman	E	16	90	120	120	39	280
Pakistan	E	19	10,000	80	200	70	460
Panama	B	8	60	300	100	34	260
Papua New Guinea	E	10	550	45	390	130	1,000
Paraguay	E	17	270	110	170	65	390
Peru	C	14	1,500	110	240	190	280
Philippines	C	14	4,800	90	240	170	310
Poland	A		50	4,100	12	8	16
Portugal	A		15	5,000	12	8	16
Puerto Rico	A		20	1,300	30	20	40
Qatar	B	8	5	520	41	14	110
Réunion	E	3	5	930	39	13	110
Romania	A		150	1,000	60	41	85
Russian Federation	A		1,000	800	75	49	100

	Annex Table	PMDF from model 1** (%)	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 estimate* Lower estimate	Upper estimate
Rwanda	E	34	6,300	6	2,300	980	4,200
Samoa ***			5	1,300	15	8	30
Saudi Arabia	D		150	590	23	12	46
Senegal	C	34	4,100	12	1,200	840	1,600
Sierra Leone	E	36	4,200	6	2,100	900	3,600
Singapore	A		5	5,400	9	6	12
Slovakia	A		10	3,700	14	9	19
Slovenia	A		5	3,800	17	11	23
Solomon Islands	E	8	10	280	60	17	180
Somalia	E	50	7,100	7	1,600	770	2,400
South Africa	E	7	3,600	70	340	110	930
Spain	A		30	8,700	8	6	11
Sri Lanka	D		210	610	60	31	120
Sudan	C	33	13,000	12	1,500	1,000	1,900
Suriname	D		20	160	230	170	280
Swaziland	E	15	130	45	370	130	900
Sweden	A		10	5,800	8	5	11
Switzerland	A		5	6,900	8	5	11
Syria	E	16	880	95	200	70	450
Tajikistan	B	8	200	160	120	35	380
Tanzania, United Rep. of	C	26	13,000	14	1,100	800	1,300
Thailand	D		450	1,100	44	41	47
Togo	C	20	1,700	13	980	670	1,300
Trinidad/Tobago	B	2	15	660	65	21	200
Tunisia	D		130	430	70	60	75
Turkey	E	4	780	570	55	18	160
Turkmenistan	E	5	80	350	65	18	200
Uganda	C	14	10,000	11	1,100	900	1,200
Ukraine	A		220	1,200	45	30	60
United Arab Emirates	E	6	15	770	30	10	85
United Kingdom	A		75	4,600	10	7	14
United States of America	A		470	3,500	12	8	16
Uruguay	B	3	30	650	50	17	150
Uzbekistan	B	5	390	390	60	17	190
Vanuatu ***			5	580	32	16	65
Venezuela	B	4	220	630	43	14	120

	Annex Table	PMDF from model 1** (%)	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 estimate* Lower estimate	Upper estimate
Viet Nam	E	5	1,800	290	95	32	280
Western Sahara ***			70	0	850	430	1,700
Yemen	C	38	6,100	13	850	620	1,100
Yugoslavia	A		20	2,900	15	10	20
Zambia	C	13	3,100	17	870	780	930
Zimbabwe	C	14	2,200	33	610	440	780

* The MMRs have been rounded according to the following scheme: <50 : no rounding; 50 - 99 : rounded to nearest 5; 100 - 999 : rounded to nearest 10; >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.

*** Estimates using the model were not developed for countries with a total population below 300,000.

Annex Table G: Estimates of maternal mortality, numbers of maternal deaths and lifetime risk, by WHO regions (1995)*

WHO region	Maternal mortality ratio (maternal deaths per 100,000 live births)	Number of maternal deaths	Lifetime risk of maternal death 1 in :
Regional Office for Africa (AFRO)	1,100	246,000	14
Regional Office for the Americas (AMRO)	140	22,000	240
Regional Office for the Eastern Mediterranean (EMRO)	440	161,000	60
Regional Office for Europe (EURO)	37	4,000	1,300
Regional Office for South-East Asia (SEARO)	380	57,000	47
Regional Office for the Western Pacific (WPRO)	85	25,000	490
World total	**400**	**515,000**	**75**

Figures may not add to total due to rounding.

* See Appendix I for listing of countries within WHO regions

Annex Table H: Estimates of maternal mortality, numbers of maternal deaths and lifetime risk, by UNICEF regions (1995)*

UNICEF region	Maternal mortality ratio (maternal deaths per 100,000 live births)	Number of maternal deaths	Lifetime risk of maternal death 1 in :
Sub-Saharan Africa	1,100	252,000	13
Eastern and Southern Africa (ESARO)	1,200	133,000	12
Western and Central Africa (WCARO)	1,000	119,000	14
Middle East and North Africa (MENA)	360	33,000	55
South Asia (ROSA)	430	155,000	54
East Asia and the Pacific (EAPRO)	140	49,000	283
Latin America and the Caribbean (TACRO)	190	22,000	157
CEE/CIS and the Baltic States (CEE/CIS)	55	3,500	797
Industrialized countries	12	1,200	4,085
Developing countries	440	511,000	61
Least developed countries	1,000	230,000	16
World total	**400**	**515,000**	**75**

Figures may not add to total due to rounding.

* See Appendix I for listing of countries within UNICEF regions.

Appendix I:
A. Countries grouped by United Nations regions

Developed regions

Northern America, Europe, Japan, Australia and New Zealand.

Developing regions

Africa, Americas excluding Canada and United States in Northern America, Caribbean, Central America, South America, Asia excluding Japan, Oceania excluding Australia and New Zealand.

Least developed countries

Africa

Angola, Benin, Burkina Faso, Burundi, Cape Verde, Central African Republic, Chad, Comoros, Democratic Republic of the Congo, Djibouti, Equatorial Guinea, Eritrea, Ethiopia, Gambia, Guinea, Guinea Bissau, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Niger, Rwanda, Sao Tome and Principe, Sierra Leone, Somalia, Sudan, Togo, Uganda, United Republic of Tanzania, Zambia.

Asia

Afghanistan, Bangladesh, Bhutan, Cambodia, Lao People's Democratic Republic, Maldives, Myanmar, Nepal, Yemen.

Caribbean

Haiti

Oceania

Kiribati, Samoa, Solomon Islands, Tuvalu, Vanuatu.

Africa

Eastern Africa

Burundi, Comoros, Djibouti, Eritrea, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Mozambique, Réunion, Rwanda, Seychelles, Somalia, Uganda, United Republic of Tanzania, Zambia, Zimbabwe.

Middle Africa

Angola, Cameroon, Central African Republic, Chad, Congo, Democratic Republic of the Congo, Equatorial Guinea, Gabon, Sao Tome and Principe.

Northern Africa

Algeria, Egypt, Libyan Arab Jamahiriya, Morocco, Sudan, Tunisia, Western Sahara.

Southern Africa

Botswana, Lesotho, Namibia, South Africa, Swaziland.

Western Africa

Benin, Burkina Faso, Cape Verde, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Saint Helena, Senegal, Sierra Leone, Togo.

Asia

Eastern Asia

China, Hong Kong Special Administrative Region of China, Macao Special Administrative Region of China, Democratic People's Republic of Korea, Japan, Mongolia, Republic of Korea.

South-central Asia

Afghanistan, Bangladesh, Bhutan, India, Iran (Islamic Republic of), Kazakhstan, Kyrgyzstan, Maldives, Nepal, Pakistan, Sri Lanka, Tajikistan, Turkmenistan, Uzbekistan.

South-eastern Asia

Brunei Darussalam, Cambodia, East Timor, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam.

Western Asia

Armenia, Azerbaijan, Bahrain, Cyprus, Georgia, Iraq, Israel, Jordan, Kuwait, Lebanon, Occupied Palestinian Territory, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, Turkey, United Arab Emirates, Yemen.

Europe

Eastern Europe

Belarus, Bulgaria, Czech Republic, Hungary, Poland, Republic of Moldova, Romania, Russian Federation, Slovakia, Ukraine.

Northern Europe

Channel Islands, Denmark, Estonia, Faeroe Islands, Finland, Iceland, Ireland, Isle of Man, Latvia, Lithuania, Norway, Svalbard and Jan Mayen Islands, Sweden, United Kingdom.

Southern Europe

Albania, Andorra, Bosnia and Herzegovina, Croatia, Gibraltar, Greece, Holy See, Italy, Malta, Portugal, San Marino, Slovenia, Spain, The former Yugoslav Republic of Macedonia, Yugoslavia.

Western Europe

Austria, Belgium, France, Germany, Liechtenstein, Luxembourg, Monaco, Netherlands, Switzerland.

Latin America and the Caribbean

Caribbean

Anguilla, Antigua and Barbuda, Aruba, Bahamas, Barbados, British Virgin Islands, Cayman Islands, Cuba, Dominica, Dominican Republic, Grenada, Guadeloupe, Haiti, Jamaica, Martinique, Montserrat, Netherlands Antilles, Puerto Rico, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Trinidad and Tobago, Turks and Caicos Islands, United States Virgin Islands.

Central America

Belize, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama.

South America

Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Falkland Islands (Malvinas), French Guiana, Guyana, Paraguay, Peru, Suriname,Uruguay, Venezuela.

Northern America

Bermuda, Canada, Greenland, Saint Pierre and Miquelon, United States of America.

Oceania

Australia and New Zealand

Australia, New Zealand, Norfolk Island.

Melanesia

Fiji, New Caledonia, Papua New Guinea, Solomon Islands, Vanuatu.

Micronesia

Guam, Kiribati, Marshall Islands, Micronesia (Federated States of), Nauru, Northern Mariana Islands, Palau.

Polynesia

American Samoa, Cook Islands, French Polynesia, Niue, Pitcairn, Samoa, Tokelau, Tonga, Tuvalu, Wallis and Futuna Islands.

B. Countries grouped by WHO regions

Regional Office for Africa Member States

Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, Côte d'Ivoire, Democratic Republic of the Congo, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, South Africa, Swaziland, Togo, Uganda, United Republic of Tanzania, Zambia, Zimbabwe.

Regional Office for the Americas Member States

Antigua and Barbuda, Argentina, Bahamas, Barbados, Belize, Bolivia, Brazil, Canada, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Puerto Rico (associate member), Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, United States of America, Uruguay, Venezuela.

Regional Office for the Eastern Mediterranean Member States

Afghanistan, Bahrain, Cyprus, Djibouti, Egypt, Iran (Islamic Republic of), Iraq, Jordan, Kuwait, Lebanon, Libyan Arab Jamahiriya, Morocco, Oman, Pakistan, Qatar, Saudi Arabia, Somalia, Sudan, Syrian Arab Republic, Tunisia, United Arab Emirates, Yemen.

Regional Office for Europe Member States

Albania, Andorra, Armenia, Austria, Azerbaijan, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Luxembourg, Malta, Monaco, Netherlands, Norway, Poland, Portugal, Republic of Moldova, Romania, Russian Federation, San Marino, Slovakia, Slovenia, Spain, Sweden, Switzerland, Tajikistan, The former Yugoslav Republic of Macedonia, Turkey, Turkmenistan, Ukraine, United Kingdom, Uzbekistan, Yugoslavia.

Regional Office for South-East Asia Member States

Bangladesh, Bhutan, Democratic People's Republic of Korea, India, Indonesia, Maldives, Myanmar, Nepal, Sri Lanka, Thailand.

Regional Office for the Western Pacific Member States

Australia, Brunei Darussalam, Cambodia, China, Cook Islands, Fiji, Japan, Kiribati, Lao People's Democratic Republic, Malaysia, Marshall Islands, Micronesia (Federated States of), Mongolia, Nauru, New Zealand, Niue, Palau, Papua New Guinea, Philippines, Republic of Korea, Samoa, Singapore, Solomon Islands, Tokelau (associate member), Tonga, Tuvalu, Vanuatu, Viet Nam.

C. Countries grouped by UNICEF regions

Sub-Saharan Africa

Angola; Benin; Botswana; Burkina Faso; Burundi; Cameroon; Cape Verde; Central African Republic; Chad; Comoros; Congo; Congo, Democratic Republic of; Côte d'Ivoire; Equatorial Guinea; Eritrea; Ethiopia; Gabon; Gambia; Ghana; Guinea; Guinea-Bissau; Kenya; Lesotho; Liberia; Madagascar; Malawi; Mali; Mauritania; Mauritius; Mozambique; Namibia; Niger; Nigeria; Rwanda; Sao Tome and Principe; Senegal; Seychelles; Sierra Leone; Somalia; South Africa; Swaziland; Togo; Uganda; United Republic of Tanzania; Zambia; Zimbabwe.

Middle East and North Africa

Algeria; Bahrain; Cyprus; Djibouti; Egypt; Iran; Iraq; Jordan; Kuwait; Lebanon; Libyan Arab Jamahiriya; Morocco; Oman; Qatar; Saudi Arabia; Sudan; Syria; Tunisia; United Arab Emirates; Yemen.

South Asia

Afghanistan; Bangladesh; Bhutan; India; Maldives; Nepal; Pakistan; Sri Lanka.

East Asia and Pacific

Brunei Darussalam; Cambodia; China; Cook Islands; Fiji; Indonesia; Kiribati; Korea, Democratic People's Republic; Korea, Republic of; Lao People's Democratic Republic; Malaysia; Marshall Islands; Micronesia, Federated States of; Mongolia; Myanmar; Nauru; Niue; Palau; Papua New Guinea; Philippines; Samoa; Singapore; Solomon Islands; Thailand; Tonga; Tuvalu; Vanuatu; Viet Nam.

Latin America and Caribbean

Antigua and Barbuda; Argentina; Bahamas; Barbados; Belize; Bolivia; Brazil; Chile; Colombia; Costa Rica; Cuba; Dominica; Dominican Republic; Ecuador; El Salvador; Grenada; Guatemala; Guyana; Haiti; Honduras; Jamaica; Mexico; Nicaragua; Panama; Paraguay; Peru; Saint Kitts and Nevis; Saint Lucia; Saint Vincent/Grenadines; Suriname; Trinidad and Tobago; Uruguay; Venezuela.

CEE/CIS and Baltic States

Albania; Armenia; Azerbaijan; Belarus; Bosnia and Herzegovina; Bulgaria; Croatia; Czech Republic; Estonia; Georgia; Hungary; Kazakhstan; Kyrgyzstan; Latvia; Lithuania; Moldova, Republic of; Poland; Romania; Russian Federation; Slovakia; Tajikistan; The former Yugoslav Republic of Macedonia; Turkey; Turkmenistan; Ukraine; Uzbekistan; Yugoslavia.

Industrialized countries

Andorra; Australia; Austria; Belgium; Canada; Denmark; Finland; France; Germany; Greece; Holy See; Iceland; Ireland; Israel; Italy; Japan; Liechtenstein; Luxembourg; Malta; Monaco; Netherlands; New Zealand; Norway; Portugal; San Marino; Slovenia; Spain; Sweden; Switzerland; United Kingdom; United States of America.

Developing countries

Afghanistan; Algeria; Angola; Antigua and Barbuda; Argentina; Armenia; Azerbaijan; Bahamas; Bahrain; Bangladesh; Barbados; Belize; Benin; Bhutan; Bolivia; Botswana; Brazil; Brunei Darussalam; Burkina Faso; Burundi; Cambodia; Cameroon; Cape Verde, Central African Republic; Chad; Chile; China; Colombia; Comoros; Congo; Congo, Democratic Republic of; Cook Islands; Costa Rica; Côte d'Ivoire; Cuba; Cyprus; Djibouti; Dominica; Dominican Republic; Ecuador; Egypt; El Salvador; Equatorial Guinea; Eritrea; Ethiopia; Fiji; Gabon; Gambia; Georgia; Ghana; Grenada; Guatemala; Guinea; Guinea-Bissau; Guyana; Haiti; Honduras; India; Indonesia; Iran; Iraq; Israel; Jamaica; Jordan; Kazakhstan; Kenya; Kiribati; Korea, Democratic People's Republic; Korea, Republic of; Kuwait; Kyrgyzstan; Lao People's Democratic Republic; Lebanon; Lesotho; Liberia; Libyan Arab Jamahiriya; Madagascar; Malawi; Malaysia; Maldives; Mali; Marshall Islands; Mauritania; Mauritius; Mexico; Micronesia, Federated States of; Mongolia; Morocco; Mozambique; Myanmar; Namibia; Nauru; Nepal; Nicaragua; Niger; Nigeria; Niue; Oman; Pakistan; Palau; Panama; Papua New Guinea; Paraguay; Peru; Philippines; Qatar; Rwanda; Saint Kitts and Nevis; Saint Lucia; Saint Vincent/Grenadines; Samoa; Sao Tome and Principe; Saudi Arabia; Senegal; Seychelles; Sierra Leone; Singapore; Solomon Islands; Somalia; South Africa; Sri Lanka; Sudan; Suriname; Swaziland; Syria; Tajikistan; Thailand; Togo; Tonga; Trinidad and Tobago; Tunisia; Turkey; Turkmenistan; Tuvalu; Uganda; United Arab Emirates; United Republic of Tanzania; Uruguay; Uzbekistan; Vanuatu; Venezuela; Viet Nam; Yemen; Zambia; Zimbabwe.

Least developed countries

Afghanistan; Angola; Bangladesh; Benin; Bhutan; Burkina Faso; Burundi; Cambodia; Cape Verde; Central African Republic; Chad; Comoros; Congo, Democratic Republic of; Djibouti; Equatorial Guinea; Eritrea; Ethiopia; Gambia; Guinea; Guinea-Bissau; Haiti; Kiribati; Lao People's Democratic Republic; Lesotho; Liberia; Madagascar; Malawi; Maldives; Mali; Mauritania; Mozambique; Myanmar; Nepal; Niger; Rwanda; Samoa; Sao Tome and Principe; Sierra Leone; Solomon Islands; Somalia; Sudan; Togo; Tuvalu; Uganda; United Republic of Tanzania; Vanuatu; Yemen; Zambia.

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