Technical and Policy Paper No. 1

Issues in Measuring and Monitoring Maternal Mortality

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Foreword

Reproductive health care entails the provision of a comprehensive range of quality services and information. Amongst the elements of reproductive health to which UNFPA gives significant attention are family planning, maternal care, harmful practices and violence against women, prevention and management of reproductive tract infections and sexually transmitted diseases (STDs), and prevention of HIV/AIDS. Despite progress in many of these areas, maternal mortality continues to be unacceptably high in much of the developing world and particularly so in poor countries, or areas of countries where the prevalence of poverty is still acute. Such countries tend to be characterized by high levels of fertility, high rates of infectious diseases and neglect for the proper care for women during (and after) pregnancy.

Just over a decade has elapsed since the Safe Motherhood Initiative was first launched in 1987 with the aim of reducing the high levels of maternal mortality that were evidenced in many developing countries. During this period the concept of safe motherhood has evolved and broadened**.** Thus the Programme of Action of the 1994 International Conference on Population and Development (ICPD), and subsequently the Fourth World Conference on Women in Beijing in 1995, explicitly stated that programmes to reduce maternal mortality must contain a number of complementary elements.

UNFPA's approach to reducing maternal mortality includes, among other measures, assistance towards:

- expanding access to quality family planning services and information;
- prevention of abortion, management of the complications arising from unsafe abortions, as well as post-abortion family planning and counseling;
- management of the complications of pregnancy and delivery;
- training for health personnel involved in providing assistance during pregnancy, delivery and the postpartum period;
- advocacy for measures that lead to improvements in referral systems and services and transport for complications arising from emergencies;
- targeted IEC campaigns to promote reproductive health, and obstetrical and other health practices associated with maternal care; and
- research to evaluate the efficiency and effectiveness of innovative approaches to the delivery of maternal care services.

With the heightened international interest in programmes aimed at reducing levels of maternal mortality, it is important that the immense difficulties faced in reliably measuring levels and changes in its incidence are widely understood. The measurement of maternal mortality is important for assessing the types of programmes to be implemented, as well as progress that they make in reducing its incidence. This technical report has been prepared to help those concerned with formulating, monitoring and evaluating programmes to reduce maternal mortality; to better understand the scale and frequency of maternal deaths in populations; to recognize the problems of measuring maternal mortality and to suggest indicators that can be used to monitor progress.

For many developing countries, fully reliable estimates of maternal mortality will not become available until they have complete systems of civil registration. In the meantime, there is not much to be gained from spending large amounts of scarce resources on expensive methods of data collection merely to estimate broad or overall levels of maternal mortality. UNFPA will continue to work with others in seeking to improve the measurement of maternal mortality, but our priority will certainly be on programmes and activities to reduce maternal mortality from its unacceptably high level in many countries.

I would like to thank Mr Richard Leete, Senior Technical Officer, Technical and Evaluation Division, (TED), who was responsible for the preparation of this report, as well as his colleagues Dr Nicholas Dodd, Mr Richard Osborn, Dr Charlotte Gardiner, Dr Laura Laski, Ms Catherine Pierce and Mr Michael Vlassoff for making helpful comments during the course of its preparation. I would also like to thank Mr Joseph Chamie, Director, United Nations Population Division; Mr Hermann Habermann, Director, United Nations Statistics Division; and Professor John Cleland of the London School of Hygiene and Tropical Medicine, for reviewing an earlier draft.

I hope that this report will be read and used by all those concerned with programmes to reduce maternal mortality.

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1 Introduction

The relatively high rates of maternal mortality prevailing throughout much of the developing world are a consequence of the continued serious neglect of women's reproductive health, particularly that of the poorest women in the least developed countries, coupled with a legacy of ineffective programme interventions. UNFPA is fully committed to addressing and improving reproductive health through its support for country, regional and inter-regional programmes, in a manner that is consistent with the Programme of Action (PoA) of the ICPD. In particular, UNFPA helps contribute towards reducing maternal mortality through a wide range of measures that support increased access to a comprehensive range of quality reproductive health services and information.

The ICPD PoA, in support of earlier UN-sponsored International Conferences, endorsed the goal that developing countries should aim to halve 1990 levels of maternal mortality by the year 2000 and set targets for levels to be reached beyond that date (Box 1). Subsequently, UNFPA's Executive Board endorsed the use of maternal mortality as one of seven threshold indicators relating to ICPD goals to be employed by the Fund for resource allocation to country programmes. This heightened focus on maternal mortality has major implications for establishing reasonably accurate levels as well as for monitoring changes in them over time. However, maternal mortality is exceedingly difficult to estimate with any reasonable level of confidence in countries without a complete and reliable system of civil registration, which includes most developing countries.

Box 1 Maternal Mortality - ICPD Goals

Countries should strive to effect significant reductions in maternal mortality by the year 2015; a reduction in maternal mortality by one half of the 1990 levels by the year 2000 and a further one half by 2015. The realization of these goals will have different implications for countries with different 1990 levels of maternal mortality. Countries with intermediate levels of mortality should aim to achieve by the year 2005 a maternal mortality ratio below 100 per 100,000 live births and by the year 2015 a maternal mortality ratio below 60 per 100,000 live births. Countries with the highest levels of mortality should aim to achieve by 2005 a maternal mortality ratio below 125 per 100,000 live births and by 2015 a maternal mortality ratio below 75 per 100,000 live births. However, all countries should reduce maternal morbidity and mortality to levels where they no longer constitute a public health problem. Disparities in maternal mortality within countries and between geographical regions, socio-economic and ethnic groups should be narrowed (United Nations, 1995).

Objectives

The purposes of this paper are to help those concerned with programmes to improve reproductive health better understand: (i) the scale and frequency of maternal deaths in populations; (ii) the advantages and disadvantages of using surveys to measure maternal mortality; (iii) model-based estimates of maternal mortality and their limitations; and (iv) the potential of relevant process indicators of maternal health for programmatic purposes. The paper concludes by considering some of the implications arising from the discussion of these issues for programmes.

Why Many Countries Can't Measure Maternal Mortality

In *developed countries,* annual estimates of levels of maternal mortality are generally made from data obtained as a by-product of the civil registration of births and deaths. However, most *developing countries* do not have complete and reliable systems of civil registration and, given the huge constraints affecting these systems, particularly in the poorest countries, this situation is unlikely to improve quickly. On the demand side, for example, rural people often have no incentive, and may indeed incur costs, to register a household member's death. On the supply side, governments often lack sufficient resources to finance the cost of staffing, equipping and effectively maintaining a network of registration offices.

The resource requirements for sustaining civil registration systems are too large to be met by international funding agencies. Moreover, on the basis of past experience it would appear that areal pilot registration schemes are unlikely to be sustainable without continuous donor support. Civil registration systems tend to be sustained only when their products have an essential role in the operation of the legal and social welfare systems of a country.

Even in contexts where death registration is complete the cause-of-death certification is generally not sufficiently accurate to capture all maternal deaths (Box 2) - this is the case in both developed and developing countries. It is generally considered that more maternal deaths are assigned to deaths from non-maternal causes than *vice versa*. In some cultures this may occur, for example, when the deaths are the result of complications arising from illegal, or poorly performed, induced abortions.

In summary, in most developing countries the vital registration data required to compute *outcome indicators* of maternal ill-health, such as the maternal mortality ratio, the maternal mortality rate, or the lifetime risk of maternal death (Box 2), are generally either unavailable or insufficiently robust. As a result these countries have to rely mainly on survey- or model-based estimates.

Box 2 Definition, Methods of Computation and Hospital Records

What is a maternal death?

Simply stated it is a death of a woman who is pregnant, or within 6 weeks of her pregnancy, from any cause directly or indirectly related to the pregnancy or its management (AbouZahr and Royston, 1991). The tenth revision of the International Classification of Diseases makes provision for including late maternal deaths occurring between 6 weeks and one year post partum.

Five obstetric complications account for most maternal deaths, namely, post-partum haemorrhage, sepsis, unsafe induced abortion, hypertensive disorders of pregnancy, and obstructed labour. Some 75 per cent of maternal deaths occur in the last trimester and first week following the end of pregnancy (Campbell and Graham, 1996).

How is a maternal mortality ratio conventionally computed?

The number of maternal deaths in a given year is divided by the number of live births in the same year, and multiplied by 100,000. The maternal mortality ratio measures obstetric risk, with live births approximating for all pregnancies in the denominator.

Is the maternal mortality ratio the same as the maternal mortality rate?

No. The maternal mortality rate relates the number of maternal deaths in a given year to the estimated number of women of reproductive ages, taken as 15 to 49, at the mid-point of the same year - it measures the risk of women dying from a maternal death.

What is the lifetime risk of a maternal death?

Each time a woman becomes pregnant she risks dying of a maternal cause. The higher the level of maternal mortality the greater is that risk. The risk is cumulative: the more times she becomes pregnant the chances of dying increase. Lifetime risk is generally calculated with implicit assumptions about average levels of maternal mortality and fertility over the course of a woman's reproductive ages. For example, with a maternal mortality ratio of 500 per 100,000 live births, the average lifetime risk of a maternal death is 1 in 100 if a woman has an average of 2 pregnancies, increasing to 1 in 40 (2.5 per cent) if she has 5 pregnancies. Average lifetime risk conceals wide variation with the poorest (rural) woman generally facing the highest risk.

Can hospital records be used to estimate national levels of maternal mortality?

Generally not, on account of selection biases. Hospital-based births tend to be unrepresentative of all deliveries. Hospitals frequently tend to disproportionately cater for high-risk women and emergency admissions. Further, in some developing countries a high proportion of rural women do not have ready access to hospitals, which tend to be concentrated in urban areas. However, hospital records of maternal deaths do provide a useful starting point for retrospective studies and enquiries that may provide useful insights about the factors that contributed to such deaths.

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2 Frequency of Maternal Deaths

Maternal deaths are statistically infrequent events even in countries with high mortality and high fertility. Table 1 (third column) presents the results of some straightforward calculations to show the annual number of maternal deaths that

can be expected in a population of 1 million at given levels of the maternal mortality ratio and the crude birth rate. The figures show, for example, that in a country with a relatively high maternal mortality ratio, at say 500 per 100,000 live births, and relatively high fertility, with say a crude birth rate of 40 per 1000 population, there would be just 200 maternal deaths per million population over the course of a year. It is unlikely that these 200 maternal deaths would be geographically evenly distributed among the population. In many settings, it is highly probable that there would be a clustering of these deaths among the poorest women, generally those in rural areas lacking access to emergency obstetric care. The small number and geographic concentration of maternal deaths will have important implications for the targeting and the nature of programmatic interventions to reduce their incidence.

Table 1. Expected number of maternal deaths in a population of 1 million persons at given levels of the MMR and the CBR[a]

Maternal Mortality Ratio (per 100,000 live births)	Crude Birth Rate (per 1,000 population)	Expected Maternal Deaths [b] (per 1,000,000 population)
1000	50	500
1000	40	400
1000	30	300
1000	20	200
500	50	250
500	40	200
500	30	150
500	20	100
250	50	125
250	40	100
250	30	75
250	20	50
100	50	50
100	40	40
100	30	30
100	20	20

Notes: [a] For populations greater than 1 million the expected number of maternal deaths can be obtained by multiplying by the factor that they exceed 1. For example, with a population of 5.3 million simply multiply the expected number of deaths associated with the given MMR and CBR (given in the third column) by 5.3.

[b] Obtained as the CBR * (MMR/100).

3 Survey-Based Estimates

Sample surveys offer an important potential means for collecting data to estimate levels of maternal mortality in countries lacking reliable civil registration systems. They can be used in a variety of different ways to help policymakers and programme managers study maternal mortality.

Basic Approach

A basic survey approach for collecting information about maternal deaths is through a retrospective enquiry about deaths in a household. Maternal deaths can be obtained through a set of filtered questions starting with one about any death that has occurred to a female member of the household in one, or 'n', years before the reference date of the survey. In theory, the relevant questions can be readily asked in the context of a fertility or health survey. In practice, there are a number of problems that limit the potential of this type of approach for estimating levels of maternal mortality. The main reasons are:

(i) the relatively small sample size of most household surveys tends to lead to unacceptably high standard errors of estimates of levels of maternal mortality. Using the figures in Table 1 as a starting point and extending the calculations, Table 2 illustrates the expected number of maternal deaths and the associated minimum margin of error that would result in a probability survey of 5,000 households with an average of 4 persons per household in a population of 1 million. The figures show just how few maternal deaths could be expected and the high margin of error at all levels of the maternal mortality ratio. For example, if the prevailing maternal mortality ratio was 500 per 100,000 live births and the crude birth rate 40 per 1000 population the survey would be expected to net just 4 maternal deaths. The 95 per cent confidence interval around this figure is plus, or minus, almost 100 per cent. In other words random errors alone can render meaningless, or very seriously distort, estimates of the maternal mortality ratio obtained by this type of survey approach; and

(ii) non-sampling errors including: (a) respondents simply not knowing, or wanting to say, whether a woman has died as a result of a maternal cause - early maternal deaths or those arising from abortion complications in particular are exceedingly difficult to capture (Shahidullah, 1995); (b) telescoping the date of events, and (c) the general methodological and cultural difficulties of collecting information about deaths in surveys.

The trade-off with this survey approach is between canvassing a larger number of respondents, or increasing the span of years of recall data from a smaller number of respondents. The latter strategy raises the sample size and improves the stability of the estimates, but increases the possibility of non-sampling errors through recall biases for example. In summary, this type of survey approach is generally not considered to be a cost-effective means for estimating levels of maternal mortality, primarily because of the very high costs involved in canvassing a sufficiently large sample of households to obtain estimates that are not subject to very wide margins of sampling error.

Table 2: Sampling Error Associated with a Survey of 5,000 Households with an Average of 4 Persons per Household at Given Levels of MMR and CBR in a Population of 1 Million

MMR (per 100,000 live births)	CBR (per 1,000 population)	Expected Maternal Deaths (per million population)	Expected Maternal Deaths in Sample [a]	Standard Error [b]	Margin of Error (+ or -) % [c]
1000	50	500	10	156	63
1000	40	400	8	140	70
1000	30	300	6	121	81
1000	20	200	4	99	99

500	50	250	5	111	89
500	40	200	4	99	99
500	30	150	3	86	114
500	20	100	2	70	140
250	50	125	2.5	78	125
250	40	100	2	70	140
250	30	75	1.5	61	162
250	20	50	1	49	198
100	50	50	1	49	198
100	40	40	0.8	44	221
100	30	30	0.6	38	256
100	20	20	0.4	31	313

Notes: [a] Expected maternal deaths in sample = EMD * (20,000/1,000,000).

[b] Standard error = SQRT[{N (N-n)/(n-1)} p (1-p)] where N is population; n is sample numbers of persons and p is EMD/1,000,000.

[c] Margin of error = (2*SE/EMD) * 100.

Reproductive Age Mortality Surveys (RAMOS)

RAMOS, or reproductive age mortality surveys, are generally used to establish what proportion of deaths of women of reproductive ages were due to maternal causes. In this type of survey, numbers of deaths of women of reproductive ages can be obtained from a civil registration system (where cause of death information is incomplete), hospital and clinical records, or from other sources. Assignment of reproductive age deaths to a maternal cause is made after an in-depth consideration of evidence from one or a combination of medical records, oral autopsies and interviews with family members or medical personnel. From a programmatic perspective, an important advantage of a RAMOS approach is that it can identify the underlying cause groups of maternal deaths and their geographic clustering. This can provide a basis for further study of the reasons why they occurred through the use rapid assessment qualitative methods for example.

The main difficulty with the RAMOS approach is in establishing a complete, or representative, frame of deaths of women of reproductive ages. In the absence of such a frame any resulting estimates of maternal mortality are unlikely to be reliable at the national, or local, levels.

Surveys Using the Indirect Sisterhood Method

The indirect sisterhood method estimates maternal mortality from information obtained by asking four basic questions (Box 3) of all adults in household canvassed in socio-economic, demographic and health surveys. The approach is analogous to the well-established Brass technique for estimating child mortality from information on children ever born and children surviving (Brass, 1975). The sisterhood method uses the proportion of adult sisters dying due to maternal causes to derive an estimate, based on a set of underlying modeling assumptions, of the lifetime risk of maternal mortality - from which the maternal mortality ratio can be readily derived (Graham et al., 1989). The attraction of this approach is its simplicity and sampling efficiency.

Box 3. The Sisterhood Questions - Indirect Method

Four questions are asked of all adults interviewed during the survey (analysis is generally limited to responses from those aged 15 to 49 so as to keep the reference period of estimates of maternal mortality to about 12 years before the date of the survey):

How many sisters have you ever had who have reached aged 15?
How many of these sisters are alive now?
How many of these sisters are dead?
How many of these sisters died during pregnancy, childbirth, or during the 6 weeks after the end of pregnancy?

Aggregate data are used to calculate the proportion of sisters dying due to maternal causes. Adjustment factors are used to convert these proportions into estimates of maternal mortality (Graham *et al*., 1989).

A relative strength of the indirect sisterhood method is the smaller sample size required to produce estimates of maternal mortality with given margins of sampling error. This is because each respondent reports information about the life experience of all sisters, and generally there will be an average of two respondents per household. Table 3 shows, for example, that in a country with a maternal mortality ratio of say 500 per 100,000 live births, and a high crude birth rate of around 40, sisterhood estimates with a margin of error of 10 per cent and 20 per cent would require, respectively, replies from 13,000 and 3,200 respondents aged below 50.

Table 3: Approximate Number of Respondents According to Level of Maternal Mortality Ratio and Desired Margin of Error

Maternal Mortality Ratio	Reported Deaths Per 1000 Respondents	Respondents Needed by Margin of Error		
		(+ or -) 30%	(+ or -) 20%	(+ or -) 10%
		r [a] > 43	r [a] > 97	r [a] > 385
750	45	1000	2100	8000
500	30	1500	3200	13000
250	15	3000	6400	25000

Note: [a] r denotes total number of deaths.

Source: Adapted from Table 2 in Hanley *et al*. (1996).

However, despite its relative efficiency there are a number of technical problems that limit the usefulness of the sisterhood method for programmatic purposes, particularly for assessing trends in maternal mortality. These are:

(i) that the sisterhood method, using respondents aged 15-49, produces an estimate of the maternal mortality ratio that relates on average to approximately 10-12 years prior to the date of the survey. The fact that the data cannot be used to produce current estimates of maternal mortality means that sisterhood based estimates will be of very limited use for programme evaluation or for monitoring purposes. However, in some settings where fertility has not changed significantly and hence the exposure to the risk of a pregnancy-related death, and the provision of maternal health care services has also not changed markedly, the reference point of estimates may not matter very much;

(ii) the use of the sisterhood method is not advised in settings where there have been rapid changes in the level and pattern of fertility and mortality, or where fertility has declined to low levels (WHO, 1998).

Further, simulation studies suggest that sisterhood estimates tend to be significantly more variable than direct estimates (Garenne and Friedberg, 1997); and

(ii) there are several potential non-sampling errors that can affect sisterhood data, some of which have been noted above in relation to surveys using the basic approach to estimate maternal mortality. For example, there are cultural problems relating to the meaning of 'sisters' in some developing country settings; there are also problems where respondents have lost touch with sisters who have migrated, for example, and there are further problems that occur when respondents do not know why their sister died.

Surveys Using the Direct Sisterhood Method

The Demographic Health Survey (DHS) project has extended the use of the original sisterhood methodology through the incorporation of a sibling history module in selected surveys (Rutenberg *et al*., 1990; Bicego *et al*., 1997) - the so-called direct sisterhood method. Respondents are asked to provide fairly detailed information about each of the children born to their mother, that is, all siblings (Box 4). By obtaining information about all siblings, and not just sisters, it is considered that the reporting of female deaths will be more complete. However, asking all the relevant questions is much more demanding on both interviewers and interviewees, particularly when the respondent has many siblings, than is the case with the four indirect sisterhood questions. Hence this methodology has cost and trade-off implications. However, in theory the data yielded provide the opportunity for computing direct and somewhat more recent estimates of maternal mortality.

Box 4. The Sisterhood Questions - Direct Method

From each respondent
How many children did your mother give birth to including yourself?
How many of these births did your mother have before you were born?
What was the name given to your oldest (next oldest) brother or sister?

About each sibling (survivorship status and age)
Is .... male or female?
Is .... still alive?
How old is ....?

About siblings who have died
In what year did .... die?
How old was .... when s/he died?

About each dead sister
Was .... pregnant when she died?
Did .... die during childbirth?
Did .... die within 2 months after end of a pregnancy/childbirth?
Was her death due to complications of pregnancy/childbirth?
How many children did .... give birth to during her lifetime?

A detailed evaluation of the results of sibling history data collected in 14 DHS surveys showed that a significant proportion of respondents had considerable difficulties in the placement, or dating, of adult deaths, and that there was severe under-reporting of maternal deaths that had occurred several years before the date of the survey (Stanton, *et al.*, 1997). The net result is that the DHS data cannot be used for analysing time trends in maternal mortality, and even point estimates calculated by the direct method are subject to very wide margins of sampling error. Further, the authors of the evaluation advise that given the large sampling errors associated with the survey-derived measures of maternal mortality, the sibling history module should be not be included in surveys more frequently than once in every ten years (Stanton, *et al.*, 1997).

Choice Between Direct and Indirect Sisterhood Methodology

The relatively complex nature of the questions used in the direct sisterhood approach suggests that it is unlikely to be an appropriate tool for use in poor countries with low literacy levels. Indeed, a comparison of the maternal mortality ratio estimates relating to a similar reference period made by the direct method with those made by the indirect method (but not using the exact approach as in the original sisterhood method), for a selection of African countries, shows that those made by the indirect approach tend to be significantly higher (Table 4). While it is not to be expected that differing methodologies will yield the same estimates, the magnitude of the differences is such as to seriously question the reliability of the figures made by the direct approach. The less expensive and more efficient indirect sisterhood questions should be the choice for use in surveys in countries where adult literacy remains relatively low (a different

conclusion is reached by Garenne and Friedberg, 1997) - although the limitations outlined above need to be kept in mind.

Table 4: Comparison of Direct and Indirect Sisterhood Estimates of the Maternal Mortality Ratio, DHS Surveys in Selected African Countries, 1989-1995

Country	Direct estimates of MMR 9-15 years before survey	Indirect estimates of MMR 12 years before survey
Central African Republic	783	1205
Madagascar	574	730
Malawi	269	525
Morocco	429	416
Namibia	158	384
Niger	805	859
Senegal	377	462
Sudan	322	450
Zimbabwe	178	255

Note: The direct estimates of the MMR shown here are based on maternal deaths reported by respondents relating to the period 9-15 years before the survey. The number of reported deaths for this period is likely to be subject to large recall errors. The indirect estimates of the MMR are based on all maternal deaths reported by respondents that relate up to the date of the survey but on average 12 years before it.

Source: Data from Table 4.4 in Stanton *et al*., (1997).

Censuses of Population

With the increasing realization of the limitations of surveys for measuring maternal mortality, particularly the need for very large samples to obtain reasonably reliable estimates, pressures have grown for the inclusion of maternal mortality questions, such as the four sisterhood questions, in national decennial population censuses. However, in general, census organizations may have to resist such pressures because of the additional financial and opportunity costs, as well as the perception that information of acceptable quality on the topic of mortality is unlikely to be forthcoming from a population census in most settings. Indeed, there are strong reservations about the extent to which adult mortality can be adequately measured from census data, particularly with respect to the use of the sisterhood approach (United Nations, 1998). One reason is the relative complexity of the information given the level of training of census enumerators and the time allocated for field work. Another is a great reluctance among some cultural groups to report retrospectively information about family or household member deaths (Leete and Kwok, 1986). Yet another is some tendency for households to break up following a maternal death. In summary these, and other non-sampling error problems encountered in surveys and noted above, may well apply to an even greater extent with census data.

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4 Model-Based Estimates

Partly because of the various limitations inherent in population-based estimates of maternal mortality, and partly because of the lack of any estimates for many developing countries, sets of model-based country estimates have been made. The main method has been to use regression techniques to develop estimation models based on data for countries (developed and developing) with relatively reliable maternal mortality estimates. These models are then used to predict

maternal mortality for countries lacking such estimates (for an alternative method, see Mari Bhat *et al,* 1995).

This methodology has been used in two different ways to obtain estimates of maternal mortality ratios. First, through models that estimate the maternal mortality ratio directly on the basis of selected independent variables (Stanton and Hill, 1994); and second, through models that estimate the *proportion of deaths of women of reproductive ages that are maternal* (PMDF) on the basis of selected independent variables (Stanton *et al*., 1995). In order to obtain maternal mortality ratios with this second approach, the predicted PMDF values are applied to estimated numbers of deaths of women of reproductive ages in a given year, and then related to estimated numbers of births in the same year - reproductive age deaths and births coming from different sources, but mainly from the UN Population Division's population estimates. With either approach, a major challenge is to select appropriate independent, or predictor, variables that are not highly correlated with one another, and for which comparable data are available.

WHO/UNICEF Model-Based Estimates

In 1996 WHO and UNICEF published a set of model-based country estimates of maternal mortality ratios for 1990 made primarily on the basis of this second approach (WHO and UNICEF, 1996) - in eight developing countries, RAMOS estimates were available and accepted. The model used to estimate the PMFD is built on a data set of 49 observations, roughly equally split between developed and developing countries. Essentially, the model predicts the PMDF from two independent variables - the *general fertility rate* (GFR) and the *proportion of live births assisted by a trained birth attendant* (TRATT), but excluding traditional birth attendants.

The 1990 model-based estimates of maternal mortality ratios are described as representing orders of magnitude rather than precise figures and as being subject to wide margins of error (WHO and UNICEF, 1996). They are difficult to evaluate without reliable knowledge of the individual countries except, perhaps, by comparing them with 1990 estimates of female life expectancy at birth, levels of fertility or contraceptive prevalence rates (see Figures 1 and 2). For example, in general terms one might expect there to be an inverse relationship between contraceptive prevalence rates (CPR) and the level of maternal mortality, albeit with exceptions in particular countries. In positing this relationship it is implicitly being assumed that the CPR is a proxy indicator of the availability and accessibility of health personnel.

Figure 1: WHO/UNICEF Estimates of MMRs Against UN Estimates of Female Life Expectancy at Birth 1990/5, Selected Asian Countries

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Figure 2: WHO/UNICEF Estimates of MMRs Against Contraceptive Prevalence Rates circa 1990/5, Selected Asian Countries

A further comparison of the WHO/UNICEF maternal mortality ratios with the three previously mentioned variables for Asian countries shows several of the figures to be counter-intuitive (Table 5). For example, the estimate for low-fertility Indonesia at 650 per 100,000 live births is almost double that of high-fertility Pakistan (340) and higher than for India (570); Nepal is shown to have a rate of 1500, nearly double that of Bangladesh (850) despite similar levels of female life expectancy at birth in the two countries. Affluent and very low fertility Republic of Korea is shown as having a level (130) almost twice as high as the very poor Democratic People's Republic of Korea (70). Similarly, Viet Nam (160) is shown to have a lower rate than Thailand (200) and much lower than the Philippines (280). The magnitude and pattern of these differences, although theoretically possible, are implausible - they are unlikely to be due to factors such as ethnic and cultural diversity, or spatial differences in population distribution between these countries.

Table 5: Country Ranking in Female Life Expectancy at Birth 1990/5 Compared with WHO/UNICEF MMR and Other Indicators for Same Period, Selected Asian Countries

Country	Female life expectancy at birth (years)	Maternal mortality ratio (per 100,000 live birts)	Total fertility rate (per woman)	Contraceptive prevalence rate (%)
Korea, Rep. of	74.8	130	1.6	79
Sri Lanka	74.2	140	2.2	62
Korea, DPR	73.9	70	2.1	72
Malaysia	73.0	80	3.6	48
Thailand	71.7	200	1.9	66

China	70.5	95	1.9	83
Philippines	68.2	280	4.0	40
Iran	68.0	120	5.3	65
Viet Nam	67.3	160	3.4	53
Indonesia	64.5	650	2.9	50
Pakistan	62.6	340	5.5	12
India	60.6	570	3.4	43
Myanmar	59.3	580	3.6	50
Bangladesh	55.6	850	3.4	45
Nepal	54.1	1500	5.4	23

Source: The figures in columns 2 and 4 are from United Nations (1996a); those in column 3 are from WHO and UNICEF (1996), and those in column 5 are from United Nations (1996b) and UNFPA (1997b).

The 1990 WHO/UNICEF estimates are sensitive to errors in the two independent variables used in the model. Thus the independent health variable TRATT, or proportion of births attended by trained birth attendants, can be quite different in meaning from country to country even where the observed levels are similar, as can the availability of, and access to, relevant back-up facilities needed in times of obstetric emergency. Further, the independent fertility variable, the GFR, is essentially model based for many countries, and different model age patterns of fertility could give quite different levels of GFRs.

More importantly, even if the predicted PMDF values were error free, the number of deaths of women of reproductive ages that are determined primarily on the basis of model life tables, and to a lesser extent the number of live births, that are used in the estimation procedure, appear to be insufficiently robust for use in making reliable estimates of maternal mortality ratios. Further, the actual numbers of reproductive age deaths and births for any given year, obtained from the UN's population estimates, can be subject to significant changes in the biennial revisions made of them as new census and survey data become available.

Future Directions For Model-Based Estimates

Further efforts to model the maternal mortality ratio directly, experimenting with different independent variables, such as the level of child mortality, contraceptive prevalence rate, per cent of population with access to essential obstetric care, per cent of population living in rural areas and nutritional and educational status of women of reproductive ages, would appear to be justified. This modeling approach, using female life expectancy at birth as the main independent variable, has been attempted by Stanton and Hill (1994), and selections of the resulting predictions for Asian countries from two of the models are shown in columns 4 and 5 of Table 6. The country patterns of the predicted maternal mortality ratios seem to be more readily acceptable than that yielded in the WHO/UNICEF set. For example, the maternal mortality ratio for Indonesia is shown to be lower than that for Pakistan, and that for the Republic of Korea lower than for the Democratic People's Republic of Korea - differentials that are consistent with expectations based on other population and social development indicators. While it is much less certain which set of figures, if any, accurately represents the true values, the use and evaluation of both modeling approaches would provide range estimates and would appear to be a safer statistical strategy. Moreover, it would be useful to try to develop criteria for assessing the correctness of predicted maternal mortality ratios, so as to avoid the real danger of accepting sets of model-based figures that are systematically over- or under-estimated.

Table 6: Country Ranking in Female Life Expectancy at Birth 1990/5 Compared with WHO/UNICEF MMR and Stanton and Hill's Modeled MMR [a], Selected Asian Countries

Country	Female life expectancy at birth (years)	WHO/UNICEF maternal mortality ratios	Maternal mortality ratios [b]	
			Model 1A	Model 2
Korea, Rep. of	74.8	130	26	40
Sri Lanka	74.2	140	89	129
Korea, DPR	73.9	70	37	57
Malaysia	73.0	80	59	88
Thailand	71.7	200	105	152
China	70.5	95	107	156
Philippines	68.2	280	103	152
Iran	68.0	120	100	141
Viet Nam	67.3	160	138	198
Indonesia	64.5	650	221	318
Pakistan	62.6	340	331	446
India	60.6	570	245	350
Myanmar	59.3	580	253	362
Bangladesh	55.6	850	584	706
Nepal	54.1	1500	750	1037

Notes: [a] All the MMR values shown in this table are subject to large standard errors.
[b] Both sets of model estimates were determined largely on the basis of female life expectancy at birth. Model 2 differs from model 1A in that the maternal mortality ratios used in the estimation model were increased by a factor of 1.5 to take account of assumed under-reporting.

Source: The figures in columns 2 are from United Nations (1996a); those in column 3 are from WHO and UNICEF (1996), and those in columns 4 and 5 are from Stanton and Hill (1994).

5 Process Indicators of Maternal Health

It will rarely be practicable to devise projects to monitor levels and changes in maternal mortality ratios. The targeting and assessment of programmes designed to improve maternal health can be more readily and efficiently assessed

through the development of a selection of relevant proxy and process indicators, taking into account local-level conditions and institutional factors. Such indicators can be used to point to the types of problems that need to be tackled in the delivery of services to reduce maternal mortality. However, there is no consensus yet about the most relevant indicators that will inform about the level and changes in maternal mortality. Some indicators that were initially thought of as suitable proxy measures of the maternal mortality ratio, such as the perinatal mortality rate, have been shown not to be reliable (Akalin *et al*., 1997). Further, while several process indicators relating to maternal health have been proposed in various lists compiled by international organizations and other groups, many of them have not yet been thoroughly field-tested, evaluated and used for programmatic purposes.

UNFPA has recently proposed a comprehensive set of indicators, including a sub-set relating to maternal health, for use in monitoring national population and reproductive health programmes (UNFPA, 1997a). However, many of the indicators included in the UNFPA list have also not yet been field tested, particularly in terms of issues relating to the cost and feasibility of collecting the data necessary for their construction, the frequency at which they should be monitored, their applicability at different geographical levels, and which combination of indicators to use for specific programming purposes. Work on these issues is currently in progress. Nevertheless, the UNFPA list includes a choice of indicators about which there is an emerging international consensus on their potential usefulness and a selection of these are summarized below - additional details about concepts, definitions, computation and sources of data can be found in Koblinsky *et al*., 1995; UNFPA, 1997a; UNICEF, WHO and UNFPA, 1997; WHO, 1997.

Indicators of unmet need for family planning and obstetric services

(i) % of obstetric and gynaecological admittances due to abortion complications - aims to show the extent of progress towards the goal of minimal admittances due to induced abortion complications; and

(ii) % of delivering women who developed obstetric complications and received emergency obstetric care (EmOC) - aims to inform about the extent to which obstetric care is being received by those in need, with the goal being universal access to EmOC.

Indicators of utilisation, coverage and access

(iii) *% of births attended by skilled health personnel (excluding traditional birth attendants)* - aims to inform about the extent of progress towards the goal of universal access to, and utilization of, intrapartum care;

(iv) *% of service delivery points able to provide basic essential obstetric care (EOC) (including parenteral antibiotics; parenteral oxytocic drugs; parenteral sedatives for eclampsia; manual removal of placenta; and manual removal of retained products)* - aims to inform about the extent of availability of basic EOC and progress towards the goal of universal access to basic EOC; and

(v) *% of district hospitals able to provide C-sections and blood transfusions* - aims to inform about the extent of progress towards the goal of the availability of EOC at all district hospitals, as well as the quality of available services.

Indicators of quality of care

(vi) *% of deliveries that are C-section* - aims to inform about whether EOC facilities are providing life-saving obstetric services and the quality of care of the services provided. The proportion of C-section births should be within the acceptable range; that is, they should account for a minimum of 5 per cent and a maximum of 15 per cent of all births as defined by WHO standards; and

(vii) *% of pregnant women attending antenatal services who received (a) iron/folate (100 tablets), (b) tetanus immunization (two doses)* - aims to inform about extent to which pregnant women receive iron folate tablets and tetanus immunization. These data provide important pointers for assessing the quality of antenatal services that are being provided.

In addition to the above process indicators, obstetric complications that lead directly to maternal deaths may be taken as outcome measures for programmatic purposes. Information could be collected on post-partum haemorrhage and sepsis for example, using a combination of retrospective oral autopsies and clinical and observational records, to examine quality-of- care issues and to identify preventable causes of death.

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6 Programme Implications

There is little to be gained from spending scarce programme resources on very expensive surveys merely to try to estimate broad levels of maternal mortality. Where no better figures are available, a cost-effective way of getting an order-of-magnitude estimate of maternal mortality, relating to about 10-12 years in the past, is through the inclusion of the four sisterhood questions in a suitable household survey. Model-based figures may serve as very rough working estimates where no population-based estimates are available. However, it is important to be aware of their limitations and that they might provide an unstable and potentially misleading benchmark against which to measure progress. In

general, estimates of the maternal mortality ratio derived from different sources and/or through the use of different methodologies are unlikely to be comparable and may give misleading impressions about change, and sometimes even in its direction.

For the various reasons outlined in the chapters above, in the majority of developing countries it will not be possible to regularly monitor changes in maternal mortality through the maternal mortality ratio. Further, the maternal mortality ratio is itself a notoriously unreliable indicator for countries with small populations. Even if there were effective mechanisms for collecting high quality data, random errors arising from the small number of events would make interpretation difficult. Hence greater use will have to be made of proxy and process indicators for assessing the impact of programme support for improving maternal health.

While RAMOS studies may not always be able to provide reliable national estimates of the level of maternal mortality, this approach has much potential for programmatic purposes. It offers the potential to focus on the underlying cause groups of maternal deaths and their geographic clustering in particular settings. Such results can provide a basis for further policy-relevant study, through the use of cost-effective rapid assessment procedures, of the reasons why they occurred and what interventions are required.

The expected number of maternal deaths (and their spatial distribution) in any particular country will have important implications for the type of programme activity proposed. For example, in countries with small and medium population sizes with maternal mortality ratios at, say, around 250, it will be extremely difficult to design direct programmes to reduce maternal mortality to target levels without knowledge of the spatial distribution of deaths, simply because of the small number of maternal deaths involved. In such settings it may be best to concentrate on measures to improve access to, and availability of, reproductive health services in the poorest and least-served areas.

Programme Interventions

The types of interventions that can be implemented to reduce levels of maternal mortality in a given country will depend on many factors (including scale, geographical distribution and cause) and will need to be considered within the context of the country's overall reproductive health framework.

In general, high levels of maternal mortality indicate weaknesses in the coverage and quality of reproductive health services, including family planning. Improving access to, and availability of, quality family planning information and services, particularly among high-risk groups such as teenagers, women over age 39 and those of high parity, helps reduce maternal mortality (Fortney, 1987). Although it has to be recognised that many maternal deaths occur among women though to be at lower risk.

In some countries, significant proportions of mothers give birth without the help of a trained birth attendant and are out of reach of emergency care to deal with obstetric complications. The lack of services, both human and physical, results in many readily avoidable maternal deaths, particularly among the rural poor. This unmet need requires both the extension of emergency obstetric services and improvements in the quality of delivery (Maine *et al.*, 1997). Specifically, this requires: (i) strengthening of referral systems; (ii) support for the training of health providers who work at the primary health care level, involved in providing assistance during pregnancy, delivery and the postpartum period, particularly in life-saving skills, ensuring the availability of adequate supplies of medicines, and ensuring hygienic delivery practices; and (iii) measures that support the availability and access, on a 24-hour basis, to fully equipped emergency obstetric services for pregnant women with complications.

Further, targeted IEC campaigns, particularly among the poorest women, can help to promote reproductive health and obstetrical and other health practices associated with safe motherhood. Advocacy efforts directed towards political leaders and policy makers emphasizing the seriousness of maternal morbidity and mortality may lead to additional funds for the promotion of improvements in services and the training of personnel to treat complications arising from emergency situations.

Maternal mortality is often high in settings where induced abortion is illegal but its incidence is nevertheless fairly widespread. In countries where maternal mortality is high because of unsafe abortions, efforts should be directed at the prevention of abortion by meeting the unmet demand for family planning services. Further, programmes are needed to support the management of the complications arising from unsafe abortions, as well as post-abortion family planning and counseling.

Interventions to reduce maternal deaths generally need to be targeted at the poorest areas and groups at highest risk, where the provision of health services and amenities is least. They should take into consideration issues relating to coverage, equity, quality of care, women's satisfaction .and cost-effectiveness (Mother Care Matters, 1997). Meetings with women's groups and appropriate NGOs about how best to develop and deliver maternal health services that are conducive to women's needs will also help ensure their suitability and acceptance at the community level.

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7 Conclusion

Against the background of heightened international and national interest in maternal health, it is important that the immense difficulties faced in reliably measuring levels and changes in maternal mortality in developing countries are widely understood. Programme managers need to be aware of the main measurement problems and at the same time be cognizant with the scale, dimensions and spatial distribution of maternal mortality. Regular current monitoring of maternal health status through the maternal mortality ratio, at intervals of less than 10 years, is not viable in most developing countries. Robust and regular estimates will generally only become available in the long run when countries have complete and reliable systems of civil registration.

For the short run it will often be necessary to rely on proxy and process indicators for targeting interventions and assessing their impact, although the task of compiling the relevant indicators poses many challenges. In particular, it needs to be recognized that in many developing countries the capacity for collecting and processing the data required for producing the proposed indicators is very weak. There appears to be an inverse relationship between the availability of data on maternal mortality and the magnitude of the problem. The coverage and quality of the statistical information obtained as a by-product of service and administrative systems are highly variable, and surveys tend to be *ad hoc* and donor driven. A new strategy for the development of sustainable integrated population and health information systems, including the role of technical assistance, will have to emerge to give meaning to the indicator movement.

The efforts and attention of programme managers should be focused on sub-populations in greatest need of reproductive health services, particularly in poor (rural) areas where health personnel and obstetric care facilities are most lacking. International and national attempts to improve the measurement of maternal mortality should continue. Maternal mortality is too high in most developing countries**,** and this needs to be repeatedly emphasized to show that much remains to be done to reduce it to acceptable levels.

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