Maternal Mortality Estimates in Latin America and the Caribbean:
## A BRIEF OVERVIEW

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1. Introduction

Of the one thousand women around the world who die every day from complications of pregnancy and childbirth, 99% are from developing countries. Most of them are poor and have limited or no access to comprehensive, skilled pregnancy and childbirth care. Almost all of these deaths are preventable. By signing the Millennium Declaration, in particular the fifth Millennium Development Goal (MDG 5: improve maternal health), countries committed themselves to preventing these needless deaths. Keeping this promise is a matter of basic human rights.

However, in order to target the most affected populations with life-saving policies and programs, governments need accurate information about maternal mortality in their countries. Unfortunately, measuring maternal mortality is complicated by the fact that nations with the least developed health system infrastructure also tend to lack reliable mechanisms for identifying, registering, and counting maternal deaths. National statistics on maternal mortality, therefore, vary considerably from maternal death estimates: Official government figures for 2008 showed a total of 5,670 maternal deaths in Latin America, substantially fewer than the 9,075 estimated by the United Nations Maternal Mortality Estimation Inter-agency Group (MMEIG)[1] or the 7,864 estimated by the Institute for Health Metrics and Evaluation (IHME)[2] for the same period (see Figure 1).

Figure 1. Maternal Deaths in Latin America in 2008
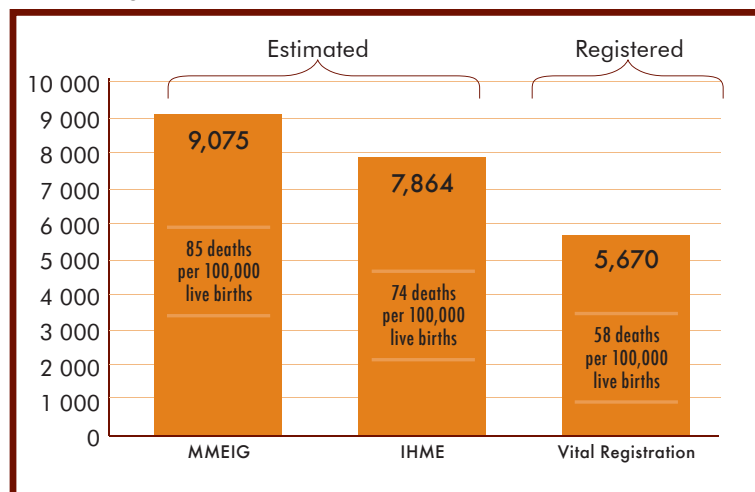
In this paper we will explain and compare the different approaches to measuring maternal mortality, focusing on examples from Latin America and the Caribbean (LAC).

2. How is maternal mortality measured?

Maternal mortality is commonly measured as the number of maternal deaths in a population divided by the number of live births (normally deaths per 100,000 live births). The ratio – called the maternal mortality ratio (MMR) – highlights the risk of maternal death relative to childbirth.

[1] MMEIG is comprised of four agencies: the World Health Organization, the United Nations Children's Fund, the United Nations Population Fund and the World Bank. Their annual estimates make up the official data used by the United Nations to measure progress towards MDG 5.
[2] IHME, based at the University of Washington in Seattle, releases annual country estimates since 1990.

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The most common source of maternal mortality data is the national vital registration system, tracked by ministries of health or national statistical agencies. The Pan American Health Organization (PAHO) also uses these statistics for cross-national comparisons in its annual report on the Health Situation in the Americas. For this reason, in this paper we refer to statistics published by PAHO as "national statistics."

Box 1. WHO definition of Maternal Death

The death of a woman while pregnant or within 42 days of termination of a pregnancy, irrespective of the duration and site of pregnancy, from any cause related to or aggravated by the pregnancy or its management but not from accidental or incidental causes.

There are two issues of concern when using information from vital registration systems. First, since some national vital registration systems lack full coverage and completeness, many deaths are not registered. This leads to undercounting. The second factor is misclassification of maternal deaths (see Box 1). Even when vital registration systems are complete, a large fraction of maternal deaths are incorrectly reported as non-maternal in the registration system: even in many developed countries, as many as one-third or even one-half of maternal deaths are misclassified.

Some countries complement the information from vital registration systems with other data sources, such as household surveys (e.g. Demographic and Health Surveys – DHS), census data, the "Sisterhood Method" (estimates of maternal mortality based on information about survival of adult sisters) and Reproductive Age Mortality Studies (RAMOS). However, current procedures for country data reporting result in important inconsistencies in the types of statistics countries report to PAHO each year. For example, a country might report figures based on vital statistics one year and a RAMOS-type study the next, or might adjust reported statistics for misclassification one year but not the next. PAHO does not routinely collect information on the methods used by the ministries of health in calculating maternal mortality.

3. Estimating the MMR

In seeking to develop accurate MMR estimates, social scientists make a series of statistical adjustments to the "measured MMR," as reported by national registration systems. These include adjusting for misclassification of maternal deaths, for under-registration of deaths of women aged 15 to 44, and for under-registration of births. As the latter two generally offset each other, the main difference between "measured MMR" and "estimated MMR" is due to the misclassification adjustment factor, which can range from 1.1 (10% of maternal deaths misclassified) to 2.0 (50% of maternal deaths misclassified). Despite similarities, the methodologies employed by MMEIG and IHME – two international groups that have provided annual estimates for every country since 1990 – differ in significant ways (see Table 1).

The MMEIG methodology
The MMEIG methodology divides countries into three groups according to the type of information available (see Box 2). For Group A countries, MMEIG estimates are based on national vital registration data. Estimation of MMR for Group B countries is a two-step process. First, the proportion of female deaths that are maternal is estimated through a model in which three predicting factors are used

Box 2. MMEIG classification of countries

Group A: Countries with good vital registration data (half of the LAC countries).

Group B: Countries with other types of data sources (half of the LAC countries).

Group C: Countries with no adequate data sources (no LAC countries).

as a measure of risk exposure: GDP per capita as a measure of economic development; proportion of live births attended by a skilled birth assistant as a measure of health care; and the general fertility rate (live births per

Table 1. Comparison of MMEIG and IHME maternal mortality estimation methodologies

	MMEIG	IHME
Data source for births and population	United Nations Population Division	United Nations Population Division
Data source for mortality rates among reproductive age women	WHO Life Tables	IHME Life Tables
Data source for proportion maternal deaths	Mainly vital registration data. Some other national sources.	Mainly vital registration data. Some other national and sub-national sources.
Misclassification adjustment for vital registration data	Deaths increased by a factor of 1.5 for most countries. Usually held constant over estimation period (1990-2008). Deaths from other sources are increased by a factor of 1.1.	Deaths increased using an algorithm that redistributes deaths from causes ("garbage codes") assumed to erroneously contain maternal deaths. Varies by country and over time. On average, the adjustment factor is 1.4 – but large variation around this value.
Regression approach	A linear regression model is used only for countries that lack good vital registration system (10 of 20 Latin American countries).	A linear regression model is used for all countries.
Dependent variable in regression	Log of the proportion of deaths that are maternal among reproductive age women.	Log of the age-specific maternal death rate.
Main predictor variables	GDP per capita Skilled attendants at birth General fertility rate	GDP per capita Female education by age Neonatal mortality rate Total fertility rate HIV seroprevalence rate
Country and regional effects	Modeled using variable intercept terms for country and region.	Modeled using a temporal-spatial locally weighted regression in which observations from other time periods and neighbor countries influence the country-specific estimate.
Treatment of AIDS	Maternal deaths attributed to AIDS are estimated separately from the regression model.	Maternal deaths attributed to AIDS are calculated within the regression model using HIV seroprevalence rate as a predictor variable.

women aged 15-49). Second, this proportion is applied to United Nations (UN) estimates of the total number of deaths of reproductive age women divided by the UN estimates of the total number of births. For most countries, the data entered in the model are adjusted by 1.5, a median value to correct for misclassification. As the model does not include AIDS-related deaths, an independent estimate of indirect maternal deaths from AIDS is added to the ratio. MMEIG provides free and open access to its research data. The results are reproducible and can be independently confirmed.

The IHME methodology
The IHME model is applied to all countries regardless of the quality of their vital registration systems. The predictor variables of this model are different: GDP per capita, female education by age, neonatal mortality rate, total fertility rate and HIV seroprevalence rate. Through the last factor, maternal AIDS deaths are modeled directly in the regression. Another important difference with the MMEIG model is the approach to adjusting for misclassification. The IHME reassigns deaths as maternal from causes in the International Classification of Diseases (ICD) assumed to erroneously contain maternal deaths ("garbage codes"). These adjustments vary by country and over time within a given country. The average value of the adjustment factor is 1.4, a bit lower than the 1.5 used by MMEIG. The IHME group has not released its data and methods, so it is not possible to independently confirm or reproduce its results.

4. Comparing levels and trends in maternal mortality in LAC countries
From the description of the methodological approaches to measuring or estimating MMR, we can compare the levels and trends in the various figures for countries in LAC.[3] Figure 2 shows data for each country over the period 1990-2008. The black line in each figure represents the MMEIG point estimates while the grey area represents a range of uncertainty

surrounding the estimates. Similarly, the red line represents the IHME point estimates, while the pink area around it represents the range of uncertainty around the estimates. The blue line represents the national statistics reported by the ministries of health to PAHO.

Comparison of MMEIG and IHME MMRs
Two of the most probable sources of difference in the MMR estimates between the groups are 1) their treatment of AIDS-related deaths and 2) their adjustment of vital registration data for misclassification. The two groups differ sharply, for example, in their estimate of the MMR for Haiti – the country with the highest level of AIDS-related mortality in the region. We suspect that this difference is caused by the different treatment of AIDS within the model. For most of the other countries, a major cause of differences in estimates lies in the different adjustments to vital registration data for misclassification (MMEIG adjusts the maternal death estimates by 50% for most countries, whereas the IHME group, on average, adds only 40% more deaths).

For some countries, like Bolivia and Brazil, there is fairly close agreement between the MMEIG and IHME point estimates in both level and trend over time. In other countries, like Ecuador and El Salvador, the MMEIG point estimates exceed those of IHME, but both show similar declines in the ratios over time. In countries like Mexico, both the level and trend in estimates are different.

Comparison of national statistics with MMEIG and IHME MMRs
In countries such as Argentina, Chile, and Nicaragua, the national statistics (blue lines in Figure 2) as reported by PAHO lie below both the IHME and MMEIG estimates. In other countries like Brazil, Guatemala, and the Dominican Republic, the country data lie above both the IHME and MMEIG estimates. And in some

[3] This analysis takes into account information available in September 2011. However, both IHME and MMEIG have released new estimates in 2012. These new estimates will be taken into account when we do further analysis and conduct the case studies recommended as part of this report.

Figure 2. MMR national statistics and estimates for selected LAC countries, 1990-2008
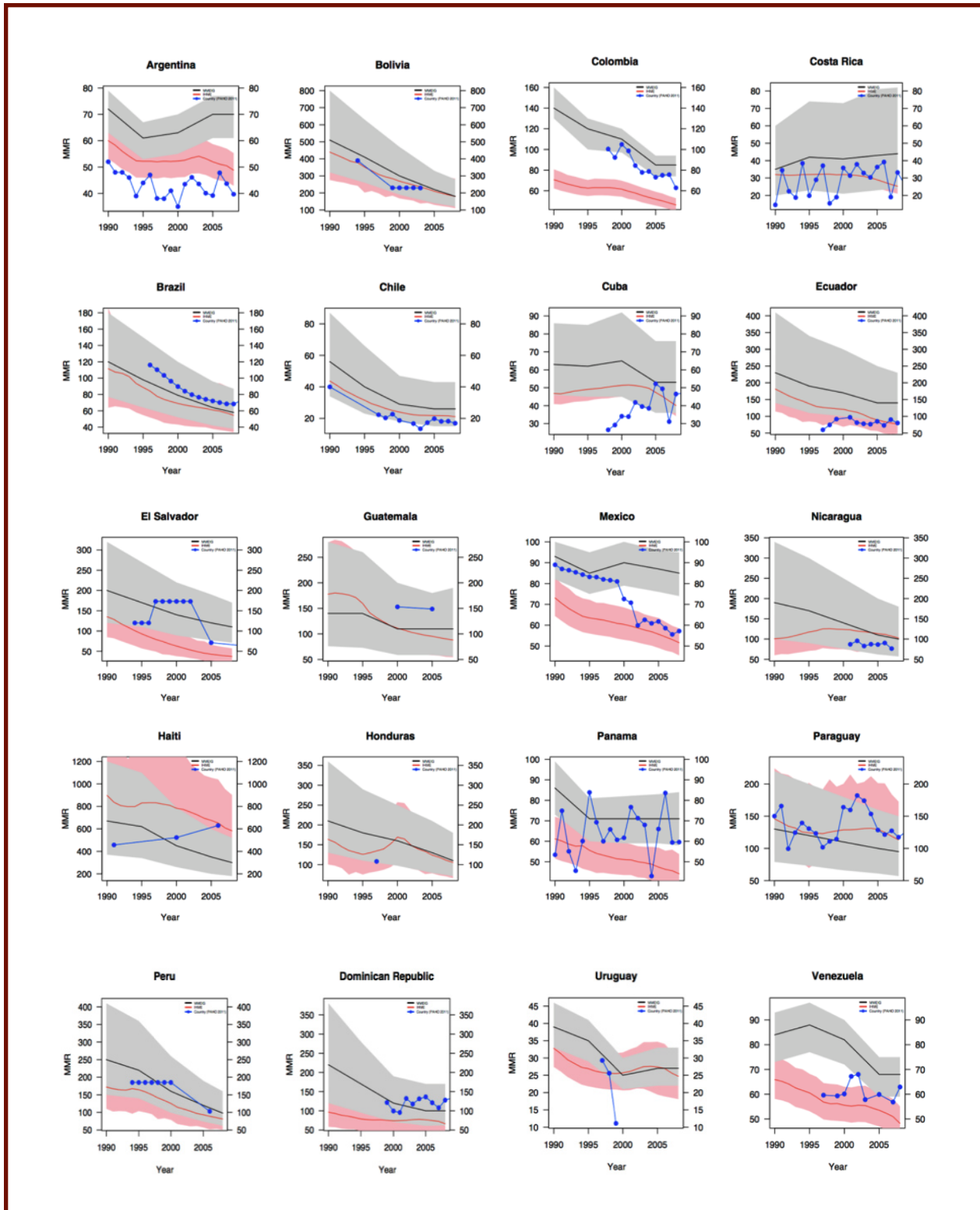
cases, like Mexico, Colombia, and Venezuela, national statistics lie in between: with MMEIG estimates below and IHME estimates above them. Understanding these differences would require analysis on a country-by-country basis, using information on the individual components (proportion of maternal deaths, total deaths among women in reproductive age and number of births) used in the calculations by the ministries of health and IHME.

Progress towards MDG 5 and MMEIG and IHME estimates

Although IHME estimates are generally lower than those from MMEIG, MMR trends tend to be similar. So, to a large extent, the measurement of progress toward MDG 5 does not vary much between the two methods. Both show that countries like Brazil, Chile, Peru, and Bolivia have made great strides in reducing maternal mortality – by more than 50% since 1990; whereas countries like Mexico, Argentina, and Costa Rica have made less progress – achieving reductions of less than 30% since 1990. However, there are some notable exceptions to the general concordance between the sets of estimates. For example, in the case of Nicaragua, MMEIG estimates show substantial progress in reducing maternal mortality – with a decline of nearly 50% – but IHME estimates show no progress at all. While the two groups are in close agreement in their estimates of the MMR in 2008 (of around 100 deaths per 100,000 live births), they differ substantially in the estimates for 1990.

5. Conclusions and recommendations

Accurate measurement of maternal mortality is difficult due to problems in data measurement. Complex models such as those used by MMEIG and IHME are designed to provide the best possible MMR estimates for a large group of countries. Of necessity, they are based on a number of assumptions made because of limited information. Therefore, the resulting estimates have a large range of uncertainty.

Below are a number of recommendations regarding the interpretation of the multiple data sources available for MMR:[4]

- To understand the causes of differences between estimates, one needs to look at input and intermediate data used in the calculations. Thus, GTR strongly recommends that data are made available on a country-by-country basis. For IHME, this means publicly releasing the country-specific data on which their estimates are based. For PAHO, it means collecting the necessary metadata on the methods and the data sources used by each country in calculating the MMR.

- Latin American and Caribbean Demographic Centre (CELADE) and PAHO could play an important role in sharing knowledge about data sources as well as differences in methods and calculations among countries in the region. A concrete step would be to undertake a case study for two or three countries to explain the sources of differences between MMEIG, IHME, and national statistics. Possible countries could be Guatemala and El Salvador (as RAMOS studies have recently been completed there) and Mexico (because national statistics were closer to MMEIG estimates in the past but are closer to IHME estimates in the present). Taking actions of this sort will promote reconciliation among the figures – which will be critical to measure achievements towards the MDGs in 2015.

- Both MMEIG and IHME have each independently assembled a data set of observations on maternal mortality. It would be very useful to combine these data sources and present them online as a central repository of maternal mortality data.

- MMR should be used with care – especially when the overall counts are low, as will usually be the case among countries with small populations. The plausibility of MMR should be assessed, by comparing it to other indicators such as infant and child mortality, fertility, education, and access to health care.

We must not forget that national data hide major differences within a country, both across regions and social groups. In order to redress inequalities and truly make progress towards MDG 5, it is important to develop policies on the basis of the needs of specific populations. In LAC, it is a priority to develop and strengthen national registration systems so that they can accurately measure and track maternal mortality, including among vulnerable groups.

Until accurate registration systems are in place in every country, it is important to remember that models may give the illusion that maternal mortality is actually being measured, when it is not. Estimates can be a useful guide, but they do not replace reliable national vital registration and surveillance systems.

Even with their limitations due to underestimation and misregistration of maternal deaths, national registration systems are still among the best sources for understanding the causes of maternal mortality in each country, and they should be utilized. To obtain more consistent and reliable information, the way forward in the LAC region is to strengthen both the vital registration systems and the institutional registration systems in clinics and hospitals. This would permit a cross-validation between the two systems. Significant resources must be allocated to developing national capacities in terms of measuring maternal mortality and strengthening basic data collection systems, and to supporting studies that go beyond rates and ratios to understand the causes of maternal mortality and the impact of interventions. Without such efforts, we are left with a paucity of data and extreme difficulty in measuring maternal mortality. As the statistician John Tukey once said: "The combination of some data and an aching desire for an answer does not ensure that a reasonable answer can be extracted from a given body of data." We must do better.

[4] These recommendations were adapted from Stupp et al., 2011 and from AbouZahr, 2011. In addition, CELADE added some region-specific considerations.

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Data Sources

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