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AN ASSESSMENT OF DHS MATERNAL MORTALITY DATA AND ESTIMATES

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An Assessment of DHS Maternal Mortality Data and Estimates

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Preface

The Demographic and Health Surveys (DHS) Program is one of the principal sources of international data on fertility, family planning, maternal and child health, nutrition, mortality, environmental health, HIV/AIDS, malaria, and provision of health services.

One of the objectives of The DHS Program is to continually assess and improve the methodology and procedures used to carry out national-level surveys as well as to offer additional tools for analysis. Improvements in methods used will enhance the accuracy and depth of information collected by The DHS Program and relied on by policymakers and program managers in low- and middle-income countries.

While data quality is a main topic of the DHS Methodological Reports series, the reports also examine issues of sampling, questionnaire comparability, survey procedures, and methodological approaches. The topics explored in this series are selected by The DHS Program in consultation with the U.S. Agency for International Development.

It is hoped that the DHS Methodological Reports will be useful to researchers, policymakers, and survey specialists, particularly those engaged in work in low- and middle-income countries, and will be used to enhance the quality and analysis of survey data.

Sunita Kishor

Director, The DHS Program

Abstract

This report evaluates the data quality of sibling survival history in DHS surveys and assesses its impact on maternal mortality estimates. The data are from 112 surveys conducted between 1990 and 2013; the surveys all included a sibling history module. We examined three aspects of data quality: completeness in sibling death reporting, completeness in reporting of all siblings and their age; and completeness in reporting of time of death during a calendar year and pregnancy status at the time of death. The overall quality of sibling history data is similar to the quality of data of individual women respondents in terms of age-misreporting. Reporting deaths in relation to pregnancy status and placing the deaths to calendar time remain major challenges for the respondents. The classification of maternal death relies on the reported timing of a sister's death in relation to her pregnancy, delivery, and postpartum period. Many countries had very high non-response rates (10%-40%) for pregnancy status at the time of death, a situation that introduces substantial misclassification bias into identification of maternal deaths. DHS surveys currently report maternal mortality estimates without any adjustment for missing responses to timing of death. This may substantially underestimate the maternal mortality ratio (MMR) and other maternal mortality indicators in countries with high non-response rates. Trend analysis, however, suggests that the missing responses have declined significantly in the recent rounds of DHS surveys. We recommend developing a standard protocol for handling missing data on maternal status at the time of death and adjusting maternal mortality estimates with an appropriate statistical method for handling missing data.

KEY WORDS: maternal mortality, sibling survival history, sisterhood method, data quality

Executive Summary

The Demographic and Health Surveys (DHS) remain the main source of empirical data for estimation of maternal mortality in developing countries. Through the *direct sisterhood method*, maternal mortality ratios (MMRs) are calculated using DHS data from sibling histories provided by survey respondents. For classification of female deaths as *maternal deaths*, this method relies on the reported timing of a sister's death in relation to her pregnancy, delivery, and postpartum period. The two main objectives of this report were to examine the quality of the sibling history data collected by DHS and to evaluate the extent of underestimation bias associated with MMRs produced from DHS data.

In recent years, DHS has implemented a sibling survival history module for male respondents. The data from male respondents were not included in this analysis because they are not included in the DHS country reports. Moreover, the DHS maternal mortality data used by United Nations (UN) organizations (World Health Organization, United Nations Children's Fund, United Nations Population Fund, and the World Bank) and the Institute for Health Metrics and Evaluation (IHME) to estimate global trends are limited to the female respondents.

We examined the completeness of reporting of vital events, age, timing of death in relation to the calendar, and timing of death in relation to maternal status (during pregnancy, during delivery, or during the postpartum period), which are the data used to ascertain maternal death.

Our extensive analyses suggest that the overall quality of sibling history data is similar to the quality of data from individual respondents (women age 15-45) in DHS surveys in terms of age-reporting (e.g., age-heaping, missing in reported age and date of birth and age-displacement). We did not find any discerning patterns of sister underreporting or age-displacement to avoid responding to the questions on female deaths. Similarly, our findings did not suggest higher female death underreporting, in comparison to male deaths.

However, reporting events and placing the events to calendar time remain major challenges by the respondents based on recall of memory. This was a problem for deaths in both recent and distant past periods. The examination of the countries with multiple rounds of DHS surveys suggests that the response rate improved significantly in recent DHS survey rounds in most countries.

One of our key interests was to examine the impact of missing responses for classification of death (maternal or non-maternal) in MMR estimates. This was done by comparing MMR estimates based on the standard DHS method with MMR estimates adjusted for missing data. We used four statistical methods for analyzing data with missing values: complete case analysis, weighting for non-response rate, single imputation with hot deck, and multiple imputation methods.

Many countries reported very high non-response rates (10%-40%) for pregnancy status at the time of death, a situation that introduces substantial misclassification bias into identification of maternal deaths. The MMR estimates for the standard DHS method (sisterhood method) and the complete case analysis method (with non-responses on maternal death classification questions removed) were compared and found to be similar—country average MMR: 531 deaths per 100,000 live births—indicating likely similar bias in the presence of high non-response rates for pregnancy status at the time of death. In contrast, all other methods (weighting, hot deck, and multiple imputations) show considerably higher MMR estimates (country average MMR 596, 605 and 609, respectively), suggesting substantial underestimation bias in the MMR values in DHS reports, specifically in countries with high non-response rates on the timing of female deaths.

Current reporting in DHS country reports substantially underestimates maternal mortality in several developing countries. Appropriate correction for non-response regarding the timing of female deaths may reduce the underestimation bias associated with DHS maternal mortality estimates.

Confidence interval of MMR estimates was quite large in most DHS surveys. The relative margin-of-error of MMR varied from 20% to 40% in most (71.3%) DHS surveys. All surveys have more than 10% relative margin-of-error (RME). Countries with low MMR had higher relative margin-of-errors. Given such a large margin-of-error, it will remain a challenge to track MDG 5 progress in reducing maternal mortality 75% by 2015 in a country using DHS data alone. However, by applying modeling techniques, the Maternal Mortality Estimation Interagency Group (MMEIG)—consisting of WHO/UNICEF/UNFPA and the World Bank—and the Institute for Health Metrics and Evaluation (IHME) have successfully utilized the DHS sisterhood data for tracking global maternal mortality trends. Recent studies from these two organizations have consistently indicated that maternal mortality has declined substantially since 1990. It was possible to track such a remarkable achievement because of the availability of empirical MMR data from DHS surveys.

While the overall value of DHS maternal mortality estimates is undeniable, our examination of the quality of data and estimation methods suggests that there are additional opportunities for improving maternal mortality estimates in DHS surveys. We provide few recommendations in the report for improving sibling survival history module and addressing challenges of underestimation of MMR in DHS surveys.

1. Introduction

At the Millennium Summit in September 2000, the Millennium Development Goals (MDGs) were developed by nations and world leaders to inspire cooperation and partnership to reduce extreme poverty and improve the status of health, education, and the environment of the global community (UN General Assembly 2000). Specific time-bound targets were established with an achievement deadline of 2015. The achievement of these targets is being measured using established indicators of health and poverty. With 2015 quickly approaching, the accurate and standardized measurement of indicators becomes even more important to ensure and confirm that the goals have been achieved and to identify countries and populations that are still exposed to poverty and poor health conditions, thereby allowing a focused aid effort in these areas.

The fifth of the eight MDGs is to improve maternal health (MDG 5) with a key indicator to measure this goal identified as the maternal mortality ratio (MMR), a ratio of the number of maternal deaths that occur for every 100,000 live births. The target established at the Millennium Summit was to reduce the MMR by three-quarters between 1990 and 2015.

Accurate estimation of maternal mortality, particularly in developing countries, is made difficult by the lack of complete vital registration systems. The evaluation of safe motherhood programs and the monitoring of progress in achieving Millennium Development Goal-5 (MDG 5)—reducing the maternal mortality ratio by three-quarters between 1990 and 2015—remains a major challenge because of difficulties measuring maternal mortality in the face of weak information systems. Only 60% of 230 countries have at least 90% birth registration coverage, and only 47% of countries have at least 90% death registration coverage (United Nations 2014). According to the World Health Organizations (WHO), more than 100 developing countries do not have a functioning vital registration system (WHO 2014). Even where a good vital registration system is available, as in most developed countries, misclassification and underestimation of maternal mortality is common.

In the absence of complete vital registration with good attribution of causes of deaths, the most commonly employed methods for estimation of maternal mortality are household surveys with direct death inquiry, indirect and direct sisterhood methods, and reproductive age mortality surveys (RAMOS). For countries that have no data available on maternal mortality, regression-based methods are used to estimate maternal mortality (Graham et al. 2008b).

The Demographic and Health Surveys (DHS) Program has long been the primary source of data and information to monitor and track key indicators of a country's health status through its population. With the launch of the Safe Motherhood Initiative in 1987 and the subsequent increased interest in maternal health and mortality, DHS responded the following year by introducing the maternal mortality module to the DHS questionnaire. Since 1988, the maternal mortality module has been implemented in 60 countries, representing all regions, including 39 countries in sub- Saharan Africa, 15 countries in North Africa/West Asia/Europe, and 6 countries in Latin America and the Caribbean. Further, a number of countries have collected data on maternal health and mortality in more than one survey round, allowing governments and donor agencies to track and measure a country's progress toward achieving MDG 5 (Arifeen et al. 2014). Through modeling, the MMR estimates from the DHS survey data are also used by WHO/UNICEF/UNFPA and the World Bank and by the Institute for Health Metrics and Evaluation (IHME) for tracking global progress in reaching MDG 5. For several of the developing countries, the first DHS survey was conducted only recently, thus providing valuable insight into the maternal health status of the female population in the countries for the first time. Prior to the DHS survey, information about maternal deaths was largely unknown or was estimated using complex modeling.

1.1. Objectives

The purpose of this report was to assess the data quality bias in estimates of the indicators of maternal mortality in the DHS surveys. The report updates the previous assessment conducted by Stanton, Abderrahim, and Hill in 1997 (Stanton et al. 1997), which examined data from 14 DHS surveys conducted between 1989 and 1995. A further aim of this study was to examine whether some of the deficiencies identified in the earlier report were resolved in subsequent survey rounds.

This report is based on analysis of data from 112 DHS surveys (in 46 countries) for which standardized data on sibling history were publicly available. These surveys were conducted between 1990 and 2012, which covered the five phases of DHS survey implementation: DHS-II (1989-93), DHS-III (1993-1997), MEASURE DHS+ (1997-2003), MEASURE DHS (2003-2008), and MEASURE DHS Phase-III (2008-2013). For purposes of chronological ordering in this report, the last three phases are referred to as DHS-IV, DHS-V and DHS-VI, respectively.

Of the 112 surveys included in this report, the number in each DHS phase is as fdlows: DHS-II (8 surveys), DHS-III (28 surveys), DHS-IV (28 surveys), DHS-V (28 surveys), and DHS-VI (20 surveys). Thirteen of the 46 countries have only one round of survey data, 11 countries have two rounds, 15 countries have three rounds, and five countries have four rounds of survey data. Indonesia is the only country with five rounds of survey data. In general, DHS surveys are conducted every five years in many countries. An exception is Peru, where surveys are conducted every year on a rolling sampling plan. In this report, we have included seven rounds of survey data from Peru. Table 1.1 shows the countries included in this assessment of maternal mortality and the number of survey rounds carried out in each country.

Table 1.1 DHS survey countries included in this assessment of maternal mortality by number of survey rounds carried out in each country, 1990-2013

Number of survey rounds					
1	**2**	**3**	**4**	**5**	**7***
Brazil	Benin	Bolivia	Madagascar	Indonesia	Peru
Burundi	Chad	Burkina Faso	Malawi		
Central African Republic	Congo (Brazzaville)	Cambodia	Mali		
Congo Dem. Republic	Dominican Republic	Cameroon	Uganda		
Guatemala	Gabon	Côte d'Ivoire	Zimbabwe		
Jordan	Haiti	Ethiopia			
Liberia	Lesotho	Guinea			
São Tomé and Príncipe	Morocco	Kenya			
Sierra Leone	Nepal	Mozambique			
South Africa	Nigeria	Namibia			
Swaziland	Philippines	Niger			
Timor-Leste	Rwanda	Senegal			
Togo		Tanzania			
		Zambia			

*Rolling sampling survey

On occasions, the DHS Program had implemented dedicated surveys aiming at examining maternal mortality and morbidities in some countries. Some examples are Bangladesh Maternal Mortality and Health Care Surveys in 2001 and 2010, Afghanistan Mortality Survey 2010, and Ghana Maternal Health Survey 2007. These surveys used different study instruments, including verbal autopsy, and were based on very large sample size. The data from these specialized surveys were not included in the analysis for this report.

In recent years, DHS implemented a sibling survival history module in the surveys of men (Merdad, Hill, and Graham 2013). Considering that the maternal mortality data from the surveys of women are currently included in DHS country reports and used by the Maternal Mortality Estimation Interagency Group (MMEIG), consisting of WHO/UNICEF/UNFPA and the World Bank, and by the Institute for Health Metrics and Evaluation (IHME)—the two agencies that routinely report global maternal mortality—we limit our analysis of data for this report to women respondents only.

1.2. Methods

The valid estimation of maternal mortality requires accurate and complete reporting of the events (deaths due to maternal causes) among at-risk women (age 15-49) during a reference calendar period. To ascertain the quality of DHS data for maternal mortality estimation, we examined three related aspects of research: (1) completeness in sibling death reporting, (2) completeness in reporting of all sisters and their age, and (3) completeness in reporting of the time of death during a calendar year.

Completeness of sibling death reporting

Maternal mortality is a subset of deaths from any cause. We examined the completeness of death reporting from any cause by the Brass growth balance method (Brass 1975). We compared the completeness of reporting between male (brothers) and female (sisters) populations to ascertain whether there were any systematic biases (underreporting) in the reporting of death from any cause for females.

Completeness of reporting of sisters and their age

A comparison of the age structure of sisters to that of respondents was conducted to assess any possibility of age coverage errors, age-displacement, and/or underreporting of sisters. We estimated the Whipple Index for assessing digit preference in age reporting. We also examined the underreporting (under-enumeration) of siblings by comparing the responses in the sibling history records with the parity distribution of respondents' mothers.

Completeness of reporting time of death and other vital events

Studies suggest that maternal mortality risk is higher at younger and older ages than at mid-reproductive ages between 20 and 40 years. We compared the age-specific distribution of deaths to the age-specific distribution of births for assessing the underreporting of deaths at the extremes of the reproductive age boundary.

Missing data are a common problem in surveys. This may be due to non-response to some questions by respondents. Some subjects may decline to provide values deliberately for fear of confidentiality or lack of appropriate knowledge. Missing data reduce the statistical power of the study and may introduce bias. We examined *missingness* in the reporting of vital events, age, calendar period of death, and timing of death in relation to pregnancy (during pregnancy, during delivery, or during the postpartum period). In statistical literature, *missingness* refers to the overall status of missing response or incomplete data/variables in the data set.

Adjustment for missing data on time of death in relation to pregnancy

We applied four statistical methods for assessing the impact of underestimation bias (from missing responses) in estimates of the maternal mortality ratio (MMR). We compared the MMR estimates from the standard DHS method to a) complete case analysis (missing cases dropped from analysis), b) weighting for non-response (inversely weighted by the response rate which inflated the maternal death proportions by the extent of missingness), c) single imputation with hot deck method, and (d) multiple imputations method.

Gakidou and King (2006) propose to apply a weighting method for correcting mortality selectivity bias when using the sisterhood method for mortality estimation because of the lower selection probability of sibships with high mortality. Moreover, women who have died with no surviving sister have zero probability of selection in the sisterhood sampling scheme, which may also introduce underestimation bias. Gakidou and King suggest correcting such selectivity bias though weighting. However, subsequent simulation work shows that the application of such weighting overestimates mortality (Masquelier 2013). A similar weighting scheme applied by Obermeyer et al. (2010) also increased the mortality estimates substantially. Earlier, Trussell and Rodriguez (1990) had shown that maternal mortality estimates obtained by the DHS method are unbiased because of compensating mechanisms in the sisterhood method: underestimation bias due to the non-inclusion of zero surviving sisters is compensated for by the overestimation risk of excluding the surviving respondents, under the assumption that the mortality risks of the sisters are independent. Reniers, Masquelier, and Gerland (2011) consider that the adjustment with weighting is controversial and prefer to use unweighted data. In this report, we have not applied any weighting correction for selectivity bias, if any. However, we have used survey design weights in the analysis to yield the correct population representation of the sample.

2. Contribution of DHS to Global Maternal Mortality Estimations

The Demographic and Health Surveys (DHS) Program collects data that allow for the calculation of several indicators of maternal mortality including the *maternal mortality ratio* (MMR), the *maternal mortality rate* (MMRate), the *proportion of maternal mortality among all adult female deaths* (PMDF), and a woman's *lifetime risk of maternal death* (LTR). These indicators and the data required to calculate and measure each are summarized below.

2.1. Indicators of Maternal Mortality

To standardize the measurement and calculation of maternal mortality indicators, determining the timing of death in relation to the woman's pregnancy is critical. The following definitions are used to help define and measure maternal mortality (WHO 2011):

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

Pregnancy-related death: A pregnancy-related death is the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of cause. Technically, DHS data provide pregnancy-related deaths, not maternal deaths.

Late pregnancy-related death: A late pregnancy-related death is the death of a woman from direct or indirect obstetric causes more than 42 days but less than one year after termination of pregnancy. Pregnancy-related death and late pregnancy-related death definitions were introduced in the Tenth Revision of the International Classification of Diseases (ICD-10).

A true maternal death requires specific cause of death information while pregnancy-related and late pregnancy-related deaths are defined on the basis of the timing of death with regards to the woman's pregnancy and delivery, irrespective of the relationship between the cause of death and the pregnancy. Therefore, accidental deaths or deaths due to violence that may or may not have occurred because of the condition of being pregnant will be included in the pregnancy-related death categories but not as maternal deaths.

A significant interest has emerged in recent years regarding the late-pregnancy related deaths, especially in developed countries, after recognizing that about 14% of pregnancy-related deaths in the United States occurred after 42 days but before 365 days of delivery (Berg et al. 2010). DHS surveys do not collect late pregnancy-related death information.

In addition to data on the cause or timing of death of a woman during pregnancy, childbirth, and postpartum, information on fertility measures within the population are needed for maternal mortality indicators. Birth histories enable estimation of the number of live births and the general fertility rate (GFR) and are routinely collected as part of the DHS questionnaire.

Using the definitions just described, the following indicators of maternal mortality can be calculated.

2.1.1. Maternal Mortality Ratio (MMR)

The maternal mortality ratio (MMR) is the most commonly used indicator of maternal mortality and is defined as the number of maternal deaths per 100,000 live births:

$$\frac{Number\ of\ maternal\ deaths}{Number\ of\ live\ births}\ x\ 100{,}000 = MMRatio$$

By definition, the MMR limits measurement of the risk of maternal death to those deaths due to obstetric causes by expressing the relationship *per number of live births* as opposed to *per women of childbearing age*. Therefore, it expresses the risk of maternal death based on the *frequency of childbearing*. However, because data are limited or nonexistent on the number of pregnancies that do not end in a live birth, this also means that the MMR will overestimate obstetric risk by underestimating the number of pregnancies during which a woman is at risk of maternal death. Further, the MMRatio between countries or populations cannot be compared because the measure is not standardized to the age distribution within a country.

2.1.2. Maternal Mortality Rate (MMRate)

The maternal mortality rate (MMRate) is a measure of the risk of maternal death to a woman of reproductive age, typically defined as 15-49 years of age.

$$\frac{Number\ of\ maternal\ deaths}{Number\ of\ women\ age\ 15-49}\ x\ 1000 = MMRate$$

This measure is clearly related to the number of pregnancies within a population for which a woman is at risk of maternal death yet it does not directly account or adjust for the fertility rate within a country and therefore is not directly comparable between countries. However, it does reflect the magnitude of the burden of maternal deaths as a cause of death among women.

DHS estimates the maternal mortality rate using the following formula:

$$\frac{number\ of\ maternal\ deaths}{number\ of\ woman\ \ person\text{-}years}\ x\ 1000 = MMRate$$

The MMRate and MMRatio can be calculated from each other by applying the general fertility rate (GFR) in a country and using the following formula:

$$\frac{MMRate}{GFR} = MMRatio$$

The GFR is the ratio of live births to women age 15-49.

2.1.3. Proportion of Female Deaths that are Maternal (PMDF)

The proportion of maternal deaths among females of reproductive age is a third indicator that provides information about the burden of maternal deaths compared to all other causes of death among women age 15-49. This indicator is defined as follows:

$$\frac{Number\ of\ maternal\ deaths}{Number\ of\ deaths\ among\ women\ age\ 15-49} = PMDF$$

2.1.4. Lifetime Risk of Maternal Death (LTR)

The lifetime risk of maternal death is defined as the risk of a woman dying from maternal causes during the 35 years of her reproductive lifeti me. It has been described as th e cumulative loss of human life due to maternal death over the course of a female life and can be used as an indicator of the im pact of maternal mortality in a population (Wilmoth 2009). There is m ore than one way of estimating LTR depending on how one defines lifetime risk and the starting point of either birth or 15 years of age. The general consensus is that the lifetim e risk of maternal death calcula tion should be conditional on the wom an surviving to reproductive age (Wilmoth 2009). The equation for L TR that is reported in the DHS country reports is as follows:

$$(1 - LTR) = (1 - MMR)^{TFR}$$

2.2. Maternal Mortality Measurement Challenges

Maternal mortality is one of the m ore difficult indicators to measure and track over tim e because of misclassification, sampling error, and non-sam pling error (Graham et al. 2008a). The identification of a death as a maternal death is defined based on both ti ming and cause of death. Ideally , maternal mortality measurement would be based on complete and accurate death registry records with validated and verified cause of death. However, identifying the cause of death as maternal is difficult even in developed countries with adequate vital registry systems and is often underreported. This lack of accurate classification of death is amplified in developing countries, which may have limited or no vital or civil registry systems to track and count deaths in the population.

There are several opportunities and options for m easuring maternal mortality. Graham et al. (2008b) outlined five empirical methods in addition to a brief discussion of analytical methods available including statistical modeling and adjustments for known underreporting of deaths and maternal deaths. The empirical approaches include the use of data from death regist rations, health facility surveys, censuses, population-based surveys, surveillance, and com posite approaches that draw on all five sources of data to identify female deaths of reproduc tive age, known as the reproductive age mortality studies (RAMOS). These empirical approaches all have benefits and drawbacks. The larger, m ore general approaches, such as a census providing a limited range of information on the maternal death (e.g., without causes of death), can be used to estimate maternal health indicators for a small geographical area, but they are done only every 10 years. A death registrati on system may be considered the gold standard but is not full y functional in most developing countries. In contrast, surve ys or surveillance can provide more maternal mortality information in developing countries, but the potential for uncertainty in the estimates due to sampling and non-sampling error is larger (Graham et al. 2008b).

To estimate maternal mortality, the number of maternal deaths over a period of time must be ascertained. This enumeration can be done actively or passively depending on the data source. Death registries or health facility statistics are based on passive identification of deaths through review of records and the subsequent determination of the fraction of those deaths that are maternal or pregnancy related. Active identification is conducted in surveys or surveillance through the interview process and active inquiry into deaths and cause or timing of death. In general, passive surveillan ce yields estimates that are more prone to non-sampling errors, including underreporting (i.e., omissions), and bias due to the underrepresentation of certain population subgroups (Graham et al. 2008b).

Many measurement and sampling techniques rely on pregnancy-related deaths as a surrogate for maternal deaths because this estimate only requires the respondent or data gatherer to know the tim ing of the death (in relation to the pregnancy), without regard to the cause of the death. As a result of rely ing on tim ing alone to estimate maternal deaths, this definition can lead to the inclusion of accidental or incidental deaths that have no association with the pregnancy, therefore producing an overestimation of maternal deaths. It

has been argued, however, that this overestimation is counterbalanced by the inherent underreporting of maternal deaths. Further, recent studies have shown that a large portion of the accidental or violent deaths among pregnant women may actually be maternal deaths (considering aggravated risk due to pregnancy status), thus reducing the impact of overcounting.

Further compounding the challenges of accurate and complete reporting associated with estimating maternal mortality is the fact that maternal mortality, relative to child mortality and many other health indicators, is a rare event. Therefore, to obtain estimates that do not have extremely wide confidence intervals, a large sample size is required. For this reason, many of the survey methods used in current practice have to include a very large sample population or else rely on the respondent's recall over the past 5 to 7 years in order to obtain enough deaths to estimate maternal mortality. Obtaining a large enough sample from a household survey is often costly and therefore may not be considered feasible. In addition, the longer the recall period prior to the survey, the greater the likelihood of reduced accuracy of age and date reporting as well as cause or timing of death, although this phenomenon is not strictly the case—for example, omission of deaths or siblings from a respondent's history may be related to factors other than duration of recall (e.g., age of respondent, migration of sibling).

Currently, more than 100 developing countries do not have registry systems in place to count the births and deaths in their population. Among researchers in the field of maternal mortality, new and enhanced methods have been developed to address this data gap in resource-poor countries (Graham et al. 2008a; Hill et al. 2006). Information gathered by censuses and household surveys that rely on respondent recall of sibling births and survival status have been used in many studies that estimate and compare adult and maternal mortality (Blanc et al. 2013; Hogan et al. 2010; Kassebaum et al. 2014). The majority of the country-specific DHS modules have used sibling histories to estimate adult mortality for over 20 years. While these histories are not the gold standard approach to estimating maternal mortality, evaluations have shown the value and validity of these approaches in the absence of vital registry data (Graham et al. 2008b; Hill et al. 2006; Merdad et al. 2013), while recent research has provided insight into simple ways to improve the accuracy and completeness of the data collected through these methods (Helleringer et al. 2014a; Helleringer et al. 2014b).

Descriptions of the methods currently used to measure maternal mortality from survey data in the absence of vital registries are summarized here.

Indirect sisterhood method of estimation

The *sisterhood method* of collecting data to calculate maternal mortality is also referred to as the *indirect method* and was the first method used in the DHS maternal mortality module initiated in 1988. This approach is adapted from the method first developed by Graham et al. (1989) to estimate adult mortality indirectly based on the survivorship of siblings. In the DHS, a series of questions was asked of a sample of adult respondents regarding their sisters born to the same mother, including (1) how many sisters were ever-married; (2) the vital status of these sisters; and (3) if dead, whether they died while pregnant, during childbirth, or during the six weeks following delivery (Graham et al. 1989). The reporting of deaths covers a large interval time, and as a result the indirect sisterhood method generates a maternal mortality estimate for a period centered around l0-12 years before the survey. Based on this series of questions, the risk and magnitude of pregnancy-related death can be obtained; however, "true" maternal mortality cannot be estimated because the exact cause of death cannot be ascertained with this level of questioning and recall. Therefore, it is solely the timing of the sister's death that defines maternal mortality with the indirect sisterhood method used in the earliest DHS surveys. The amount of overestimation of maternal mortality that this non-cause-specific death variable creates is unclear, however many experts believe that the overestimation is minimal. A study in Bangladesh reported that 63 of 304 maternal deaths were misreported as non-maternal deaths using the sisterhood method when a comparison was made with surveillance records (Shahidullah 1995). Further, the overestimation that may occur by including potentially non-maternal

deaths may be compensated for by the fact that some deaths resulting from abortion may not be reported in developing countries. Many induced abortions are not reported by women in areas where the procedure is restricted or illegal. It may also be that the respondent did not know that her sister was pregnant and therefore, any death that occurred as a result of that pregnancy would not be included in the count of maternal deaths (Gerdts et al. 2013). Misclassification and underreporting of maternal deaths due to abortion was demonstrated by Walker et al. (2004), which showed that second trimester deaths due to abortions were misclassified both as non-abortion-related maternal deaths as well as non-maternal deaths. Overall, the direction and amount of the bias in the sisterhood method is unclear from the existing studies.

Direct sisterhood method of estimation

The direct estimation of maternal mortality is the method currently used in the DHS maternal mortality module and in the datasets included in this analysis. This method is based on the same principles as the indirect method but collects additional data to allow for the calculation of person-years of exposure time necessary for the calculation of age-specific mortality rates. Maternal mortality is still defined based on the timing of the sister's death in relation to pregnancy but includes deaths up to two months after the end of a pregnancy, as opposed to six weeks. This revision was made to ease the reporting and recall burden on the respondent, with little impact on the accuracy of indicators. The DHS maternal mortality module questionnaire begins by asking the respondent about brothers and sisters who were born to the respondent's biological mother. The questions are presented in the following order:

1. How many children did your mother give birth to including you?
2. If more than one birth (the respondent), how many births occurred before the respondent was born?

Then for each sibling reported in #2 above, the following questions were asked of the respondent:

1. What was the name of your oldest brother or sister?
2. Is that sibling male or female?
3. Is that sibling still alive?
4. How old is that sibling?
5. How many years ago did the sibling die (if applicable)? Some surveys also ask the year the sibling died.
6. How old was the sibling when they died?

If the sibling was female and dead the following questions were asked:

1. Was the sibling pregnant?
2. Did she die during childbirth?
3. Did she die within two months after the end of a pregnancy or childbirth?
4. How many live born children did she give birth to during her lifetime?

An earlier study suggests that completion of the sibling history module takes an average of about 10 minutes of the interview (Rutenberg and Sullivan 1991).

In the earlier DHS rounds, the postpartum period was specified as 6 weeks in several countries, as per the ICD-10 definition of maternal mortality. These countries were Namibia (Phase-II), Malawi (Phase-II), Philippines (Phase-II), Central African Republic (Phase-III), Zimbabwe (Phase-III), Indonesia (Phase-III, IV, and V), and Cambodia (Phase-V). Subsequently, DHS changed the postpartum period recall duration to 2 months, for easier interpretation in developing countries. The exceptions were two countries (Peru and Philippines) where an open-ended question was asked on when the sister's death occurred: How long after giving birth to her last child did (NAME) die?

Nine surveys in six countries (Côte d'Ivoire, Indonesia, Jordan, Morocco, Peru, Senegal) collected data on the marital status of the siblings. In selected countries, the information on maternal-related deaths was collected for married sisters only.

Both the indirect and direct methods include all pregnancy-related deaths as maternal deaths. However, the direct method also requires and assumes that the respondent can report accurately on the age of living siblings and the age at death and years since death for dead siblings. This is a big assumption, especially for those siblings that are the youngest of the family and may not remember or know about siblings that were born and died either before they were born or when they were too young to remember. Further, being aware of the pregnancy status and timing of siblings requires significant recall as well. A previous evaluation of the direct sisterhood method used by DHS reported relative errors in maternal mortality estimates of 15% across 13 countries (14 surveys) when the recall period was 0 to 6years before the survey; errors were higher when the recall period was 7 to 13 years (Stanton et al. 2000).

The underreporting of siblings as well as deaths of siblings is common using this method. As mentioned above, the age of the respondent will affect the accuracy of the estimate. A recent record linkage study in Senegal noted that additional reasons for omission of siblings in a respondent's history include whether they were deceased, had migrated away from the home, had a different biological father than the respondent, or had never lived with the respondent (Helleinger et al. 2014a). In this study, 9.1% of deceased sisters were omitted from the history in addition to 16.6% of the sisters that had migrated out of the area. Reasons for omission of siblings from a respondent's history vary from country to country depending on cultural norms (e.g., matrilineal versus patrilineal social structure). It is also possible to overcount siblings by including those who were adopted into the family or of a different mother but the same father.

A recent evaluation of the sisterhood method—using a modified version of the DHS questionnaire including a siblings' survival calendar (SSC)—was conducted in Senegal with respondents from the Niakhar Health and Demographic Surveillance System (Helleringer et al. 2014b). The retrospective validation study randomly assigned respondents to be interviewed with either the DHS questionnaire or the SSC. The SSC included (1) prompting cues to help probe respondents for omitted siblings and (2) a calendar based on national landmark events to help with timing of death and age at death. Comparing the results, more female deaths were reported using the SSC (89.6%) than were reported using the DHS questionnaire (75.6%). At the same time, there was little difference in the amount of missing data between the two questionnaires (Hellerringer et al. 2014b).

A potential source of bias in the sisterhood method results from the assumption that the risk of mortality among siblings is independent. In other words, the risk of a sibling dying is not related to the risk of another sibling in that family dying. If mortality risk is related, then siblings with a higher risk of dying are less likely to be available to respond and thus bias the estimates downward.

As discussed in Stanton et al. (2000), DHS evaluated both the indirect and direct methods of estimating maternal mortality and determined that the direct method was the preferred approach for future surveys because it enables (1) calculation of rates and ratios for specified time periods, (2) monitoring of trends, (3) analysis of maternal mortality by parity, and (4) more complete assessment of data quality. Another disadvantage of the indirect sisterhood method is that it only gives lifetime risks and assumes no trend in

either MMR or fertility. In contrast, the disadvantages of the direct method, such as the longer average interview duration (8-10 minutes per interview), the need for additional training and field supervision, and the increased complexity of data analysis, were considered to be counter-balanced by the advantages (Stanton et al. 2000).

Direct household method of estimation

While the majority of the countries with DHS surveys rely on the direct sisterhood method of measuring maternal mortality, several countries have implemented the *direct household method*. The notable examples are the Bangladesh Maternal Mortality and Health Care Survey in 2001 and 2010, Afghanistan Mortality Survey 2010, and Ghana Maternal Health Survey 2007. The direct household method incorporates questions into an existing census or a household survey with a sample population large enough to provide reliable estimates. Respondents are asked about deaths that occurred in the household, regardless of sibling status, for a recall period prior to the census or survey. For deaths of women of reproductive age, there are further questions related to the timing of death to determine if the death was pregnancy-related. As mentioned earlier, because of the relative rarity of maternal deaths, household surveys need to be very large to yield reliable estimates of maternal mortality; such surveys are often not feasible or cost effective in developing countries. For this reason, most countries rely on the sisterhood method as part of a DHS survey or another small sample survey.

A study in Bangladesh allowed for a unique comparison of estimates of pregnancy-related deaths—the direct household method compared with the direct sisterhood method—compared maternal deaths from a household survey with cause of death from a verbal autopsy (Hill et al. 2006). Results indicated that pregnancy-related deaths estimated with the household and sisterhood methods were similar, while estimates of maternal deaths from the household survey were about 15% lower—although not significantly different because of overlapping confidence intervals. The sisterhood method showed greater sampling precision compared with the household method because of higher person-years of exposure in the sisterhood method. However, it should be noted that the comparability of the sisterhood method with the household survey in Bangladesh may not be generalizable to other countries that use the sisterhood method because of the emphasis in the Bangladesh survey on training and the priority given to the maternal mortality questions; in most DHS surveys, the maternal mortality module is one of the last sections covered by the interviewer (Hill et al. 2006). Both the respondent and interviewer may be tired by the time the sibling history is reached in the DHS surveys, which may affect the quality of responses. In the Afghanistan Mortality Survey 2010, the pregnancy-related mortality ratio from the direct household method was 39% higher than the estimate from the direct sisterhood (sibling survival history) method.

2.3. Use of DHS Data for Global Maternal Mortality Estimations

Global estimations of maternal mortality have been routinely reported by the World Health Organization (WHO), UNICEF, UNFPA, and the World Bank since the 1990s. The IHME has been reporting maternal mortality since 2008. DHS surveys are the major source of primary data for maternal mortality estimation in both the UN organizations and IHME. As an example, of the 273 databases for MMR based on the sisterhood method in the WHO/UNICEF/UNFPA and the World Bank data repository, 87.8% are based on DHS survey data (WHO 2010). The other two types of surveys providing MMR estimates based on the sisterhood method—the AIDS Indicator Survey (AIS) and the Maternal Mortality and Morbidity Surveys in Bangladesh (BMMS) and Ghana (MHS)—were carried out with technical assistance provided by DHS.

IHME uses sisterhood-based maternal mortality data from DHS and from CDC's Reproductive Health Surveys (RHS)—97 surveys from 53 countries in 2008— for global mortality estimation (Hogan et al. 2010). Interested readers may consult the supplementary appendix in the Lancet for the list of the countries that used DHS in the IHME's maternal mortality estimations for the period 1990-2013 (Kassebaum et al. 2014).

3. Quality of the Sibling History Data

The data collected as part of the sibling history module in DHS surveys were significantly influenced by a study by Stanton et al. (1997) that first systematically examined the quality of maternal mortality data from DHS surveys. One of the main objectives of this study was to examine whether specific deficiencies identified in the earlier study were dealt with effectively in subsequent survey rounds.

3.1. Completeness of Vital Statistics

Table 3.1 shows that the sex of siblings was not reported or was missing in only a fraction of cases. In most countries the proportion of siblings with unknown sex was below 1%. The notable exceptions were Sierra Leone (9%) and Brazil (3.5%). Sierra Leone experienced civil war between 1991 and 2002, during which close to 1 million people were killed and 2.6 million were displaced. It may be that conflict played a role in the higher reporting of unknown sex of the siblings in Sierra Leone.

It is likely that the siblings with unknown sex are those who died immediately after birth or who died in the distant past before the birth of the respondent or when the respondent was too young to remember. DHS reports MMR only for recent periods—the last 3, 5, or 7 years before the survey—so the reporting of unknown sex of siblings may not have any major implications for maternal mortality estimation.

Although reporting of unknown sex was low, an examination of the trends between DHS-II and DHS-VI shows that the proportion declined substantially over the period in most countries (Figure 3.1).

Table 3.1 Percentage of siblings with unknown sex reporting, Demographic and Health Surveys 1990-2013

Country	DHS survey round	Year of survey	No. of sisters	No. of brothers	Unknown sex		No. of siblings
					Percent	No. with unknown sex	
Sub-Saharan Africa							
Benin	DHS-III	1996	14,996	15,548	1.1	334	30,879
Benin	DHS-V	2006	47,311	49,081	0.4	362	96,754
Burkina Faso	DHS-III	1998-99	16,314	17,532	1.8	612	34,458
Burkina Faso	DHS-IV	2003	31,933	33,869	0.7	464	66,266
Burkina Faso	DHS-VI	2010	46,814	50,188	0.2	167	97,169
Burundi	DHS-VI	2010-11	29,517	30,731	0.0	27	60,274
CAR	DHS-III	1994-95	15,162	15,356	0.0	0	30,518
Cameroon	DHS-III	1998	15,777	16,522	1.9	632	32,930
Cameroon	DHS-IV	2004	31,722	33,746	0.0	27	65,495
Cameroon	DHS-VI	2011	44,938	47,008	0.2	196	92,143
Chad	DHS-III	1996-97	19,715	21,218	0.4	163	41,097
Chad	DHS-IV	2004	17,474	18,373	0.0	0	35,847
Congo (Brazzaville)	DHS-V	2005	20,351	20,402	0.1	39	40,792
Congo (Brazzaville)	DHS-VI	2011-12	28,432	29,128	0.0	18	57,579
Congo Democratic Republic	DHS-V	2007	28,334	30,002	0.1	68	58,404
Côte d'Ivoire	DHS-III	1994	21,879	22,509	0.0	0	44,388
Côte d'Ivoire	DHS-V	2005	13,555	14,499	0.6	158	28,212
Côte d'Ivoire	DHS-VI	2011-12	28,527	29,733	0.1	56	58,394
Ethiopia	DHS-IV	2000	43,933	47,872	0.4	372	92,176

(Continued...)

Table 3.1 – *Continued*

Country	DHS survey round	Year of survey	No. of sisters	No. of brothers	Unknown sex		No. of siblings
					Percent	No. with unknown sex	
Sub-Saharan Africa							
Ethiopia	DHS-IV	2005	38,392	42,138	0.5	396	80,925
Ethiopia	DHS-VI	2011	47,107	51,558	0.3	262	98,927
Gabon	DHS-III	2000-01	17,991	18,003	0.6	232	36,227
Gabon	DHS-VI	2012	23,415	23,568	0.4	174	47,157
Guinea	DHS-III	1999	15,798	16,574	0.2	74	32,445
Guinea	DHS-IV	2005	19,958	21,346	0.1	55	41,359
Guinea	DHS-VI	2012	22,192	23,509	0.0	0	45,701
Kenya	DHS-III	1998	24,648	24,628	0.5	256	49,533
Kenya	DHS-IV	2003	25,508	26,165	0.4	216	51,889
Kenya	DHS-V	2008-09	24,825	24,770	0.4	210	49,804
Lesotho	DHS-IV	2004-05	16,551	17,145	0.1	34	33,730
Lesotho	DHS-V	2009-10	16,620	16,445	0.0	1	33,066
Liberia	DHS-V	2006-07	15,684	15,474	0.2	72	31,229
Madagascar	DHS-II	1992	19,845	20,389	0.0	0	40,234
Madagascar	DHS-III	1997	21,596	22,719	0.6	274	44,589
Madagascar	DHS-IV	2003-04	21,306	22,037	0.4	192	43,535
Madagascar	DHS-V	2008-09	51,193	52,466	0.1	58	103,717
Malawi	DHS-II	1992	15,107	14,792	0.9	270	30,169
Malawi	DHS-IV	2000	39,447	39,744	0.1	102	79,293
Malawi	DHS-IV	2004-05	31,195	31,538	0.1	57	62,790
Malawi	DHS-V	2010	68,386	68,532	0.2	228	137,147
Mali	DHS-III	1995-96	26,086	27,243	0.0	12	53,341
Mali	DHS-IV	2001	33,968	36,101	0.7	481	70,550
Mali	DHS-V	2006	40,897	44,708	0.5	426	86,031
Mali	DHS-V1	2012-13	20,104	21,707	0.0	0	41,811
Mozambique	DHS-III	1997	20,605	20,841	0.0	0	41,446
Mozambique	DHS-IV	2003-04	31,094	31,684	0.4	236	63,014
Mozambique	DHS-VI	2011	30,112	30,700	0.0	0	60,811
Namibia	DHS-II	1992	15,469	15,472	0.8	243	31,184
Namibia	DHS-IV	2000	19,537	18,071	0.4	168	37,776
Namibia	DHS-V	2006-07	25,974	25,270	0.3	177	51,421
Niger	DHS-II	1992	18,156	19,064	0.3	96	37,316
Niger	DHS-V	2006	26,755	28,435	0.1	58	55,248
Niger	DHS-VI	2012	34,732	36,410	0.1	59	71,201
Nigeria	DHS-III	1999	20,380	22,491	0.6	277	43,147
Nigeria	DHS-V	2008	86,223	92,541	0.6	1,155	179,919
Rwanda	DHS-IV	2000	31,993	32,882	0.8	514	65,388
Rwanda	DHS-IV	2005	35,963	36,405	0.2	159	72,527
Rwanda	DHS-VI	2010-11	41,562	42,048	0.2	170	83,779
São Tomé and Príncipe	DHS-V	2008-09	8,326	8,374	0.1	11	16,711
Senegal	DHS-II	1992-93	17,214	18,343	0.1	46	35,603
Senegal	DHS-IV	2005	42,600	43,774	0.3	220	86,594
Senegal	DHS-VI	2010-11	43,706	47,018	0.0	20	90,744
Sierra Leone	DHS-V	2008	14,619	14,750	9.0	2,921	32,291

(Continued...)

Table 3.1 – *Continued*

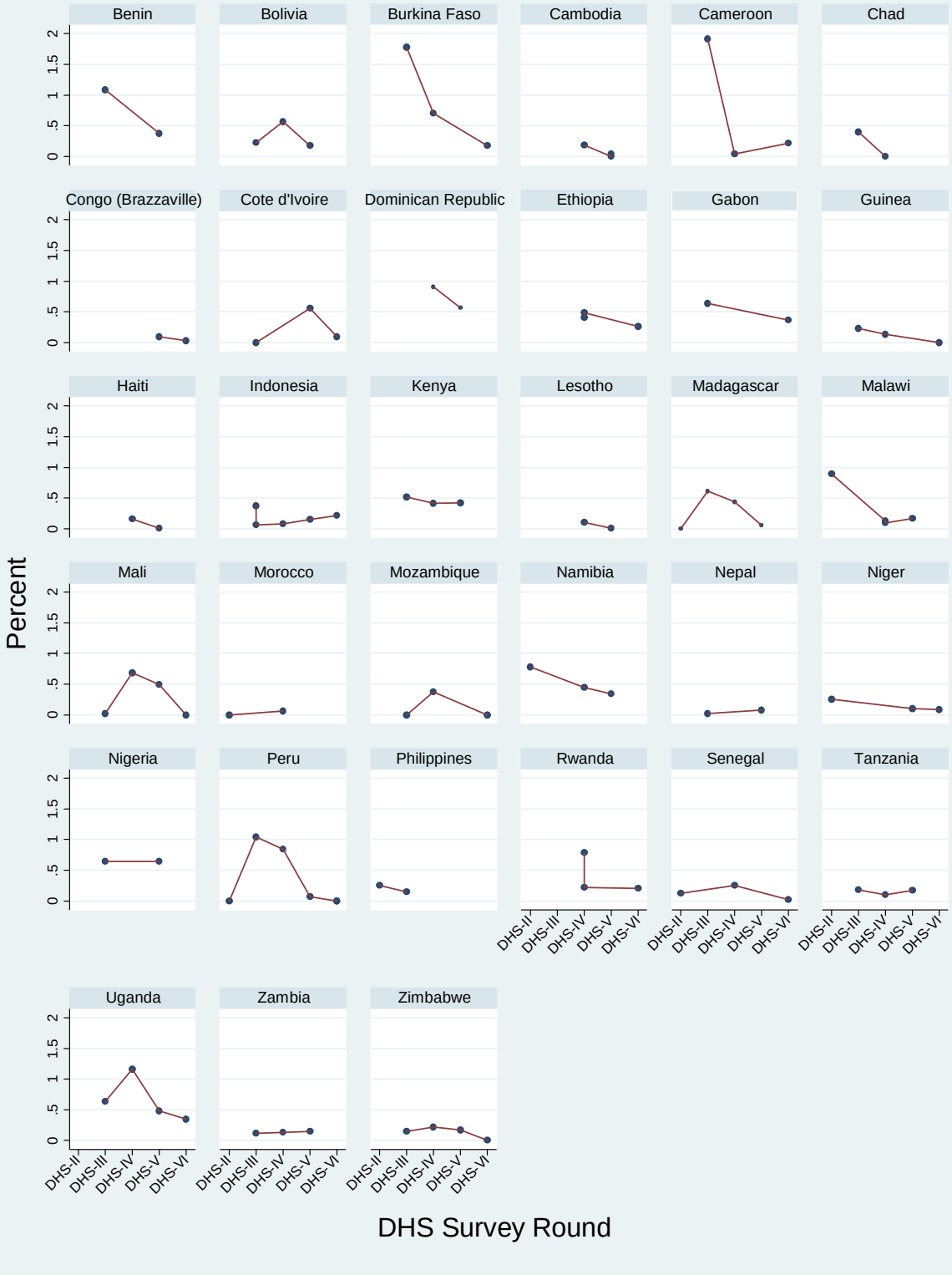
Country	DHS survey round	Year of survey	No. of sisters	No. of brothers	Unknown sex		No. of siblings
					Percent	No. with unknown sex	
Sub-Saharan Africa							
South Africa	DHS-III	1998	25,053	25,270	1.9	968	51,291
Swaziland	DHS-V	2006-07	12,774	12,820	0.3	84	25,679
Tanzania	DHS-III	1996	23,775	23,952	0.2	86	47,813
Tanzania	DHS-IV	2004-05	32,015	32,004	0.1	64	64,083
Tanzania	DHS-V	2009-10	28,309	28,425	0.2	101	56,835
Togo	DHS-III	1998	24,364	25,070	0.4	189	49,624
Uganda	DHS-III	1995	21,762	22,084	0.6	282	44,128
Uganda	DHS-IV	2000-01	23,417	23,660	1.2	554	47,631
Uganda	DHS-V	2006	28,655	29,200	0.5	282	58,137
Uganda	DHS-VI	2011	28,824	28,525	0.4	202	57,551
Zambia	DHS-III	1996-97	25,650	25,499	0.1	61	51,210
Zambia	DHS-IV	2001-02	23,721	24,035	0.1	64	47,819
Zambia	DHS-V	2007	20,404	20,775	0.2	62	41,242
Zimbabwe	DHS-III	1994	19,200	19,265	0.1	56	38,521
Zimbabwe	DHS-IV	1999	17,344	17,074	0.2	76	34,494
Zimbabwe	DHS-V	2005-06	23,720	23,349	0.2	80	47,149
Zimbabwe	DHS-VI	2010-11	21,870	21,564	0.0	0	43,434
North Africa							
Jordan	DHS-III	1997	41,211	43,325	0.0	11	84,547
Morocco	DHS-II	1992	29,488	31,012	0.0	1	60,501
Morocco	DHS-IV	2003-04	52,962	55,289	0.1	69	108,321
Asia							
Cambodia	DHS-IV	2000	39,167	40,928	0.2	147	80,242
Cambodia	DHS-V	2005-06	44,039	46,040	0.0	0	90,079
Cambodia	DHS-V	2010-11	44,897	47,085	0.0	35	92,018
Indonesia	DHS-III	1994	86,744	91,884	0.4	675	179,302
Indonesia	DHS-III	1997	81,320	85,439	0.1	104	166,863
Indonesia	DHS-IV	2002-03	77,938	85,122	0.1	131	163,191
Indonesia	DHS-V	2007	87,620	91,617	0.1	267	179,503
Indonesia	DHS-VI	2012	91,067	96,274	0.2	395	187,736
Nepal	DHS-III	1996	25,349	27,057	0.0	12	52,418
Nepal	DHS-V	2006	26,377	27,418	0.1	41	53,836
Philippines	DHS-II	1993	43,047	44,641	0.3	221	87,909
Philippines	DHS-III	1998	39,134	40,745	0.1	120	79,998
Timor-Leste	DHS-VI	2009-10	30,861	32,621	0.0	12	63,494
Latin America and Caribbean							
Bolivia	DHS-III	1993-94	20,909	22,094	0.2	97	43,100
Bolivia	DHS-IV	2003-04	45,780	48,432	0.6	538	94,750
Bolivia	DHS-V	2008	42,066	44,328	0.2	151	86,679
Brazil	DHS-III	1996	35,426	36,889	3.5	2,631	74,945
Dominican Republic	DHS-IV	2002	30,892	31,795	0.9	573	63,260
Dominican Republic	DHS-V	2007	66,456	68,127	0.6	765	136,031

(Continued...)

Table 3.1 – *Continued*

Country	DHS survey round	Year of survey	No. of sisters	No. of brothers	Unknown sex		No. of siblings
					Percent	No. with unknown sex	
Latin America and Caribbean							
Guatemala	DHS-III	1995	34,757	36,631	0.6	439	71,828
Haiti	DHS-IV	2000	28,693	29,738	0.2	92	58,523
Haiti	DHS-V	2005-06	30,321	30,978	0.0	5	61,305
Peru	DHS-II	1991-92	40,639	42,927	0.0	0	83,565
Peru	DHS-III	1996	81,636	85,036	1.0	1,756	168,427
Peru	DHS-IV	2000	75,210	79,685	0.8	1,317	156,212
Peru	DHS-V	2003-08	104,265	110,752	0.1	159	215,176
Peru	DHS-VI	2009	59,682	62,888	0.0	0	122,570
Peru	DHS-VI	2010	57,075	60,170	0.0	0	117,244
Peru	DHS-VI	2011	55,096	56,875	0.0	0	111,971

Figure 3.1 Trends in reporting of missing sex of siblings by DHS survey rounds, Demographic and Health Surveys 1990-2013



Unknown or missing response on the survival status of siblings was also low in the majority of countries (Table 3.2). Countries that experienced war or conflicts (e.g., Rwanda and Cambodia) have slightly higher reporting of unknown survival status of siblings, especially for brothers. However, there were no substantial differences in the reporting of unknown/missing survival status between sisters and brothers (Figure 3.2). Because there was no systematic overreporting of unknown survival status of sisters, compared with brothers, we consider that respondents were not underreporting the deaths of sisters in order to avoid the series of questions on maternal mortality.

Table 3.2 Percentage of siblings with unknown survival status, Demographic and Health Surveys 1990-2013

Country	DHS survey round	Year of survey	Missing percent	No. of sisters	Missing percent	No. of brothers	Missing percent	No. of all siblings
Sub-Saharan Africa								
Benin	DHS-III	1996	0.1	14,996	0.0	15,548	0.1	30,545
Benin	DHS-V	2006	0.0	47,311	0.0	49,081	0.0	96,392
Burkina Faso	DHS-III	1998-99	0.2	16,314	0.2	17,532	0.2	33,846
Burkina Faso	DHS-IV	2003	0.0	31,933	0.0	33,869	0.0	65,802
Burkina Faso	DHS-VI	2010	0.0	46,814	0.0	50,188	0.0	97,002
Burundi	DHS-VI	2010-11	0.1	29,517	0.3	30,731	0.2	60,247
CAR	DHS-III	1994-95	0.1	15,162	0.0	15,356	0.1	30,518
Cameroon	DHS-III	1998	0.0	15,777	0.1	16,522	0.0	32,298
Cameroon	DHS-IV	2004	0.0	31,722	0.0	33,746	0.0	65,468
Cameroon	DHS-VI	2011	0.1	44,938	0.1	47,008	0.1	91,946
Chad	DHS-III	1996-97	0.1	19,715	0.0	21,218	0.0	40,933
Chad	DHS-IV	2004	0.0	17,474	0.0	18,373	0.0	35,847
Congo (Brazzaville)	DHS-V	2005	0.0	20,351	0.0	20,402	0.0	40,753
Congo (Brazzaville)	DHS-VI	2011-12	0.1	28,432	0.1	29,128	0.1	57,560
Congo Democratic Republic	DHS-V	2007	0.1	28,334	0.1	30,002	0.1	58,337
Côte d'Ivoire	DHS-III	1994	0.0	21,879	0.0	22,509	0.0	44,388
Côte d'Ivoire	DHS-V	2005	0.0	13,555	0.1	14,499	0.1	28,054
Côte d'Ivoire	DHS-VI	2011-12	0.0	28,527	0.1	29,733	0.0	58,260
Ethiopia	DHS-IV	2000	0.1	43,933	0.5	47,872	0.3	91,804
Ethiopia	DHS-IV	2005	0.1	38,392	0.2	42,138	0.2	80,530
Ethiopia	DHS-VI	2011	0.1	47,107	0.1	51,558	0.1	98,665
Gabon	DHS-III	2000-01	0.0	17,991	0.0	18,003	0.0	35,995
Gabon	DHS-VI	2012	0.0	23,415	0.1	23,568	0.1	46,983
Guinea	DHS-III	1999	0.1	15,798	0.1	16,574	0.1	32,372
Guinea	DHS-IV	2005	0.0	19,958	0.0	21,346	0.0	41,304
Guinea	DHS-VI	2012	0.0	22,192	0.1	23,509	0.0	45,701
Kenya	DHS-III	1998	0.0	24,648	0.0	24,628	0.0	49,277
Kenya	DHS-IV	2003	0.0	25,508	0.0	26,165	0.0	51,673
Kenya	DHS-V	2008-09	0.1	24,825	0.0	24,770	0.1	49,595
Lesotho	DHS-IV	2004-05	0.1	16,551	0.1	17,145	0.1	33,696
Lesotho	DHS-V	2009-10	0.2	16,620	0.2	16,445	0.2	33,065
Liberia	DHS-V	2006-07	0.3	15,684	0.3	15,474	0.3	31,157
Madagascar	DHS-II	1992	0.1	19,845	0.1	20,389	0.1	40,234
Madagascar	DHS-III	1997	0.1	21,596	0.1	22,719	0.1	44,316
Madagascar	DHS-IV	2003-04	0.0	21,306	0.0	22,037	0.0	43,343

(Continued...)

Table 3.2 – *Continued*

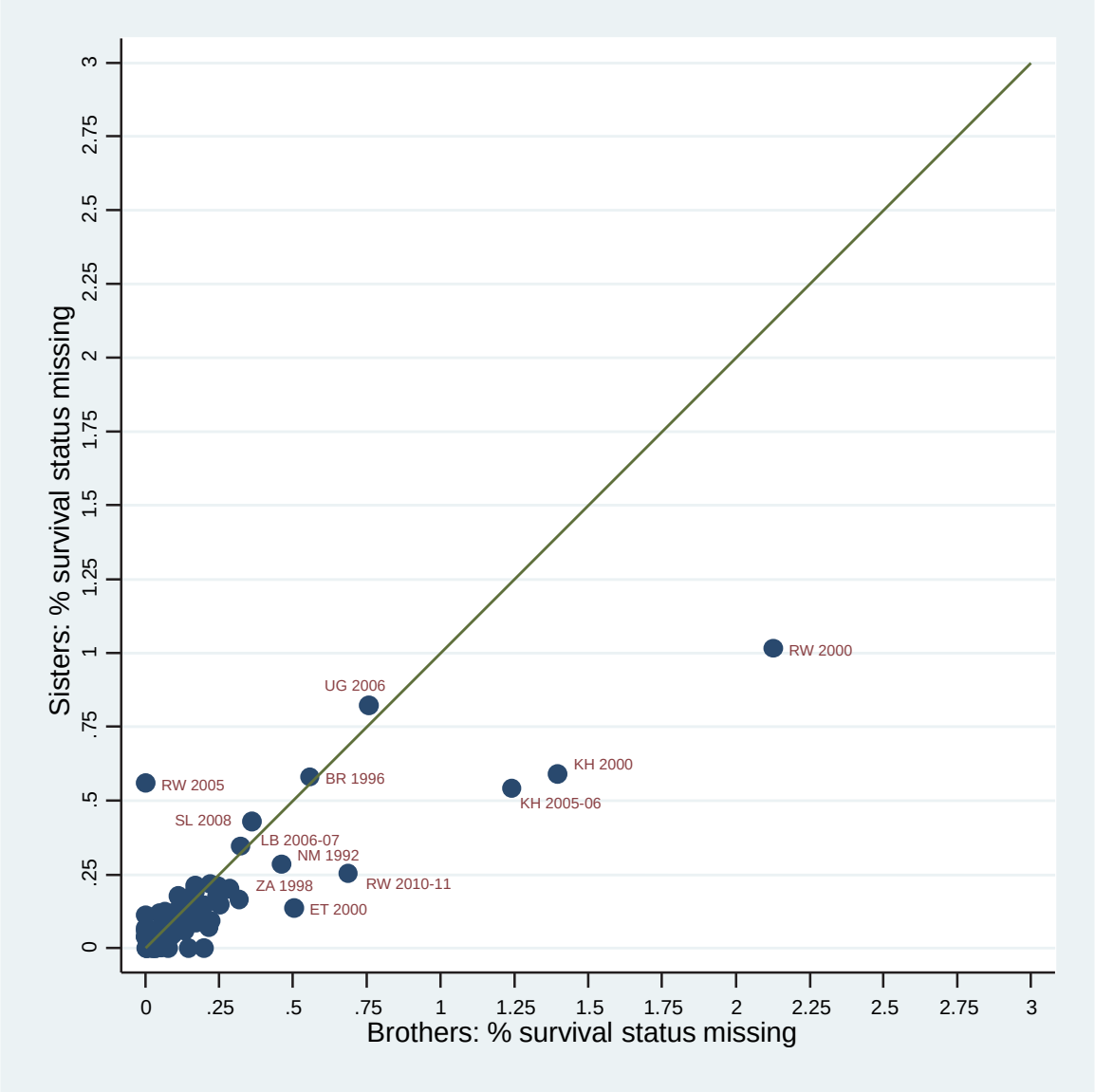
Country	DHS survey round	Year of survey	Missing percent	No. of sisters	Missing percent	No. of brothers	Missing percent	No. of all siblings
Sub-Saharan Africa								
Madagascar	DHS-V	2008-09	0.0	51,193	0.1	52,466	0.0	103,659
Malawi	DHS-II	1992	0.1	15,107	0.2	14,792	0.1	29,899
Malawi	DHS-IV	2000	0.0	39,447	0.0	39,744	0.0	79,191
Malawi	DHS-IV	2004-05	0.0	31,195	0.0	31,538	0.0	62,733
Malawi	DHS-V	2010	0.0	68,386	0.1	68,532	0.0	136,918
Mali	DHS-III	1995-96	0.0	26,086	0.0	27,243	0.0	53,329
Mali	DHS-IV	2001	0.1	33,968	0.1	36,101	0.1	70,069
Mali	DHS-V	2006	0.0	40,897	0.1	44,708	0.0	85,605
Mali	DHS-VI	2012-13	0.0	20,104	0.0	21,707	0.0	41,811
Mozambique	DHS-III	1997	0.0	20,605	0.0	20,841	0.0	41,446
Mozambique	DHS-IV	2003-04	0.1	31,094	0.2	31,684	0.1	62,778
Mozambique	DHS-VI	2011	0.1	30,112	0.2	30,700	0.1	60,811
Namibia	DHS-II	1992	0.3	15,469	0.5	15,472	0.4	30,941
Namibia	DHS-IV	2000	0.1	19,537	0.1	18,071	0.1	37,608
Namibia	DHS-V	2006-07	0.2	25,974	0.1	25,270	0.1	51,244
Niger	DHS-II	1992	0.0	18,156	0.1	19,064	0.0	37,220
Niger	DHS-V	2006	0.0	26,755	0.1	28,435	0.0	55,190
Niger	DHS-VI	2012	0.0	34,732	0.0	36,410	0.0	71,142
Nigeria	DHS-III	1999	0.1	20,380	0.1	22,491	0.1	42,871
Nigeria	DHS-V	2008	0.2	86,223	0.2	92,541	0.2	178,764
Rwanda	DHS-IV	2000	1.0	31,993	2.1	32,882	1.6	64,875
Rwanda	DHS-IV	2005	0.6	35,963	0.0	36,405	1.0	72,368
Rwanda	DHS-VI	2010-11	0.3	41,562	0.7	42,048	0.5	83,609
São Tomé and Príncipe	DHS-V	2008-09	0.0	8,326	0.2	8,374	0.1	16,700
Senegal	DHS-II	1992-93	0.0	17,214	0.1	18,343	0.1	35,557
Senegal	DHS-IV	2005	0.0	42,600	0.1	43,774	0.0	86,373
Senegal	DHS-VI	2010-11	0.0	43,706	0.1	47,018	0.1	90,724
Sierra Leone	DHS-V	2008	0.4	14,619	0.4	14,750	0.4	29,370
South Africa	DHS-III	1998	0.2	25,053	0.3	25,270	0.2	50,323
Swaziland	DHS-V	2006-07	0.1	12,774	0.1	12,820	0.1	25,594
Tanzania	DHS-III	1996	0.0	23,775	0.1	23,952	0.1	47,727
Tanzania	DHS-IV	2004-05	0.0	32,015	0.0	32,004	0.0	64,019
Tanzania	DHS-V	2009-10	0.0	28,309	0.1	28,425	0.1	56,734
Togo	DHS-III	1998	0.0	24,364	0.0	25,070	0.0	49,435
Uganda	DHS-III	1995	0.1	21,762	0.2	22,084	0.1	43,846
Uganda	DHS-IV	2000-01	0.2	23,417	0.3	23,660	0.2	47,077
Uganda	DHS-V	2006	0.8	28,655	0.8	29,200	0.8	57,855
Uganda	DHS-VI	2011	0.2	28,824	0.2	28,525	0.2	57,349
Zambia	DHS-III	1996-97	0.0	25,650	0.0	25,499	0.0	51,149
Zambia	DHS-IV	2001-02	0.0	23,721	0.0	24,035	0.0	47,755
Zambia	DHS-V	2007	0.1	20,404	0.1	20,775	0.1	41,180
Zimbabwe	DHS-III	1994	0.0	19,200	0.1	19,265	0.1	38,465
Zimbabwe	DHS-IV	1999	0.2	17,344	0.2	17,074	0.2	34,418
Zimbabwe	DHS-V	2005-06	0.0	23,720	0.1	23,349	0.1	47,069
Zimbabwe	DHS-VI	2010-11	0.1	21,870	0.1	21,564	0.1	43,434

(Continued...)

Table 3.2 – *Continued*

Country	DHS survey round	Year of survey	Missing percent	No. of sisters	Missing percent	No. of brothers	Missing percent	No. of all siblings
North Africa								
Jordan	DHS-III	1997	0.0	41,211	0.0	43,325	0.0	84,536
Morocco	DHS-II	1992	0.1	29,488	0.1	31,012	0.1	60,500
Morocco	DHS-IV	2003-04	0.0	52,962	0.1	55,289	0.1	108,252
Asia								
Cambodia	DHS-IV	2000	0.6	39,167	1.4	40,928	1.0	80,095
Cambodia	DHS-V	2005-06	0.5	44,039	1.2	46,040	0.9	90,079
Cambodia	DHS-V	2010-11	0.1	44,897	0.0	47,085	0.2	91,982
Indonesia	DHS-III	1994	0.0	86,744	0.0	91,884	0.0	178,627
Indonesia	DHS-III	1997	0.0	81,320	0.0	85,439	0.0	166,759
Indonesia	DHS-IV	2002-03	0.1	77,938	0.0	85,122	0.1	163,060
Indonesia	DHS-V	2007	0.0	87,620	0.1	91,617	0.0	179,237
Indonesia	DHS-VI	2012	0.0	91,067	0.1	96,274	0.0	187,341
Nepal	DHS-III	1996	0.1	25,349	0.2	27,057	0.1	52,406
Nepal	DHS-V	2006	0.1	26,377	0.0	27,418	0.1	53,794
Philippines	DHS-II	1993	0.1	43,047	0.1	44,641	0.1	87,688
Philippines	DHS-III	1998	0.0	39,134	0.1	40,745	0.1	79,878
Timor-Leste	DHS-VI	2009-10	0.0	30,861	0.0	32,621	0.0	63,481
Latin America and Caribbean								
Bolivia	DHS-III	1993-94	0.1	20,909	0.0	22,094	0.1	43,003
Bolivia	DHS-IV	2003-04	0.1	45,780	0.1	48,432	0.1	94,212
Bolivia	DHS-V	2008	0.1	42,066	0.2	44,328	0.2	86,395
Brazil	DHS-III	1996	0.6	35,426	0.6	36,889	0.6	72,314
Dominican Republic	DHS-IV	2002	0.1	30,892	0.0	31,795	0.1	62,687
Dominican Republic	DHS-V	2007	0.0	66,456	0.1	68,127	0.0	134,583
Guatemala	DHS-III	1995	0.1	34,757	0.1	36,631	0.1	71,388
Haiti	DHS-IV	2000	0.0	28,693	0.0	29,738	0.0	58,430
Haiti	DHS-V	2005-06	0.0	30,321	0.0	30,978	0.1	61,300
Peru	DHS-II	1991-92	0.1	40,639	0.2	42,927	0.2	83,565
Peru	DHS-III	1996	0.2	81,636	0.2	85,036	0.2	166,671
Peru	DHS-IV	2000	0.1	75,210	0.1	79,685	0.1	154,895
Peru	DHS-V	2003-08	0.1	104,265	0.1	110,752	0.1	215,017
Peru	DHS-VI	2009	0.1	59,682	0.1	62,888	0.1	122,570
Peru	DHS-VI	2010	0.1	57,075	0.2	60,170	0.1	117,244
Peru	DHS-VI	2011	0.1	55,096	0.1	56,875	0.1	111,971

Figure 3.2 Percentage of siblings with missing survival status by sex, Demographic and Health Surveys 1990-2013



Note: DHS country codes in two characters are listed in the Appendix (Table A1).

3.2. Accuracy and Completeness of Age Reporting

Age is an important variable in demographic studies. Knowing correct age is critical for identifying at-risk women (age 15-49) and ascertaining age-specific and age-adjusted risks of maternal mortality. In the countries lacking birth certificates and complete vital registration systems, misreporting of age is common in surveys and censuses. Age data frequently show excess digit preference, commonly at 0 or 5, leading to age heaping. Age heaping is often considered a measure of survey data quality. We use the Whipple Index as a demographic measure to examine the extent of age heaping. Compared to the Myers Index, which is used for age heaping assessment of any preferred values, the Whipple Index is preferred for identifying digit preference at 0 and 5. An early study examining the quality of age reporting found that the most common digit preferences in DHS surveys are the final digits of 0 and 5 (Pullum 2006). For this reason, we have limited the analysis of age heaping to calculation of the Whipple Index only. This index is obtained

by summing age returns between 23 and 62 years inclusive and finding what percentage is reported by the sum of the returns of years ending with 0 and 5 to one-fifth of the total sum (United Nations 1955). The UN recommends measuring age heaping using the Whipple Index, with the following classifications of data quality (United Nations 1974):

Value		of Whipple index
I.	Highly accurate data	Less than 105
II.	Fairly accurate data	105-109.9
III.	Approximate data	110-124.9
IV.	Rough data	125-174.9
V.	Very rough data	175 and more

We have included all the reported siblings and applied the standard age range for the Whipple Index calculation so that the UN classification shown above may be used for assessing the quality of age data. Table 3.3 shows the Whipple Index for age reporting of sisters and brothers. Four of the 112 surveys—Chad 1996-97, Lesotho 2004-05, Malawi 1992, and Zambia 1996-97—have highly accurate data on age reporting with minimal digit preference (Whipple Index <105). None of the surveys have an index value of 175 or higher (very rough data). Digit preference in age reporting of brothers and sisters was similar in all countries (Figure 3.3).

Table 3.3 Digit preference in age reporting of surviving siblings according to the Whipple Index, Demographic and Health Surveys 1990-2013

Country	DHS survey round	Year of survey	Whipple Index		
			Sisters	Brothers	All siblings
Sub-Saharan Africa					
Benin	DHS-III	1996	122.6	124.9	123.7
Benin	DHS-V	2006	130.6	128.4	129.5
Burkina Faso	DHS-III	1998-99	128.9	133.9	131.5
Burkina Faso	DHS-IV	2003	119.8	123.7	121.8
Burkina Faso	DHS-VI	2010	126.9	124.7	125.8
Burundi	DHS-VI	2010-11	123.0	119.3	121.2
CAR	DHS-III	1994-95	109.0	117.6	113.3
Cameroon	DHS-III	1998	123.5	120.6	122.1
Cameroon	DHS-IV	2004	119.1	119.8	119.4
Cameroon	DHS-VI	2011	121.9	128.0	125.0
Chad	DHS-III	1996-97	104.2	98.1	101.1
Chad	DHS-IV	2004	104.1	109.5	106.8
Congo (Brazzaville)	DHS-V	2005	119.3	122.8	121.0
Congo (Brazzaville)	DHS-VI	2011-12	115.9	117.2	116.5
Congo Democratic Republic	DHS-V	2007	114.6	115.1	114.9
Côte d'Ivoire	DHS-III	1994	130.4	129.5	129.9
Côte d'Ivoire	DHS-V	2005	130.3	128.6	129.4
Côte d'Ivoire	DHS-VI	2011-12	133.1	133.9	133.5
Ethiopia	DHS-IV	2000	116.3	115.5	115.9
Ethiopia	DHS-IV	2005	123.5	127.0	125.3
Ethiopia	DHS-VI	2011	125.6	127.7	126.7
Gabon	DHS-III	2000-01	119.7	124.9	122.3

(Continued...)

Table 3.3 – *Continued*

Country	DHS survey round	Year of survey	Whipple Index		
			Sisters	Brothers	All siblings
Sub-Saharan Africa					
Gabon	DHS-VI	2012	117.7	121.3	119.5
Guinea	DHS-III	1999	115.5	116.9	116.2
Guinea	DHS-IV	2005	119.5	120.6	120.0
Guinea	DHS-VI	2012	128.4	123.3	125.8
Kenya	DHS-III	1998	123.1	123.8	123.4
Kenya	DHS-IV	2003	119.9	119.0	119.4
Kenya	DHS-V	2008-09	119.7	119.5	119.6
Lesotho	DHS-IV	2004-05	103.6	103.0	103.3
Lesotho	DHS-V	2009-10	104.9	110.4	107.5
Liberia	DHS-V	2006-07	123.3	124.3	123.8
Madagascar	DHS-II	1992	117.8	126.5	122.2
Madagascar	DHS-III	1997	130.8	124.2	127.5
Madagascar	DHS-IV	2003-04	124.7	123.8	124.3
Madagascar	DHS-V	2008-09	120.7	123.1	121.9
Malawi	DHS-II	1992	104.4	105.5	104.9
Malawi	DHS-IV	2000	114.9	113.7	114.3
Malawi	DHS-IV	2004-05	115.4	120.0	117.7
Malawi	DHS-V	2010	118.2	119.1	118.6
Mali	DHS-III	1995-96	114.0	121.3	117.7
Mali	DHS-IV	2001	132.6	135.8	134.3
Mali	DHS-V	2006	118.1	117.4	117.7
Mali	DHS-VI	2012-13	120.1	124.5	122.4
Mozambique	DHS-III	1997	119.4	121.7	120.5
Mozambique	DHS-IV	2003-04	112.1	112.8	112.5
Mozambique	DHS-VI	2011	114.1	116.0	115.0
Namibia	DHS-II	1992	109.3	110.3	109.8
Namibia	DHS-IV	2000	115.2	119.0	117.0
Namibia	DHS-V	2006-07	105.8	109.2	107.4
Niger	DHS-II	1992	120.9	122.5	121.7
Niger	DHS-V	2006	123.9	125.1	124.5
Niger	DHS-VI	2012	119.2	121.1	120.2
Nigeria	DHS-III	1999	144.4	153.1	148.9
Nigeria	DHS-V	2008	134.6	139.2	137.0
Rwanda	DHS-IV	2000	123.5	123.1	123.3
Rwanda	DHS-IV	2005	126.6	126.5	126.5
Rwanda	DHS-VI	2010-11	117.7	120.6	119.1
São Tomé and Príncipe	DHS-V	2008-09	119.1	116.9	118.0
Senegal	DHS-II	1992-93	118.2	116.6	117.4
Senegal	DHS-IV	2005	113.8	113.9	113.8
Senegal	DHS-VI	2010-11	113.6	117.5	115.6
Sierra Leone	DHS-V	2008	143.7	147.4	145.5
South Africa	DHS-III	1998	119.6	121.9	120.7
Swaziland	DHS-V	2006-07	105.5	113.8	109.6
Tanzania	DHS-III	1996	117.1	112.2	114.7

(Continued...)

Table 3.3 – *Continued*

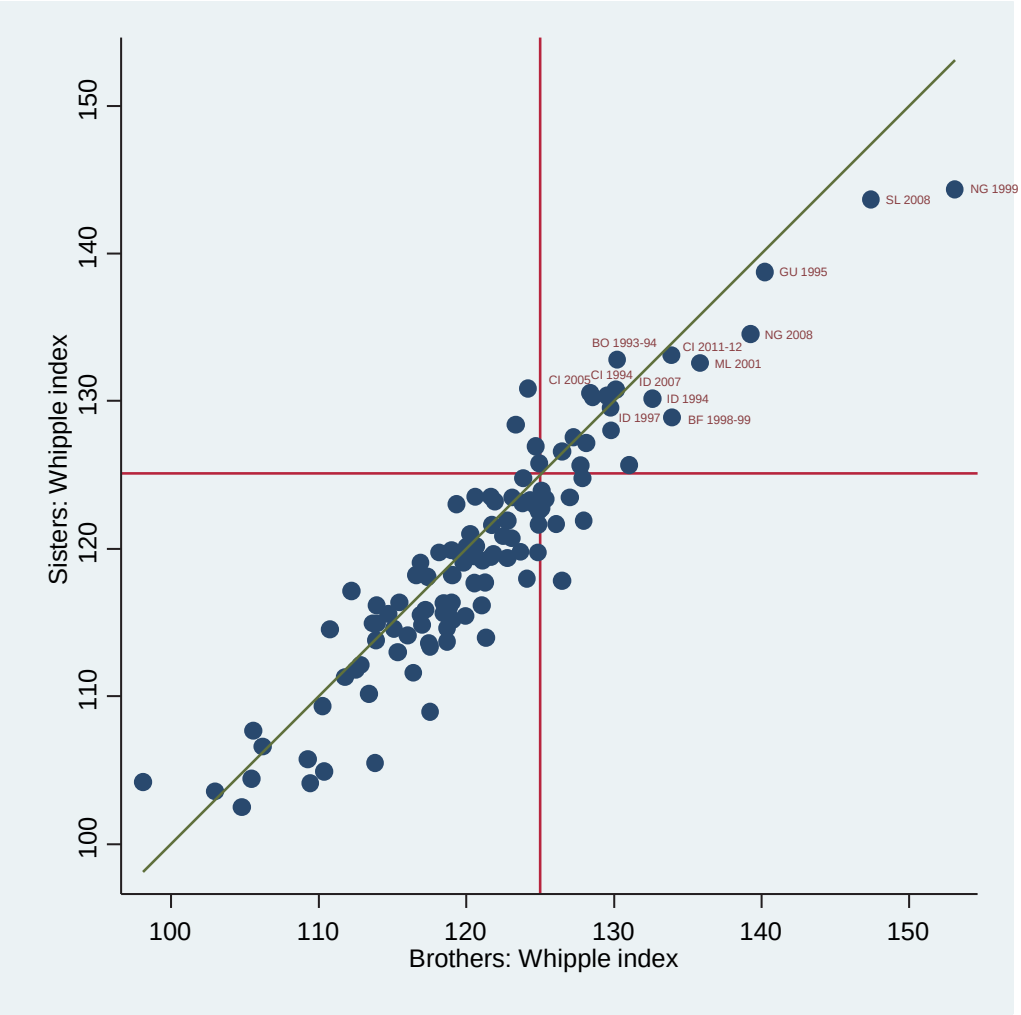
Country	DHS survey round	Year of survey	Whipple Index		
			Sisters	Brothers	All siblings
Sub-Saharan Africa					
Tanzania	DHS-IV	2004-05	114.8	117.0	115.9
Tanzania	DHS-V	2009-10	120.1	120.0	120.1
Togo	DHS-III	1998	118.0	124.1	121.0
Uganda	DHS-III	1995	115.6	114.7	115.1
Uganda	DHS-IV	2000-01	121.6	124.9	123.3
Uganda	DHS-V	2006	119.7	118.2	119.0
Uganda	DHS-VI	2011	123.5	121.7	122.6
Zambia	DHS-III	1996-97	102.5	104.8	103.6
Zambia	DHS-IV	2001-02	106.6	106.2	106.4
Zambia	DHS-V	2007	114.6	110.8	112.6
Zimbabwe	DHS-III	1994	114.9	114.0	114.5
Zimbabwe	DHS-IV	1999	116.1	113.9	115.1
Zimbabwe	DHS-V	2005-06	113.7	118.7	116.2
Zimbabwe	DHS-VI	2010-11	116.1	121.1	118.6
North Africa					
Jordan	DHS-III	1997	125.8	124.9	125.4
Morocco	DHS-II	1992	114.6	118.7	116.7
Morocco	DHS-IV	2003-04	111.3	111.8	111.5
Asia					
Cambodia	DHS-IV	2000	124.8	127.9	126.2
Cambodia	DHS-V	2005-06	113.4	117.6	115.4
Cambodia	DHS-V	2010-11	113.0	115.3	114.1
Indonesia	DHS-III	1994	130.2	132.6	131.4
Indonesia	DHS-III	1997	129.5	129.8	129.7
Indonesia	DHS-IV	2002-03	127.5	127.3	127.4
Indonesia	DHS-V	2007	130.8	130.1	130.4
Indonesia	DHS-VI	2012	121.0	120.2	120.6
Nepal	DHS-III	1996	123.2	121.9	122.5
Nepal	DHS-V	2006	111.6	116.4	114.0
Philippines	DHS-II	1993	116.3	118.5	117.4
Philippines	DHS-III	1998	115.6	118.5	117.0
Timor-Leste	DHS-VI	2009-10	121.7	126.1	123.9
Latin America and Caribbean					
Bolivia	DHS-III	1993-94	132.8	130.3	131.5
Bolivia	DHS-IV	2003-04	128.0	129.8	128.9
Bolivia	DHS-V	2008	125.7	131.0	128.4
Brazil	DHS-III	1996	111.8	112.5	112.1
Dominican Republic	DHS-IV	2002	116.3	119.0	117.7
Dominican Republic	DHS-V	2007	116.0	118.8	117.4
Guatemala	DHS-III	1995	138.8	140.2	139.5
Haiti	DHS-IV	2000	110.2	113.4	111.8
Haiti	DHS-V	2005-06	107.7	105.6	106.6
Peru	DHS-II	1991-92	122.9	124.7	123.8

(Continued...)

Table 3.3 – *Continued*

Country	DHS survey round	Year of survey	Whipple Index		
			Sisters	Brothers	All siblings
Latin America and Caribbean					
Peru	DHS-III	1996	123.4	125.4	124.4
Peru	DHS-IV	2000	127.2	128.1	127.7
Peru	DHS-V	2003-08	121.6	121.8	121.7
Peru	DHS-VI	2009	120.1	120.7	120.4
Peru	DHS-VI	2010	122.8	125.1	123.9
Peru	DHS-VI	2011	121.9	122.8	122.3

Figure 3.3 Whipple Index values for digit preference in age reporting of surviving siblings by sex, Demographic and Health Surveys 1990-2013



Note: Some countries with high Whipple Index values are shown with the DHS country labels (the list of country codes is provided in the Appendix).

Figure 3.4 shows trends in the Whipple Index for countries with multiple DHS survey rounds. In some countries, age reporting has improved substantially over time, as suggested by the decreasing trend in the Whipple Index. These countries include Bolivia, Cambodia, the Republic of Congo (Brazzaville), Haiti, Indonesia, Nepal, Nigeria and Rwanda. In contrast, the Whipple Index increased substantially in three countries: Benin, Malawi, and Zambia.

Figure 3.4 Trends in the Whipple Index for digit preference in age reporting of surviving siblings by sex and DHS survey rounds, Demographic and Health Surveys 1990-2013

Table 3.4 shows the extent of missingness in the age reporting of surviving siblings by sex. In most survey rounds and countries, the percent missing rate was less than 1%. The notable exceptions were Brazil, Lesotho, Madagascar, Namibia, Sierra Leone, South Africa, and Zimbabwe, which exhibit substantially higher reporting of "age not known" for siblings. The pattern of missingness of age reporting was similar for both sisters and brothers (Figure 3.5). Therefore, it is unlikely that respondents intentionally reported lack of knowledge of the age of sisters to avoid the series of questions on maternal mortality.

In several countries the problem of missing responses for age of siblings improved over successive DHS survey rounds. Figure 3.6 shows trends in missing data on age of surviving sisters between survey rounds DHS-II and DHS-VI.

Table 3.4 Percentage of surviving siblings with current age missing by sex, Demographic and Health Surveys 1990-2013

Country	DHS survey round	Year of survey	Percentage of surviving siblings with current age missing			No. of siblings
			Sister	Brother	All siblings	
Sub-Saharan Africa						
Benin	DHS-III	1996	0.2	0.2	0.2	22,802
Benin	DHS-V	2006	0.4	0.3	0.3	78,168
Burkina Faso	DHS-III	1998-99	1.5	1.4	1.5	26,295
Burkina Faso	DHS-IV	2003	0.4	0.5	0.4	53,124
Burkina Faso	DHS-VI	2010	0.2	0.2	0.2	77,447
Burundi	DHS-VI	2010-11	0.2	0.2	0.2	43,811
CAR	DHS-III	1994-95	0.0	0.0	0.0	24,688
Cameroon	DHS-III	1998	0.4	0.4	0.4	25,606
Cameroon	DHS-IV	2004	0.6	0.6	0.6	51,061
Cameroon	DHS-VI	2011	0.4	0.4	0.4	72,092
Chad	DHS-III	1996-97	0.1	0.1	0.1	31,268
Chad	DHS-IV	2004	0.7	0.6	0.7	27,011
Congo (Brazzaville)	DHS-V	2005	0.6	0.6	0.6	33,089
Congo (Brazzaville)	DHS-VI	2011-12	0.3	0.3	0.3	47,866
Congo Democratic Republic	DHS-V	2007	0.5	0.5	0.5	45,752
Côte d'Ivoire	DHS-III	1994	0.1	0.1	0.1	36,530
Côte d'Ivoire	DHS-V	2005	0.4	0.5	0.4	22,125
Côte d'Ivoire	DHS-VI	2011-12	0.9	0.9	0.9	46,206
Ethiopia	DHS-IV	2000	0.0	0.0	0.0	65,905
Ethiopia	DHS-IV	2005	0.5	0.5	0.5	62,752
Ethiopia	DHS-VI	2011	0.1	0.1	0.1	75,861
Gabon	DHS-III	2000-01	1.3	1.6	1.4	30,090
Gabon	DHS-VI	2012	2.2	2.0	2.1	39,718
Guinea	DHS-III	1999	0.4	0.4	0.4	24,670
Guinea	DHS-IV	2005	0.5	0.5	0.5	30,252
Guinea	DHS-VI	2012	0.1	0.1	0.1	35,368
Kenya	DHS-III	1998	0.9	1.0	0.9	43,151
Kenya	DHS-IV	2003	1.4	1.6	1.5	44,035
Kenya	DHS-V	2008-09	0.2	0.2	0.2	43,686
Lesotho	DHS-IV	2004-05	0.6	0.7	0.7	27,044
Lesotho	DHS-V	2009-10	5.8	6.1	5.9	26,209

(Continued...)

Table 3.4 – *Continued*

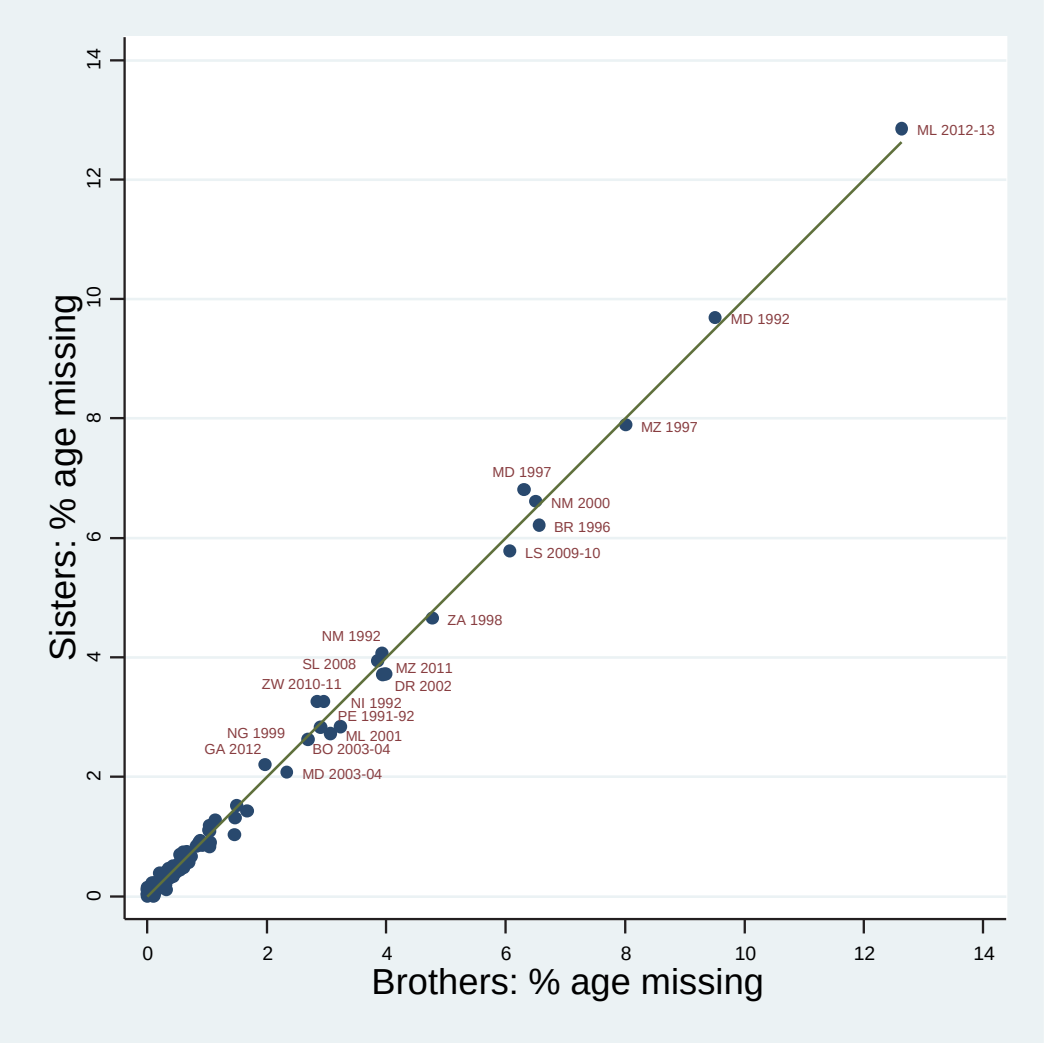
Country	DHS survey round	Year of survey	Percentage of surviving siblings with current age missing			No. of siblings
			Sister	Brother	All siblings	
Sub-Saharan Africa						
Liberia	DHS-V	2006-07	0.9	0.9	0.9	27,162
Madagascar	DHS-II	1992	9.7	9.5	9.6	33,264
Madagascar	DHS-III	1997	6.8	6.3	6.5	38,338
Madagascar	DHS-IV	2003-04	2.1	2.3	2.2	39,360
Madagascar	DHS-V	2008-09	0.5	0.5	0.5	89,502
Malawi	DHS-II	1992	0.1	0.1	0.1	20,746
Malawi	DHS-IV	2000	0.1	0.0	0.0	56,963
Malawi	DHS-IV	2004-05	0.2	0.3	0.2	48,686
Malawi	DHS-V	2010	0.2	0.2	0.2	99,547
Mali	DHS-III	1995-96	0.1	0.2	0.2	39,439
Mali	DHS-IV	2001	2.7	3.1	2.9	53,932
Mali	DHS-V	2006	0.8	0.9	0.9	63,429
Mali	DHS-VI	2012-13	12.9	12.6	12.7	37,728
Mozambique	DHS-III	1997	7.9	8.0	8.0	32,950
Mozambique	DHS-IV	2003-04	0.4	0.3	0.3	49,461
Mozambique	DHS-VI	2011	3.7	4.0	3.9	50,439
Namibia	DHS-II	1992	4.1	3.9	4.0	26,645
Namibia	DHS-IV	2000	6.6	6.5	6.6	32,774
Namibia	DHS-V	2006-07	1.1	1.0	1.0	43,570
Niger	DHS-II	1992	3.3	3.0	3.1	26,986
Niger	DHS-V	2006	0.4	0.4	0.4	41,645
Niger	DHS-VI	2012	0.5	0.4	0.5	52,975
Nigeria	DHS-III	1999	2.6	2.7	2.7	37,704
Nigeria	DHS-V	2008	1.1	1.1	1.1	148,258
Rwanda	DHS-IV	2000	0.4	0.2	0.3	44,504
Rwanda	DHS-IV	2005	0.8	1.0	0.9	49,062
Rwanda	DHS-VI	2010-11	0.1	0.1	0.1	60,805
São Tomé and Príncipe	DHS-V	2008-09	1.0	1.5	1.2	14,144
Senegal	DHS-II	1992-93	0.3	0.3	0.3	27,401
Senegal	DHS-IV	2005	0.7	0.6	0.6	71,118
Senegal	DHS-VI	2010-11	0.0	0.0	0.0	74,547
Sierra Leone	DHS-V	2008	3.9	3.9	3.9	23,124
South Africa	DHS-III	1998	4.7	4.8	4.7	43,834
Swaziland	DHS-V	2006-07	0.4	0.5	0.5	21,592
Tanzania	DHS-III	1996	0.4	0.5	0.5	39,189
Tanzania	DHS-IV	2004-05	0.0	0.1	0.1	50,839
Tanzania	DHS-V	2009-10	0.1	0.1	0.1	47,774
Togo	DHS-III	1998	0.1	0.1	0.1	38,389
Uganda	DHS-III	1995	1.1	1.0	1.1	34,278
Uganda	DHS-IV	2000-01	0.7	0.7	0.7	36,017
Uganda	DHS-V	2006	0.2	0.3	0.2	42,270
Uganda	DHS-VI	2011	0.4	0.3	0.4	43,875
Zambia	DHS-III	1996-97	0.5	0.4	0.5	41,083

(Continued...)

Table 3.4 – *Continued*

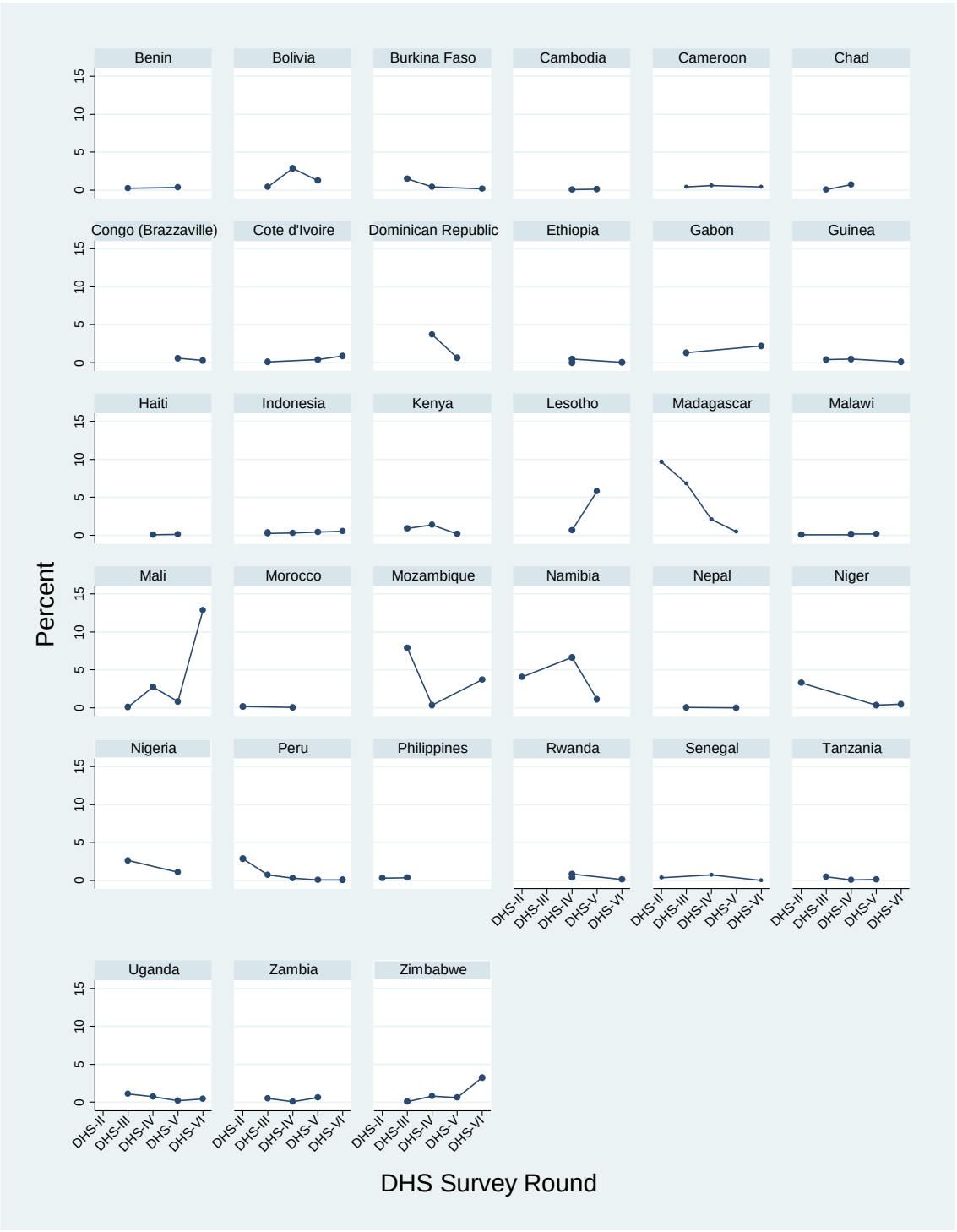
Country	DHS survey round	Year of survey	Percentage of surviving siblings with current age missing			No. of siblings
			Sister	Brother	All siblings	
Sub-Saharan Africa						
Zambia	DHS-IV	2001-02	0.1	0.1	0.1	37,893
Zambia	DHS-V	2007	0.6	0.7	0.6	33,466
Zimbabwe	DHS-III	1994	0.1	0.1	0.1	32,691
Zimbabwe	DHS-IV	1999	0.8	1.0	0.9	29,813
Zimbabwe	DHS-V	2005-06	0.6	0.6	0.6	40,161
Zimbabwe	DHS-VI	2010-11	3.3	2.8	3.1	36,753
North Africa						
Jordan	DHS-III	1997	0.0	0.0	0.0	75,264
Morocco	DHS-II	1992	0.2	0.1	0.2	49,787
Morocco	DHS-IV	2003-04	0.1	0.1	0.1	90,184
Asia						
Cambodia	DHS-IV	2000	0.0	0.1	0.1	63,011
Cambodia	DHS-V	2005-06	0.1	0.1	0.1	70,561
Cambodia	DHS-V	2010-11	0.1	0.1	0.1	76,733
Indonesia	DHS-III	1994	0.3	0.4	0.4	149,372
Indonesia	DHS-III	1997	0.2	0.2	0.2	145,848
Indonesia	DHS-IV	2002-03	0.3	0.3	0.3	145,823
Indonesia	DHS-V	2007	0.4	0.4	0.4	158,138
Indonesia	DHS-VI	2012	0.5	0.6	0.6	161,060
Nepal	DHS-III	1996	0.1	0.0	0.0	38,981
Nepal	DHS-V	2006	0.0	0.0	0.0	42,421
Philippines	DHS-II	1993	0.3	0.3	0.3	79,498
Philippines	DHS-III	1998	0.3	0.4	0.4	71,381
Timor-Leste	DHS-VI	2009-10	0.2	0.2	0.2	53,318
Latin America and Caribbean						
Bolivia	DHS-III	1993-94	0.4	0.4	0.4	35,205
Bolivia	DHS-IV	2003-04	2.8	3.2	3.0	76,744
Bolivia	DHS-V	2008	1.2	1.1	1.2	71,670
Brazil	DHS-III	1996	6.2	6.6	6.4	61,206
Dominican Republic	DHS-IV	2002	3.7	3.9	3.8	55,921
Dominican Republic	DHS-V	2007	0.7	0.6	0.7	120,473
Guatemala	DHS-III	1995	0.2	0.1	0.2	59,378
Haiti	DHS-IV	2000	0.1	0.0	0.0	43,829
Haiti	DHS-V	2005-06	0.1	0.1	0.1	46,724
Peru	DHS-II	1991-92	2.8	2.9	2.9	72,942
Peru	DHS-III	1996	0.7	0.7	0.7	138,164
Peru	DHS-IV	2000	0.3	0.3	0.3	129,828
Peru	DHS-V	2003-08	0.0	0.0	0.0	181,061
Peru	DHS-VI	2009	0.0	0.0	0.0	105,196
Peru	DHS-VI	2010	0.0	0.0	0.0	100,308
Peru	DHS-VI	2011	0.1	0.1	0.1	96,551

Figure 3.5 Percentage of living siblings with reported age missing by sex, Demographic and Health Surveys 1990-2013



Note: The survey rounds with more than 2% age missing are shown with DHS country code labels (the list of country codes is provided in the Appendix)

Figure 3.6 Trends in missing age for surviving sisters by DHS survey rounds, Demographic and Health Surveys 1990-2013



Conventionally, MMR is defined as the num ber of maternal deaths divided by the number of live births during a reference period. Considering the difficulti es, DHS does not collect data on live births from siblings (i.e., sisters). Instead, the MMR is estimated by dividing the age-standardized MMRate by the GFR from the respondents. The MMRate is estimated as an incidence rate from the number of maternal deaths

reported over *women person-years of observation*. The calculation of women person- years requires accurate and complete information on the age distribution of female siblings during the observation period (usually 5 or 7 years before the interview date). The DHS questionnaire directly asks the current age of the surviving siblings at the time of interview. The duration of exposure (person-years of observation) for each 5-year age category of the surviving siblings is calculated from the reported age. However, for the siblings who died, the duration of survival during the observation period is ascertained from two data sources: age at death and how long ago (before the interview date) the sibling died. The complete information on these two variables is necessary to correctly measure the years of exposure and hence the estimation of maternal mortality indicators such as the MMR and the MMRate. Table 3.5 shows the extent of missing data on age and years since death. An important finding is that a large proportion of respondents had difficulty relating timing of death to a calendar. Additionally, several countries exhibited very high non-response rates for the variable, *years since died from the date of interview*. Similarly, age at death was missing in high proportions in some countries. These problems may displace the timing of deaths in rela tion to a calendar period, resulting in incorrect estimation of maternal mortality for the reference period.

Table 3.5 Percentage of dead siblings with missing age at death and missing years since death, Demographic and Health Surveys 1990-2013

Country	DHS survey round	Year of survey	Missing information	Percentage of dead siblings with missing age at death and missing years since death			No. of all siblings
				Sisters	Brothers	All siblings	
Sub-Saharan Africa							
Benin	DHS-III	1996	Age at death	2.15	2.26	2.26	7,727
			Years since death	1.32	1.30	1.30	
			Both	1.01	1.05	1.05	
Benin	DHS-V	2006	Age at death	1.98	1.95	1.95	18,197
			Years since death	1.33	1.46	1.46	
			Both	0.48	0.57	0.57	
Burkina Faso	DHS-III	1998-99	Age at death	0.05	0.04	0.04	7,480
			Years since death	9.13	9.59	9.59	
			Both	0.05	0.04	0.04	
Burkina Faso	DHS-IV	2003	Age at death	3.12	3.38	3.38	12,660
			Years since death	2.82	2.93	2.93	
			Both	2.59	2.70	2.70	
Burkina Faso	DHS-VI	2010	Age at death	0.58	0.57	0.57	19,519
			Years since death	0.47	0.44	0.44	
			Both	0.15	0.17	0.17	
Burundi	DHS-VI	2010	Age at death	0.40	0.37	0.37	16,315
			Years since death	0.29	0.26	0.26	
			Both	0.07	0.07	0.07	

(Continued...)

Table 3.5 – *Continued*

Country	DHS survey round	Year of survey	Missing information	Percentage of dead siblings with missing age at death and missing years since death			No. of all siblings
				Sisters	Brothers	All siblings	
Sub-Saharan Africa							
Cameroon	DHS-III	1998	Age at death	0.23	0.21	0.21	6,679
			Years since death	0.80	0.94	0.94	
			Both	0.06	0.08	0.08	
Cameroon	DHS-IV	2004	Age at death	2.42	2.72	2.72	14,394
			Years since death	1.62	1.71	1.71	
			Both	1.20	1.27	1.27	
Cameroon	DHS-VI	2011	Age at death	1.24	1.42	1.42	19,784
			Years since death	0.94	0.99	0.99	
			Both	0.45	0.49	0.49	
Central African Republic	DHS-III	1994-95	Age at death	0.20	0.17	0.17	5,814
			Years since death	0.24	0.34	0.34	
			Both	0.04	0.04	0.04	
Chad	DHS-III	1996-97	Age at death	0.53	0.72	0.72	9,651
			Years since death	0.49	0.62	0.62	
			Both	0.34	0.47	0.47	
Chad	DHS-IV	2004	Age at death	0.98	0.99	0.99	8,835
			Years since death	0.55	0.57	0.57	
			Both	0.16	0.15	0.15	
Congo (Brazzaville)	DHS-V	2005	Age at death	2.04	2.15	2.15	7,663
			Years since death	2.42	2.10	2.10	
			Both	1.67	1.58	1.58	
Congo (Brazzaville)	DHS-VI	2011-12	Age at death	0.35	0.35	0.35	9,661
			Years since death	1.74	1.56	1.56	
			Both	0.28	0.27	0.27	
Congo Democratic Republic	DHS-V	2007	Age at death	2.17	2.45	2.45	12,522
			Years since death	2.03	2.49	2.49	
			Both	1.12	1.14	1.14	
Cote d'Ivoire	DHS-V	1994	Age at death	1.79	2.56	2.56	7,852
			Years since death	0.87	1.57	1.57	
			Both	0.68	1.33	1.33	
Cote d'Ivoire	DHS-V	2005	Age at death	0.25	0.28	0.28	5,889
			Years since death	0.35	1.05	1.05	
			Both	0.09	0.14	0.14	
Cote d'Ivoire	DHS-VI	2011-12	Age at death	3.41	3.15	3.15	12,038
			Years since death	3.59	3.63	3.63	
			Both	1.93	1.70	1.70	

(Continued...)

Table 3.5 – *Continued*

Country	DHS survey round	Year of survey	Missing information	Percentage of dead siblings with missing age at death and missing years since death			No. of all siblings
				Sisters	Brothers	All siblings	
Sub-Saharan Africa							
Ethiopia	DHS-IV	2000	Age at death	0.27	0.27	0.27	25,598
			Years since death	0.36	0.38	0.38	
			Both	0.25	0.26	0.26	
Ethiopia	DHS-V	2005	Age at death	1.21	1.26	1.26	17,648
			Years since death	1.83	1.94	1.94	
			Both	1.09	1.14	1.14	
Ethiopia	DHS-VI	2011	Age at death	0.21	0.23	0.23	22,708
			Years since death	0.59	0.46	0.46	
			Both	0.14	0.12	0.12	
Gabon	DHS-IV	2000	Age at death	5.46	4.76	4.76	5,898
			Years since death	2.05	2.48	2.48	
			Both	1.73	1.86	1.86	
Gabon	DHS-VI	2012	Age at death	12.11	11.29	11.29	7,242
			Years since death	12.22	11.25	11.25	
			Both	8.72	7.33	7.33	
Guinea	DHS-IV	1999	Age at death	2.01	1.98	1.98	7,675
			Years since death	2.73	3.00	3.00	
			Both	0.58	0.47	0.47	
Guinea	DHS-V	2005	Age at death	0.95	1.11	1.11	11,036
			Years since death	1.07	1.21	1.21	
			Both	0.31	0.45	0.45	
Guinea	DHS-VI	2012	Age at death	0.27	0.29	0.29	10,319
			Years since death	0.70	0.60	0.60	
			Both	0.07	0.07	0.07	
Kenya	DHS-III	1998	Age at death	3.60	4.15	4.15	6,115
			Years since death	2.50	3.18	3.18	
			Both	2.04	2.51	2.51	
Kenya	DHS-IV	2003	Age at death	4.53	5.30	5.30	7,617
			Years since death	2.50	3.25	3.25	
			Both	1.85	2.28	2.28	
Kenya	DHS-V	2008-09	Age at death	2.24	2.06	2.06	5,866
			Years since death	2.79	2.78	2.78	
			Both	1.65	1.54	1.54	
Lesotho	DHS-IV	2004	Age at death	3.41	3.00	3.00	6,612
			Years since death	3.91	4.00	4.00	
			Both	2.01	1.85	1.85	

(Continued...)

Table 3.5 – *Continued*

Country	DHS survey round	Year of survey	Missing information	Percentage of dead siblings with missing age at death and missing years since death			No. of all siblings
				Sisters	Brothers	All siblings	
Sub-Saharan Africa							
Lesotho	DHS-VI	2009	Age at death	22.83	24.25	24.25	6,796
			Years since death	22.84	25.29	25.29	
			Both	14.67	16.56	16.56	
Liberia	DHS-V	2007	Age at death	1.93	1.65	1.65	3,891
			Years since death	3.89	3.90	3.90	
			Both	1.36	1.22	1.22	
Madagascar	DHS-II	1992	Age at death	30.49	31.23	31.23	6,920
			Years since death	10.29	11.33	11.33	
			Both	8.06	8.96	8.96	
Madagascar	DHS-III	1997	Age at death	0.00	0.04	0.04	5,934
			Years since death	12.50	12.74	12.74	
			Both	0.00	0.01	0.01	
Madagascar	DHS-IV	2003-04	Age at death	2.60	2.29	2.29	3,971
			Years since death	5.80	4.87	4.87	
			Both	2.15	1.54	1.54	
Madagascar	DHS-V	2008-09	Age at death	1.43	1.52	1.52	14,108
			Years since death	2.58	2.58	2.58	
			Both	1.18	1.16	1.16	
Malawi	DHS-II	1992	Age at death	0.49	0.48	0.48	9,110
			Years since death	0.42	0.46	0.46	
			Both	0.09	0.12	0.12	
Malawi	DHS-IV	2000	Age at death	0.19	0.15	0.15	22,211
			Years since death	0.22	0.24	0.24	
			Both	0.07	0.05	0.05	
Malawi	DHS-IV	2004	Age at death	0.84	1.09	1.09	14,031
			Years since death	1.33	1.45	1.45	
			Both	0.51	0.73	0.73	
Malawi	DHS-VI	2010	Age at death	0.21	0.28	0.28	37,305
			Years since death	0.48	0.58	0.58	
			Both	0.11	0.15	0.15	
Mali	DHS-III	1995-96	Age at death	0.99	1.14	1.14	13,885
			Years since death	0.02	0.27	0.27	
			Both	0.00	0.09	0.09	
Mali	DHS-IV	2001	Age at death	4.99	5.49	5.49	16,068
			Years since death	5.33	5.45	5.45	
			Both	3.63	3.82	3.82	

(Continued...)

Table 3.5 – *Continued*

Country	DHS survey round	Year of survey	Missing information	Percentage of dead siblings with missing age at death and missing years since death			No. of all siblings
				Sisters	Brothers	All siblings	
Sub-Saharan Africa							
Mali	DHS-V	2006	Age at death	2.43	2.86	2.86	22,136
			Years since death	2.30	2.86	2.86	
			Both	1.45	1.92	1.92	
Mali	DHS-VI	2012-13	Age at death	11.29	12.26	12.26	4,067
			Years since death	0.06	0.07	0.07	
			Both	0.00	0.05	0.05	
Mozambique	DHS-III	1997	Age at death	60.29	59.33	59.33	8,493
			Years since death	22.50	24.07	24.07	
			Both	18.14	19.43	19.43	
Mozambique	DHS-IV	2003	Age at death	0.59	0.62	0.62	13,232
			Years since death	3.43	3.80	3.80	
			Both	0.27	0.36	0.36	
Mozambique	DHS-VI	2011	Age at death	0.00	0.00	0.00	10,291
			Years since death	11.93	12.90	12.90	
			Both	0.00	0.00	0.00	
Namibia	DHS-II	1992	Age at death	19.61	20.48	20.48	4,181
			Years since death	13.99	15.47	15.47	
			Both	11.08	11.48	11.48	
Namibia	DHS-IV	2000	Age at death	17.00	18.09	18.09	4,809
			Years since death	15.97	17.05	17.05	
			Both	11.49	12.44	12.44	
Namibia	DHS-V	2006-07	Age at death	2.56	2.68	2.68	7,600
			Years since death	4.14	4.33	4.33	
			Both	1.94	2.09	2.09	
Nigeria	DHS-IV	1999	Age at death	2.21	2.40	2.40	5,125
			Years since death	25.15	26.89	26.89	
			Both	1.80	1.90	1.90	
Nigeria	DHS-V	2008	Age at death	2.63	2.82	2.82	30,098
			Years since death	3.96	4.22	4.22	
			Both	1.80	1.89	1.89	
Rwanda	DHS-IV	2000	Age at death	1.37	1.51	1.51	19,347
			Years since death	1.31	1.39	1.39	
			Both	0.75	0.83	0.83	
Rwanda	DHS-V	2005	Age at death	4.43	4.27	4.27	22,578
			Years since death	1.85	1.98	1.98	
			Both	1.03	1.09	1.09	

(Continued...)

Table 3.5 – *Continued*

Country	DHS survey round	Year of survey	Missing information	Percentage of dead siblings with missing age at death and missing years since death			No. of all siblings
				Sisters	Brothers	All siblings	
Sub-Saharan Africa							
Rwanda	DHS-VI	2010	Age at death	0.43	0.42	0.42	22,410
			Years since death	0.45	0.47	0.47	
			Both	0.23	0.26	0.26	
Sao Tome and Principe	DHS-V	2008-09	Age at death	8.91	8.14	8.14	2,533
			Years since death	2.88	2.82	2.82	
			Both	0.77	0.69	0.69	
Senegal	DHS-II	1992-93	Age at death	0.77	1.14	1.14	8,138
			Years since death	0.61	1.02	1.02	
			Both	0.45	0.76	0.76	
Senegal	DHS-IV	2005	Age at death	2.80	2.82	2.82	15,213
			Years since death	2.67	2.80	2.80	
			Both	1.59	1.65	1.65	
Senegal	DHS-VI	2010-11	Age at death	0.00	0.00	0.00	16,125
			Years since death	0.00	0.00	0.00	
			Both	0.00	0.00	0.00	
Sierra Leone	DHS-V	2008	Age at death	7.76	8.08	8.08	6,129
			Years since death	9.52	11.12	11.12	
			Both	5.18	5.76	5.76	
South Africa	DHS-III	1998	Age at death	1.80	1.87	1.87	6,367
			Years since death	22.24	22.58	22.58	
			Both	1.44	1.66	1.66	
Swaziland	DHS-V	2006-07	Age at death	2.03	2.33	2.33	3,970
			Years since death	2.89	3.35	3.35	
			Both	1.30	1.40	1.40	
Tanzania	DHS-III	1996	Age at death	10.61	11.45	11.45	8,508
			Years since death	3.08	3.55	3.55	
			Both	2.51	2.82	2.82	
Tanzania	DHS-IV	2004-05	Age at death	0.74	0.91	0.91	13,159
			Years since death	0.88	1.04	1.04	
			Both	0.55	0.73	0.73	
Tanzania	DHS-VI	2010	Age at death	0.89	0.99	0.99	8,931
			Years since death	0.97	0.98	0.98	
			Both	0.41	0.41	0.41	
Togo	DHS-III	1998	Age at death	0.00	0.00	0.00	11,029
			Years since death	0.26	0.38	0.38	
			Both	0.00	0.00	0.00	

(Continued...)

Table 3.5 – *Continued*

Country	DHS survey round	Year of survey	Missing information	Percentage of dead siblings with missing age at death and missing years since death			No. of all siblings
				Sisters	Brothers	All siblings	
Sub-Saharan Africa							
Uganda	DHS-III	1995-96	Age at death	14.24	14.17	14.17	9,511
			Years since death	5.40	5.21	5.21	
			Both	4.15	4.09	4.09	
Uganda	DHS-IV	2000-01	Age at death	0.82	0.78	0.78	10,945
			Years since death	6.19	7.22	7.22	
			Both	0.40	0.55	0.55	
Uganda	DHS-V	2006	Age at death	0.89	0.97	0.97	15,128
			Years since death	1.06	1.41	1.41	
			Both	0.51	0.62	0.62	
Uganda	DHS-VI	2011	Age at death	2.06	2.29	2.29	13,351
			Years since death	1.28	1.41	1.41	
			Both	1.17	1.29	1.29	
Zambia	DHS-III	1996	Age at death	3.58	3.68	3.68	10,060
			Years since death	3.00	3.16	3.16	
			Both	2.26	2.39	2.39	
Zambia	DHS-IV	2001-02	Age at death	0.24	0.23	0.23	9,853
			Years since death	0.75	0.82	0.82	
			Both	0.15	0.16	0.16	
Zambia	DHS-V	2007	Age at death	0.98	1.37	1.37	7,689
			Years since death	1.39	1.75	1.75	
			Both	0.90	1.20	1.20	
Zimbabwe	DHS-III	1994	Age at death	0.35	0.43	0.43	5,752
			Years since death	0.58	0.72	0.72	
			Both	0.14	0.12	0.12	
Zimbabwe	DHS-IV	1999	Age at death	0.00	0.00	0.00	4,540
			Years since death	4.06	4.70	4.70	
			Both	0.00	0.00	0.00	
Zimbabwe	DHS-V	2005-06	Age at death	1.10	1.16	1.16	6,884
			Years since death	2.03	2.09	2.09	
			Both	0.68	0.71	0.71	
Zimbabwe	DHS-VI	2010-11	Age at death	8.41	9.24	9.24	6,640
			Years since death	11.14	12.19	12.19	
			Both	6.47	6.75	6.75	

(Continued...)

Table 3.5 – *Continued*

Country	DHS survey round	Year of survey	Missing information	Percentage of dead siblings with missing age at death and missing years since death			No. of all siblings
				Sisters	Brothers	All siblings	
North Africa							
Jordan	DHS-III	1997	Age at death	0.00	0.00	0.00	9,270
			Years since death	0.46	0.44	0.44	
			Both	0.00	0.00	0.00	
Morocco	DHS-II	1992	Age at death	1.94	2.01	2.01	10,664
			Years since death	1.27	1.22	1.22	
			Both	1.19	1.13	1.13	
Morocco	DHS-IV	2003-04	Age at death	1.12	1.10	1.10	17,992
			Years since death	0.62	0.80	0.80	
			Both	0.48	0.63	0.63	
Asia							
Cambodia	DHS-IV	2000	Age at death	0.56	0.52	0.52	16,281
			Years since death	1.05	1.06	1.06	
			Both	0.19	0.32	0.32	
Cambodia	DHS-V	2005	Age at death	1.15	1.42	1.42	18,708
			Years since death	1.14	1.41	1.41	
			Both	0.92	1.20	1.20	
Cambodia	DHS-VI	2010	Age at death	0.20	0.22	0.22	15,101
			Years since death	0.23	0.24	0.24	
			Both	0.12	0.12	0.12	
Indonesia	DHS-III	1994	Age at death	7.56	7.82	7.82	29,226
			Years since death	1.52	1.66	1.66	
			Both	1.23	1.36	1.36	
Indonesia	DHS-III	1997	Age at death	0.00	0.05	0.05	20,869
			Years since death	1.00	1.20	1.20	
			Both	0.00	0.01	0.01	
Indonesia	DHS-IV	2002-03	Age at death	3.55	3.45	3.45	17,151
			Years since death	2.16	2.73	2.73	
			Both	0.34	0.52	0.52	
Indonesia	DHS-V	2007	Age at death	0.00	0.00	0.00	21,032
			Years since death	3.12	2.87	2.87	
			Both	0.00	0.00	0.00	
Indonesia	DHS-VI	2012	Age at death	0.00	0.00	0.00	26,191
			Years since death	2.31	2.83	2.83	
			Both	0.00	0.00	0.00	

(Continued...)

Table 3.5 – *Continued*

Country	DHS survey round	Year of survey	Missing information	Percentage of dead siblings with missing age at death and missing years since death			No. of all siblings
				Sisters	Brothers	All siblings	
Asia							
Nepal	DHS-III	1996	Age at death	0.17	0.13	0.13	13,349
			Years since death	0.42	0.33	0.33	
			Both	0.13	0.09	0.09	
Nepal	DHS-V	2006	Age at death	0.00	0.00	0.00	11,333
			Years since death	0.00	0.00	0.00	
			Both	0.00	0.00	0.00	
Niger	DHS-II	1992	Age at death	9.37	9.60	9.60	10,217
			Years since death	4.54	5.64	5.64	
			Both	3.84	4.84	4.84	
Niger	DHS-V	2006	Age at death	1.00	1.18	1.18	13,520
			Years since death	0.83	1.08	1.08	
			Both	0.35	0.58	0.58	
Niger	DHS-VI	2012	Age at death	0.29	0.42	0.42	18,147
			Years since death	0.54	0.63	0.63	
			Both	0.15	0.23	0.23	
Philippines	DHS-III	1993	Age at death	2.50	2.25	2.25	8,110
			Years since death	2.45	2.76	2.76	
			Both	1.24	1.32	1.32	
Philippines	DHS-III	1998	Age at death	0.64	0.66	0.66	8,449
			Years since death	4.89	4.90	4.90	
			Both	0.54	0.42	0.42	
TimorLeste	DHS-VI	2009-10	Age at death	0.42	0.48	0.48	10,147
			Years since death	0.46	0.55	0.55	
			Both	0.37	0.41	0.41	
Latin America and Caribbean							
Bolivia	DHS-III	1994	Age at death	10.31	10.37	10.37	7,773
			Years since death	2.31	2.39	2.39	
			Both	1.68	1.76	1.76	
Bolivia	DHS-IV	2003	Age at death	0.14	0.12	0.12	17,347
			Years since death	4.30	5.35	5.35	
			Both	0.05	0.04	0.04	
Bolivia	DHS-V	2008	Age at death	0.00	0.00	0.00	14,594
			Years since death	0.89	1.56	1.56	
			Both	0.00	0.00	0.00	

(Continued...)

Table 3.5 – *Continued*

Country	DHS survey round	Year of survey	Missing information	Percentage of dead siblings with missing age at death and missing years since death			No. of all siblings
				Sisters	Brothers	All siblings	
Latin America and Caribbean							
Brazil	DHS-III	1996	Age at death	47.92	45.65	45.65	10,697
			Years since death	9.57	10.02	10.02	
			Both	7.13	6.87	6.87	
Dominican Republic	DHS-IV	2002	Age at death	2.26	1.91	1.91	6,733
			Years since death	13.42	14.35	14.35	
			Both	1.03	0.84	0.84	
Dominican Republic	DHS-V	2007	Age at death	0.00	0.00	0.00	14,048
			Years since death	4.79	5.81	5.81	
			Both	0.00	0.00	0.00	
Guatemala	DHS-III	1995	Age at death	3.13	3.46	3.46	11,943
			Years since death	3.34	3.83	3.83	
			Both	1.39	1.52	1.52	
Haiti	DHS-IV	2000	Age at death	0.14	0.19	0.19	14,587
			Years since death	0.21	0.27	0.27	
			Both	0.04	0.06	0.06	
Haiti	DHS-V	2005-06	Age at death	0.38	0.30	0.30	14,541
			Years since death	0.36	0.32	0.32	
			Both	0.25	0.21	0.21	
Peru	DHS-II	1991-92	Age at death	19.49	19.48	19.48	10,480
			Years since death	7.45	8.10	8.10	
			Both	5.82	6.44	6.44	
Peru	DHS-III	1996	Age at death	23.23	23.73	23.73	28,141
			Years since death	5.49	6.02	6.02	
			Both	4.26	4.79	4.79	
Peru	DHS-IV	2000	Age at death	0.29	0.36	0.36	24,878
			Years since death	1.98	2.28	2.28	
			Both	0.13	0.15	0.15	
Peru	DHS-V	2004-06	Age at death	0.00	0.00	0.00	33,745
			Years since death	0.42	0.45	0.45	
			Both	0.00	0.00	0.00	
Peru	DHS-V	2007-08	Age at death	0.00	0.00	0.00	33,745
			Years since death	0.42	0.45	0.45	
			Both	0.00	0.00	0.00	

(Continued...)

Table 3.5 – *Continued*

Country	DHS survey round	Year of survey	Missing information	Percentage of dead siblings with missing age at death and missing years since death			No. of all siblings
				Sisters	Brothers	All siblings	
Latin America and Caribbean							
Peru	DHS-V	2009	Age at death	0.00	0.00	0.00	17,249
			Years since death	0.66	0.80	0.80	
			Both	0.00	0.00	0.00	
Peru	DHS-VI	2011	Age at death	0.00	0.00	0.00	15,338
			Years since death	0.23	0.42	0.42	
			Both	0.00	0.00	0.00	

DHS imputes the missing values so that complete information on the year of death and age at death can be used for the calculation of the person-years of exposure for each dead sibling. Figure 3.7 shows the percentage of dead sibling's age imputed by the lag period of death (years ago died). Not surprisingly, the percentage of missing age data was higher for siblings who had died further in the past in most surveys.

Respondents often have significant difficulty remembering age at death and calendar timing of death for siblings who died many years ago. Additionally, focusing on these questions can exert undue pressure on respondents to recall sensitive events in the distant past. It is well recognized that the reporting of recent deaths is substantially more reliable than reporting of deaths that occurred in the distant past, which is the reason DHS limits analysis of mortality data to the last five to seven years. We show in Appendix (Table A2) that in the majority of the surveys (66%), less than 20% of sisters died within seven years (30% in 97 of 109 surveys for which timing of death data were publicly available). Information from only these sisters who died in the last seven years are used in mortality (maternal or from all causes) analysis. We expect a similar proportion of deaths within seven years among brothers. Considering the high level of non-response for death information—especially regarding deaths that occurred a long time ago—and because the information of deaths beyond the reference period (five to seven years before the survey) is never used by DHS for any analyses of the sibling survival data, we think it would be beneficial to examine the impact of limiting the history recall period with a *truncated sibling history module.* An example is the use of a truncated mortality listing table in the *direct household maternal mortality estimation module* of the Household Questionnaire of the Bangladesh Maternal Health Services and Maternal Mortality Survey (NIPORT et al. 2003). In this table, only the individual household members who died in the reference observation period (last three years in case of BMMS) are listed. Instead of listing all siblings born to the biological mother, following the structure in the *direct household maternal mortality estimation module*, the DHS surveys may list only the surviving siblings first and then list the siblings that died in the last seven years, with a provision of birth ordering. The listing of birth ordering is likely to improve imputation when age/date of birth is missing.

Truncated history often encourages interviewers to introduce age or calendar time displacement to avoid lengthy subsequent questions. The DHS Program's experience of the *direct household maternal mortality estimation module* in the Bangladesh Maternal Mortality and Health Care Survey in 2001 and 2010, Afghanistan Mortality Survey 2010, and Ghana Maternal Health Survey 2007 may help to minimize such biases. An example of the listing table for the household members who died during the reference period is shown in the Appendix from the BMMS questionnaire, which collected information on deaths only from the household members who died in the last three years. Despite the concerns of displacement of timing of

deaths in such time bounded, truncated survival table questions, the maternal mortality ratio (MMR) estimates in Bangladesh, Afghanistan, and Ghana showed overestimation, rather than underestimation, compared with sibling history-based estimates for the same period (Bangladesh Maternal Mortality and Health Care Survey in 2001 and 2010, Afghanistan Mortality Survey 2010, and Ghana Maternal Health Survey 2007).

However, if age or calendar displacement is a real or anticipated concern, the data collection observation period may be extended to siblings who died within eight years, instead of seven years, in the truncated sibling history module, and the information from the last year may be discarded during data analysis.

Figure 3.7 Percentage of dead siblings with age imputed by timing of death (number of years ago death occurred), Demographic and Health Surveys 1990-2013

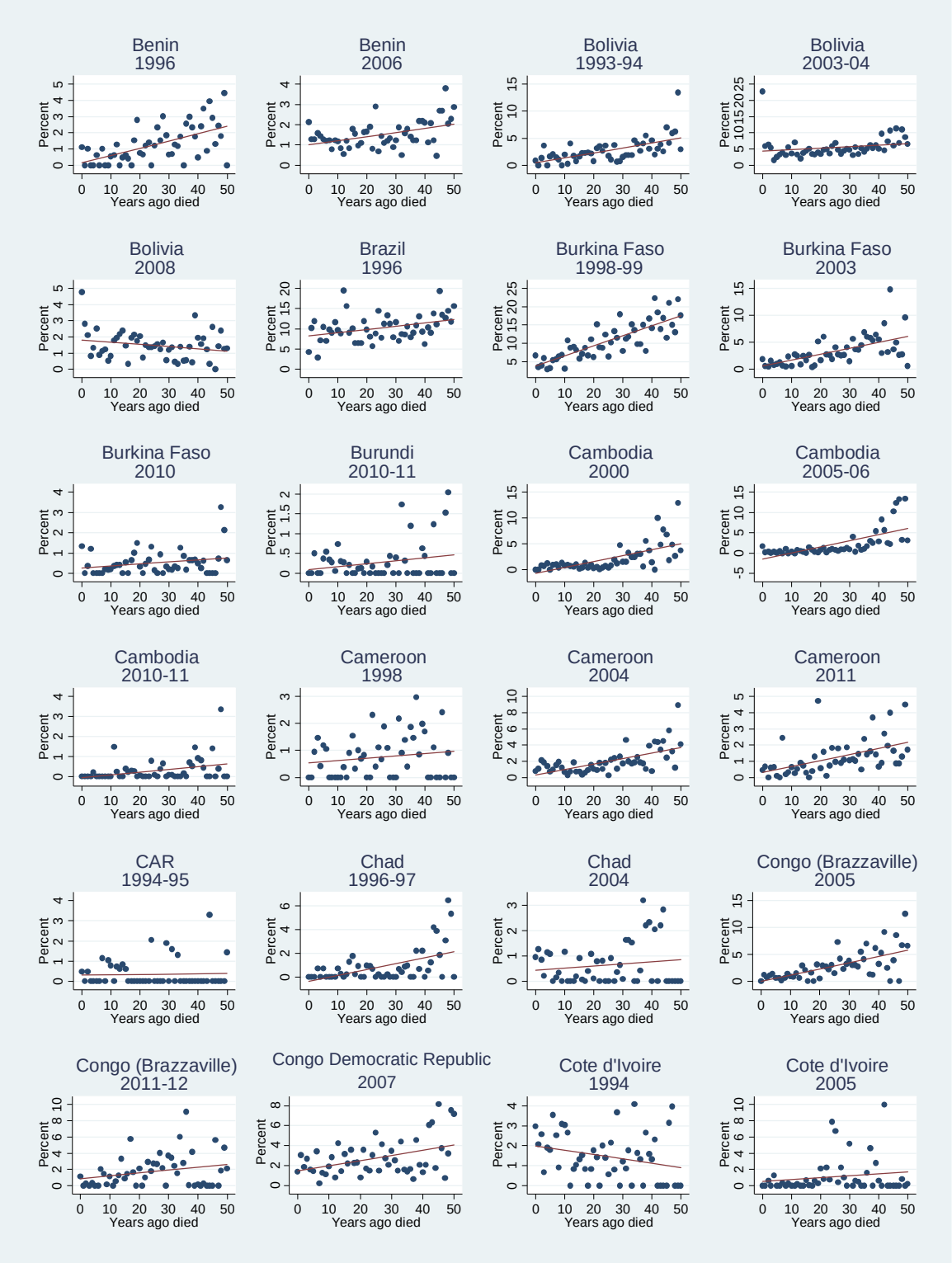


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Figure 3.7 – *Continued*

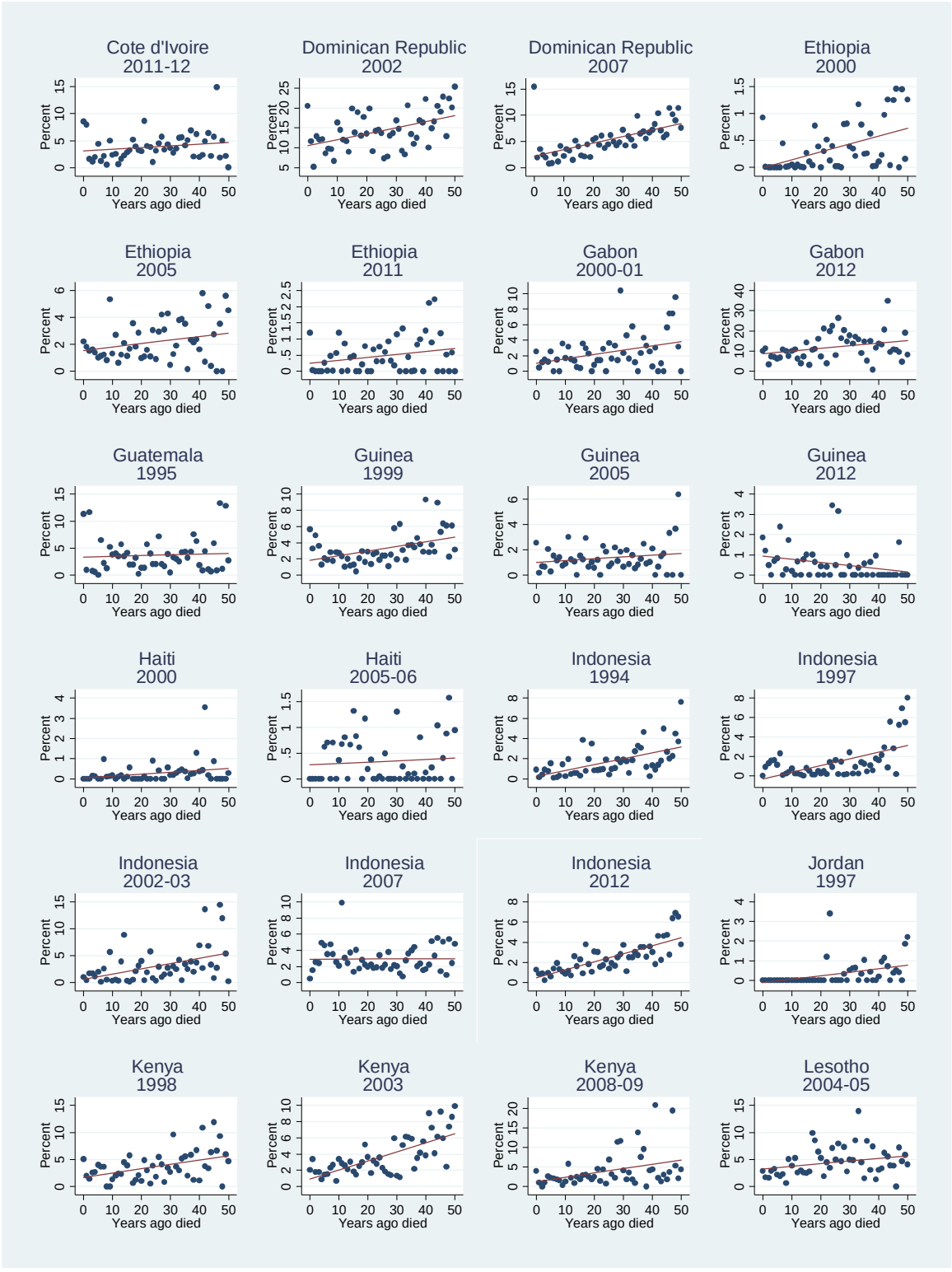

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Figure 3.7 – *Continued*

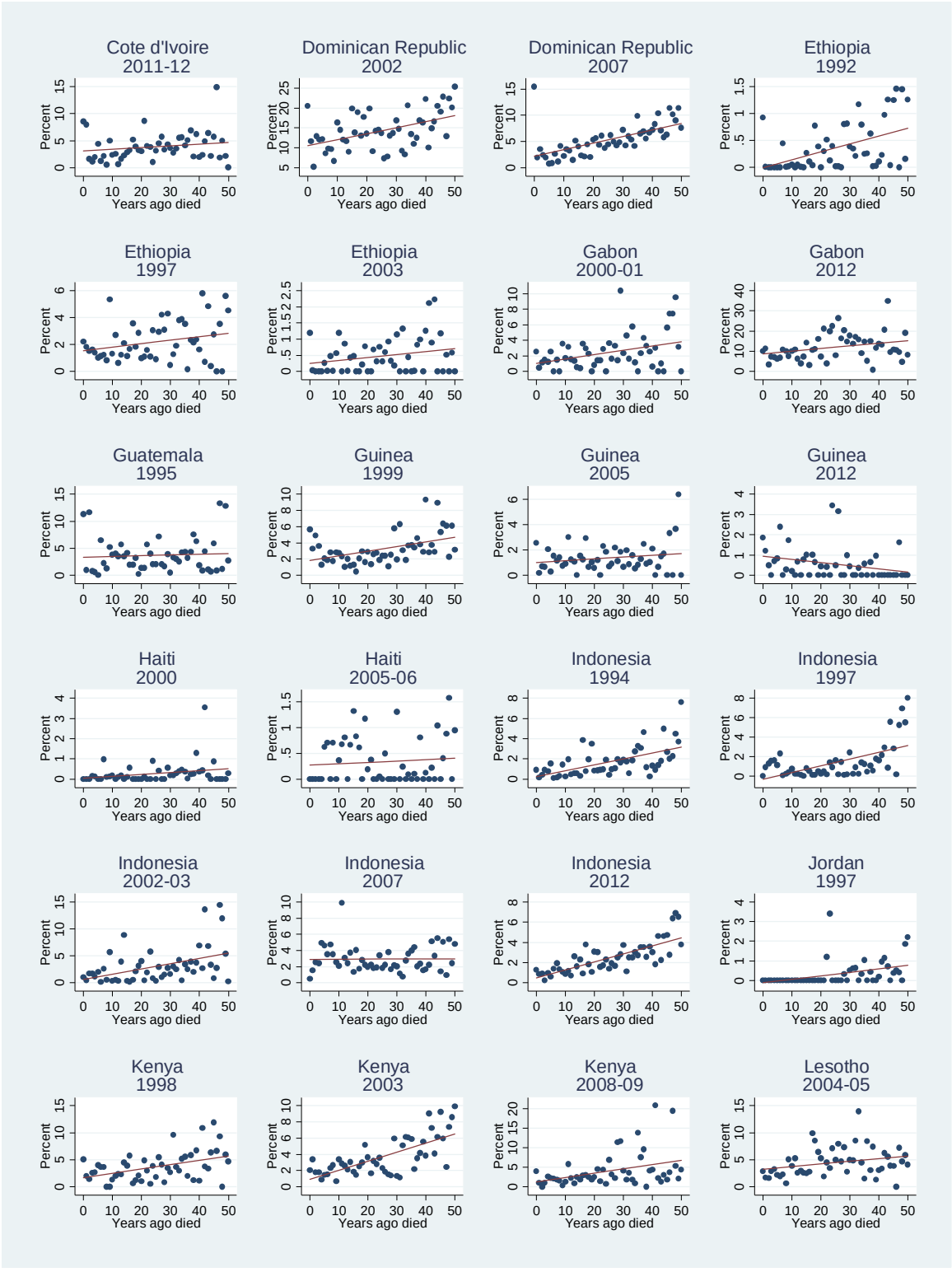

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Figure 3.7 – *Continued*

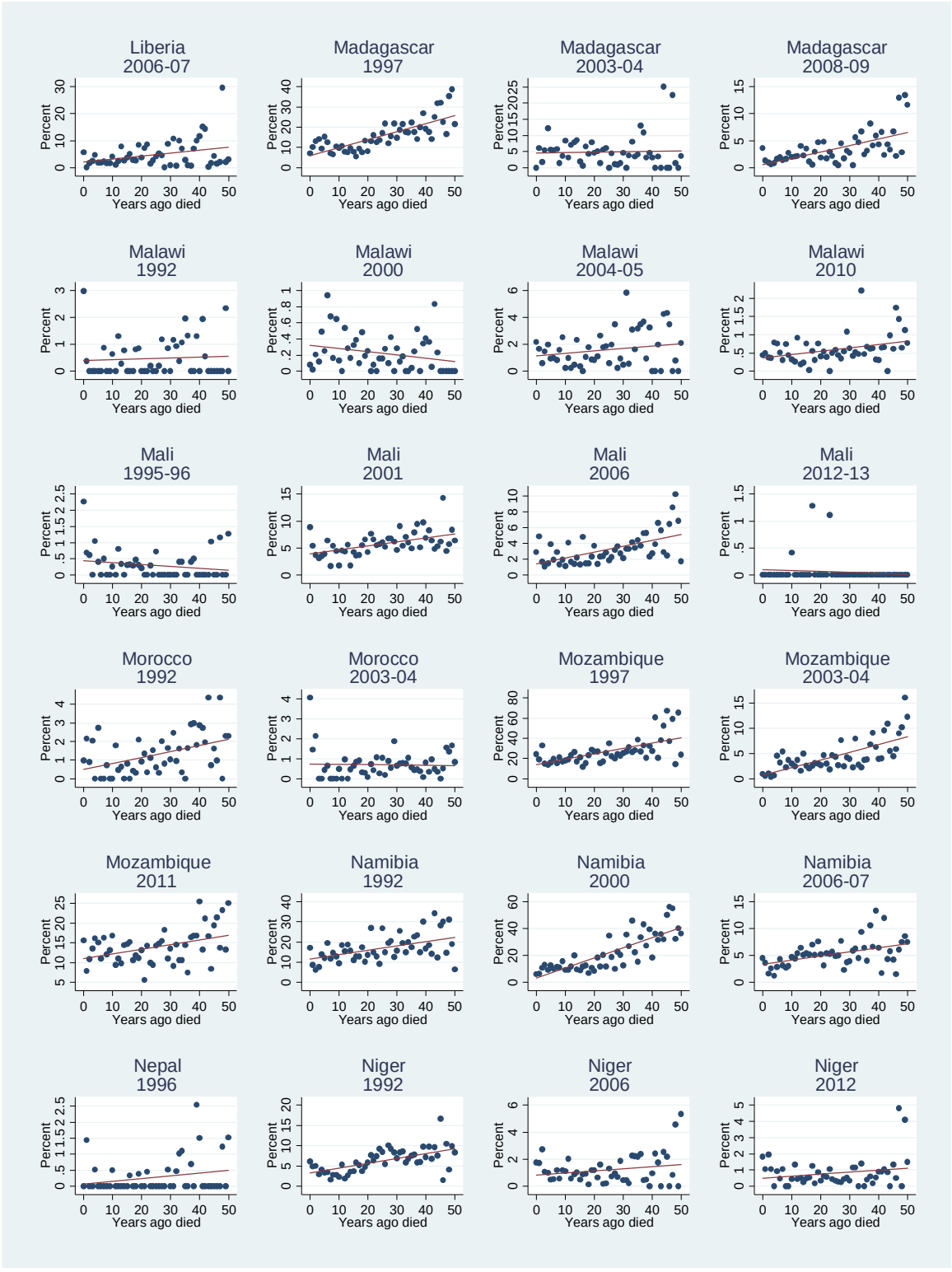

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Figure 3.7 – *Continued*

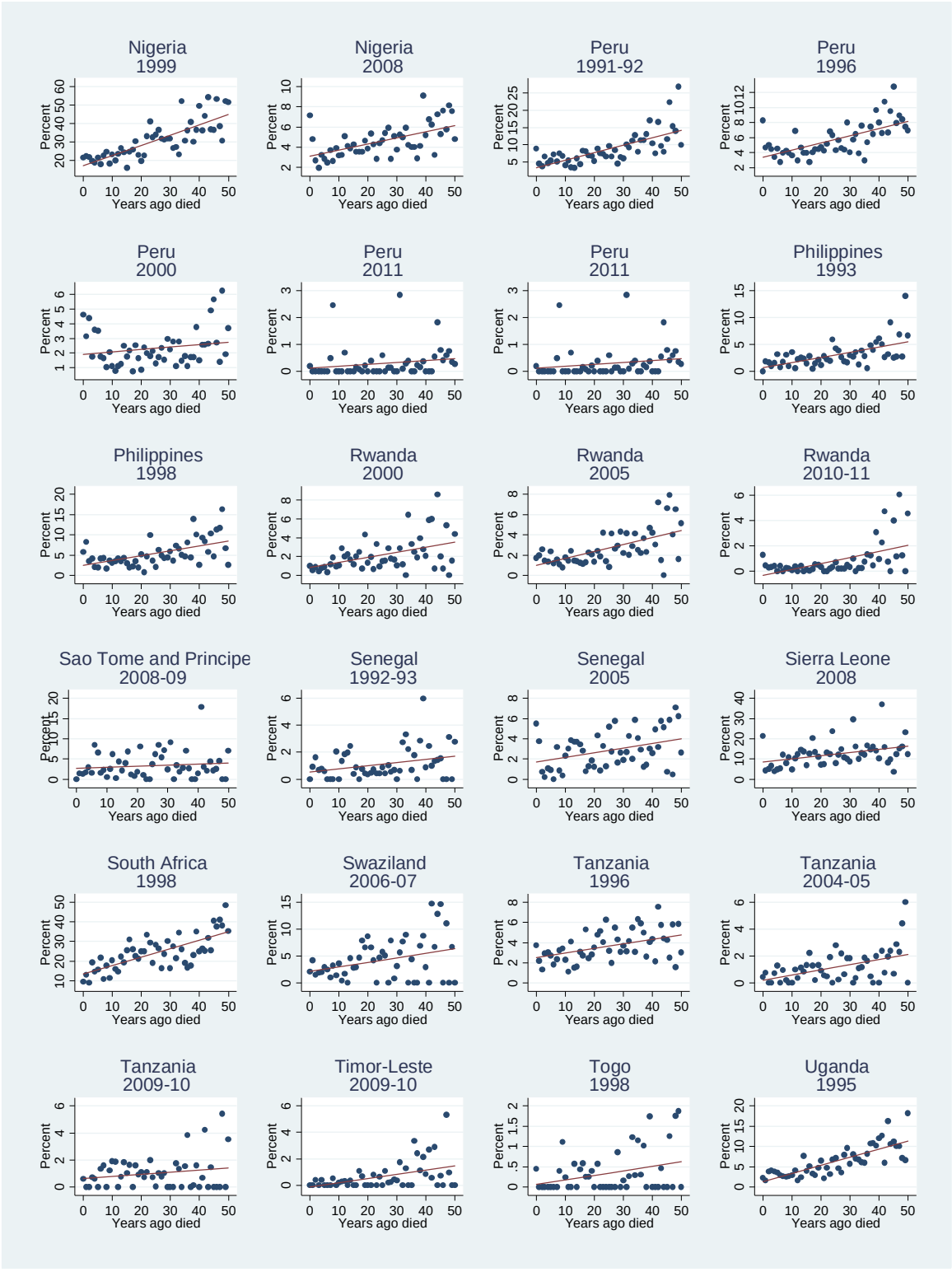

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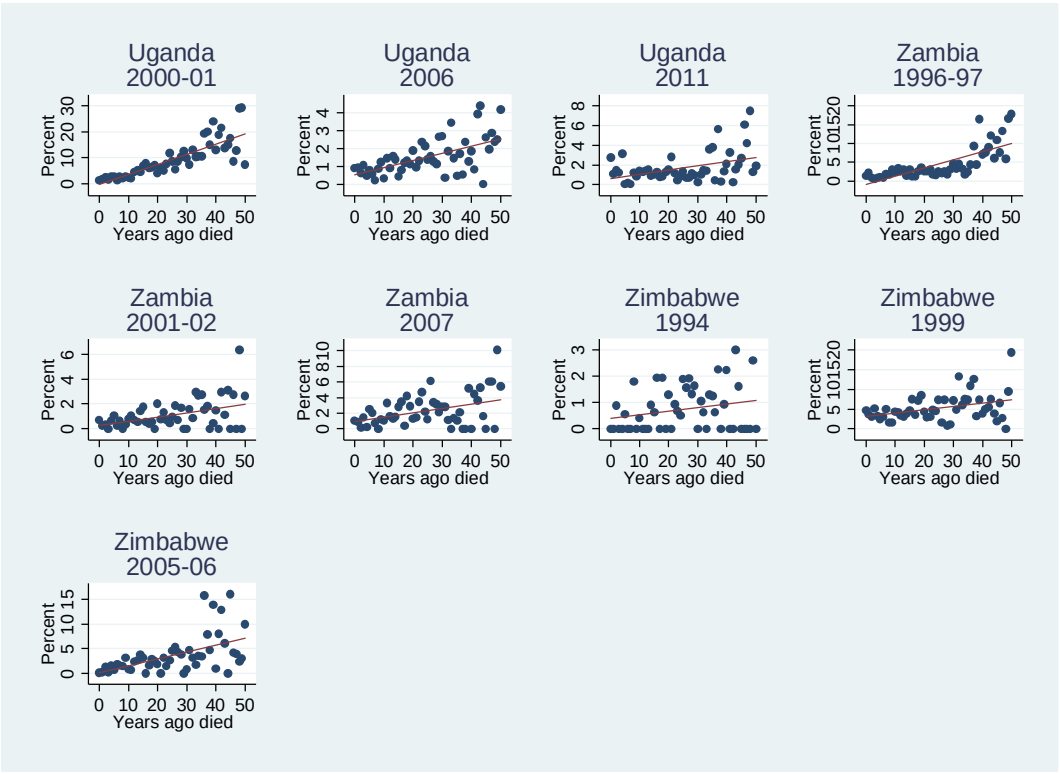
Figure 3.7 – *Continued*



Note: The Madagascar 1992, Peru 2009, and Peru 2010 survey rounds had no imputation in the publicly available files.

It is expected that the mothers of older women have completed their fertility (parity completed) while the mothers of younger women may not have yet. Furthermore, in most countries, fertility has declined in recent years. In that case, sibship size (parity of mothers) of older respondents is likely to be greater than or equal to the sibship size of younger respondents. A lower level of parity for mothers of older respondents may suggest underreporting of siblings. This may bias maternal mortality estimates because of underrepresentation of the siblings of older respondents. Table 3.6 shows the mean parity of mothers of respondents by five-year age groups of the respondents. As an illustration, the results from surveys in Indonesia during Phase-III and Phase-VI show that the mean sibship size of older women remained high through the five survey rounds, but it has declined for younger women. At each survey round, sibship size of older respondents was higher than or similar to the sibship size of younger respondents. This is an expected pattern with the recent trends in fertility reduction. In contrast, in a few countries (CAR 1994-95, Malawi 1992, Mali 1995 , Nigeria 1999) sibship size was substantially lower for older respondents, suggesting under-enumeration in these settings. Figure 3.8 shows the changes in the distribution of sibship size between DHS survey rounds in each country where more than one survey was conducted.

Table 3.6 Mean parity of mothers of respondents by age of respondent, Demographic and Health Surveys 1990-2013

Country	DHS survey round	Year of survey	Age of respondent							No. of respondents
			15-19	20-24	25-29	30-34	35-39	40-44	45-49	
Sub-Saharan Africa										
Benin	DHS-III	1996	6.7	7.0	6.9	6.6	6.4	6.3	6.0	5,491
Benin	DHS-V	2006	6.3	6.6	6.7	6.7	6.7	6.6	6.4	17,794
Burkina Faso	DHS-III	1998-99	6.6	6.8	6.6	6.4	6.2	5.8	5.4	6,445
Burkina Faso	DHS-IV	2003	6.4	6.6	6.6	6.5	6.4	6.2	6.0	12,477
Burkina Faso	DHS-VI	2010	6.6	6.7	6.9	6.8	6.8	6.6	6.4	17,087
Burundi	DHS-VI	2010-11	7.3	7.6	7.6	7.6	7.6	7.3	7.0	9,389
CAR	DHS-III	1994-95	6.6	6.6	6.4	6.1	5.8	5.3	4.9	5,884
Cameroon	DHS-III	1998	7.0	7.2	7.2	7.1	7.0	6.4	6.4	5,501
Cameroon	DHS-IV	2004	7.0	7.2	7.3	7.2	7.4	7.0	6.8	10,656
Cameroon	DHS-VI	2011	6.5	6.9	7.1	7.3	7.3	7.3	6.9	15,426
Chad	DHS-III	1996-97	7.0	6.9	6.6	6.4	6.2	5.6	5.6	7,454
Chad	DHS-IV	2004	7.3	7.0	7.1	6.9	6.7	6.4	5.9	6,085
Congo (Brazzaville)	DHS-V	2005	6.0	6.6	7.0	7.4	7.3	7.1	7.0	7,051
Congo (Brazzaville)	DHS-VI	2011-12	5.6	6.0	6.4	6.6	6.9	6.9	6.9	10,819
Congo Democratic Republic	DHS-V	2007	6.9	7.2	7.2	7.4	7.6	7.2	6.8	9,995
Côte d'Ivoire	DHS-III	1994	6.7	6.8	6.7	6.4	6.1	6.0	5.3	8,099
Côte d'Ivoire	DHS-V	2005	6.0	6.8	6.9	7.2	7.3	7.1	7.0	5,183
Côte d'Ivoire	DHS-VI	2011-12	6.1	6.7	6.8	7.1	7.5	7.1	7.4	10,060
Ethiopia	DHS-IV	2000	7.2	7.3	7.1	6.9	6.7	6.8	6.5	15,367
Ethiopia	DHS-IV	2005	7.0	7.0	7.0	7.0	6.7	6.6	6.4	14,070
Ethiopia	DHS-VI	2011	7.0	7.2	7.1	7.1	7.4	7.1	7.0	16,515
Gabon	DHS-III	2000-01	6.8	7.1	7.2	7.0	6.7	6.4	5.7	6,183
Gabon	DHS-VI	2012	6.0	6.4	6.8	6.9	6.6	7.1	7.6	8,422
Guinea	DHS-III	1999	6.1	6.1	6.0	5.9	5.5	5.4	5.2	6,753
Guinea	DHS-IV	2005	6.4	6.5	6.6	6.5	6.5	6.3	6.0	7,954
Guinea	DHS-VI	2012	6.0	6.0	6.1	6.0	6.0	5.9	5.9	9,142
Kenya	DHS-III	1998	6.9	7.3	7.5	7.7	7.6	7.3	6.8	7,881
Kenya	DHS-IV	2003	6.8	7.1	8.0	7.9	8.0	8.0	8.2	8,195
Kenya	DHS-V	2008-09	6.3	6.8	6.8	7.5	7.5	7.5	7.6	8,444
Lesotho	DHS-IV	2004-05	5.2	5.7	5.9	6.4	6.3	6.4	6.5	7,095
Lesotho	DHS-V	2009-10	4.8	5.3	5.6	6.0	6.2	6.2	6.2	7,624
Liberia	DHS-V	2006-07	5.7	5.8	5.8	5.7	5.8	5.5	5.1	7,092
Madagascar	DHS-II	1992	7.4	7.7	7.8	7.6	7.2	7.0	6.1	6,260
Madagascar	DHS-III	1997	7.0	7.4	7.7	7.6	7.5	7.1	6.4	7,060
Madagascar	DHS-IV	2003-04	6.5	6.6	6.5	6.9	7.2	6.8	6.6	7,949
Madagascar	DHS-V	2008-09	6.3	6.9	7.0	7.2	7.4	7.5	7.3	17,375
Malawi	DHS-II	1992	7.5	7.5	7.4	7.1	7.2	6.7	6.4	4,849
Malawi	DHS-IV	2000	6.9	7.1	7.2	7.1	7.0	6.8	6.5	13,220
Malawi	DHS-IV	2004-05	6.4	6.5	6.7	6.8	6.8	6.4	6.5	11,698
Malawi	DHS-V	2010	6.6	6.9	7.0	7.4	7.5	7.3	7.3	23,020
Mali	DHS-III	1995-96	7.0	7.0	6.7	6.4	6.0	5.9	5.5	9,704
Mali	DHS-IV	2001	6.9	6.8	6.7	6.5	6.2	6.0	5.6	12,849

(Continued...)

Table 3.6 – *Continued*

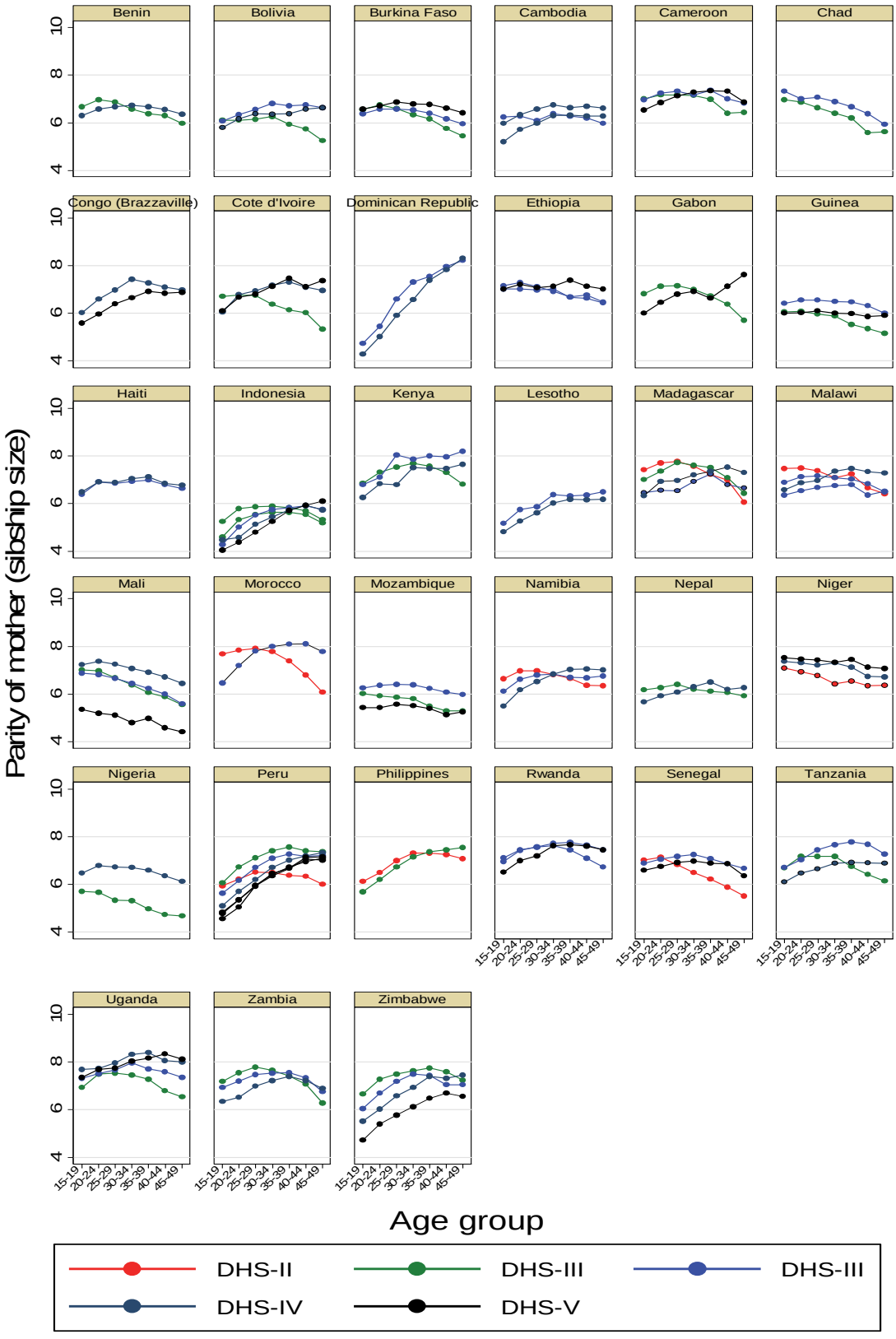
Country	DHS survey round	Year of survey	Age of respondent							No. of respon-dents
			15-19	20-24	25-29	30-34	35-39	40-44	45-49	
Sub-Saharan Africa										
Mali	DHS-V	2006	7.2	7.4	7.2	7.1	6.9	6.7	6.4	14,583
Mali	DHS-VI	2012-13	5.3	5.2	5.1	4.8	5.0	4.6	4.4	10,424
Mozambique	DHS-III	1997	6.0	5.9	5.9	5.8	5.5	5.3	5.3	8,779
Mozambique	DHS-IV	2003-04	6.3	6.4	6.4	6.4	6.2	6.1	6.0	12,418
Mozambique	DHS-VI	2011	5.4	5.4	5.6	5.5	5.4	5.1	5.3	13,745
Namibia	DHS-II	1992	6.7	7.0	7.0	6.8	6.7	6.4	6.3	5,421
Namibia	DHS-IV	2000	6.1	6.6	6.8	6.8	6.7	6.7	6.8	6,755
Namibia	DHS-V	2006-07	5.5	6.2	6.5	6.8	7.0	7.1	7.0	9,804
Niger	DHS-II	1992	7.1	6.9	6.8	6.4	6.6	6.4	6.4	6,503
Niger	DHS-V	2006	7.4	7.3	7.2	7.3	7.1	6.7	6.7	9,223
Niger	DHS-VI	2012	7.5	7.5	7.4	7.3	7.5	7.1	7.1	11,160
Nigeria	DHS-III	1999	5.7	5.7	5.3	5.3	5.0	4.7	4.7	9,810
Nigeria	DHS-V	2008	6.5	6.8	6.7	6.7	6.6	6.4	6.1	33,385
Rwanda	DHS-IV	2000	7.0	7.4	7.6	7.6	7.4	7.1	6.7	10,421
Rwanda	DHS-IV	2005	7.1	7.5	7.6	7.7	7.8	7.7	7.5	11,321
Rwanda	DHS-VI	2010-11	6.5	7.0	7.2	7.6	7.7	7.6	7.5	13,671
São Tomé and Príncipe	DHS-V	2008-09	6.4	6.9	7.8	7.7	8.4	8.1	7.5	2,615
Senegal	DHS-II	1992-93	7.0	7.1	6.8	6.5	6.2	5.9	5.5	6,310
Senegal	DHS-IV	2005	6.9	7.1	7.2	7.3	7.1	6.9	6.7	14,602
Senegal	DHS-VI	2010-11	6.6	6.8	6.9	7.0	6.9	6.9	6.4	15,688
Sierra Leone	DHS-V	2008	5.7	5.9	6.1	6.0	5.8	5.8	5.7	7,374
South Africa	DHS-III	1998	4.6	5.0	5.4	5.6	5.6	6.0	6.2	11,735
Swaziland	DHS-V	2006-07	5.8	6.2	6.5	6.7	6.8	6.5	6.8	4,987
Tanzania	DHS-III	1996	6.7	7.2	7.2	7.2	6.7	6.4	6.1	8,120
Tanzania	DHS-IV	2004-05	6.7	7.0	7.5	7.7	7.8	7.7	7.3	10,329
Tanzania	DHS-V	2009-10	6.1	6.5	6.6	6.9	6.9	6.9	6.9	10,139
Togo	DHS-III	1998	6.4	7.0	7.0	7.0	6.9	6.7	6.5	8,569
Uganda	DHS-III	1995	6.9	7.5	7.5	7.5	7.3	6.8	6.5	7,070
Uganda	DHS-IV	2000-01	7.3	7.5	7.7	8.0	7.7	7.6	7.4	7,246
Uganda	DHS-V	2006	7.7	7.7	8.0	8.3	8.4	8.1	8.0	8,531
Uganda	DHS-VI	2011	7.4	7.7	7.8	8.0	8.2	8.3	8.1	8,674
Zambia	DHS-III	1996-97	7.2	7.6	7.8	7.7	7.4	7.1	6.3	8,021
Zambia	DHS-IV	2001-02	6.9	7.2	7.5	7.5	7.6	7.3	6.7	7,658
Zambia	DHS-V	2007	6.3	6.5	7.0	7.2	7.4	7.2	6.9	7,146
Zimbabwe	DHS-III	1994	6.7	7.3	7.5	7.6	7.7	7.6	7.2	6,128
Zimbabwe	DHS-IV	1999	6.1	6.7	7.2	7.5	7.4	7.1	7.0	5,907
Zimbabwe	DHS-V	2005-06	5.5	6.0	6.6	6.9	7.4	7.3	7.5	8,907
Zimbabwe	DHS-VI	2010-11	4.7	5.4	5.8	6.1	6.5	6.7	6.6	9,171
North Africa										
Jordan	DHS-III	1997	9.5	9.5	9.4	9.3	9.2	9.1	8.5	10,165
Morocco	DHS-II	1992	7.7	7.8	7.9	7.8	7.4	6.8	6.1	9,256
Morocco	DHS-IV	2003-04	6.5	7.2	7.8	8.0	8.1	8.1	7.8	16,798

(Continued...)

Table 3.6 – *Continued*

Country	DHS survey round	Year of survey	Age of respondent							No. of respon-dents
			15-19	20-24	25-29	30-34	35-39	40-44	45-49	
Asia										
Cambodia	DHS-IV	2000	6.2	6.3	6.1	6.4	6.3	6.2	6.0	15,351
Cambodia	DHS-V	2005-06	6.0	6.4	6.6	6.8	6.6	6.7	6.6	16,823
Cambodia	DHS-V	2010-11	5.2	5.7	6.0	6.3	6.3	6.3	6.3	18,754
Indonesia	DHS-III	1994	5.3	5.8	5.9	5.9	5.8	5.7	5.3	38,334
Indonesia	DHS-III	1997	4.6	5.3	5.5	5.6	5.6	5.5	5.2	38,590
Indonesia	DHS-IV	2002-03	4.3	5.0	5.5	5.7	5.8	5.9	5.8	39,315
Indonesia	DHS-V	2007	4.5	4.6	5.1	5.4	5.7	5.9	5.7	42,951
Indonesia	DHS-VI	2012	4.0	4.4	4.8	5.3	5.7	5.9	6.1	45,607
Nepal	DHS-III	1996	6.2	6.3	6.4	6.2	6.1	6.0	5.9	10,101
Nepal	DHS-V	2006	5.7	5.9	6.1	6.3	6.5	6.2	6.3	10,793
Philippines	DHS-II	1993	6.1	6.5	7.0	7.3	7.3	7.3	7.1	15,029
Philippines	DHS-III	1998	5.7	6.2	6.7	7.2	7.4	7.5	7.6	13,983
Timor-Leste	DHS-VI	2009-10	6.5	6.2	5.8	5.5	5.3	5.3	5.1	13,137
Latin America and Caribbean										
Bolivia	DHS-III	1993-94	6.1	6.1	6.2	6.3	5.9	5.7	5.2	8,603
Bolivia	DHS-IV	2003-04	6.1	6.3	6.6	6.8	6.7	6.7	6.6	17,654
Bolivia	DHS-V	2008	5.8	6.2	6.4	6.4	6.4	6.6	6.6	16,939
Brazil	DHS-III	1996	5.3	6.3	7.1	7.4	7.8	8.0	8.0	12,612
Dominican Republic	DHS-IV	2002	4.7	5.5	6.6	7.3	7.5	8.0	8.2	23,384
Dominican Republic	DHS-V	2007	4.3	5.0	5.9	6.6	7.4	7.8	8.3	27,195
Guatemala	DHS-III	1995	6.4	7.0	7.1	6.9	6.8	6.9	6.5	12,403
Haiti	DHS-IV	2000	6.4	6.9	6.8	6.9	7.0	6.8	6.6	10,159
Haiti	DHS-V	2005-06	6.5	6.9	6.9	7.1	7.1	6.9	6.8	10,757
Peru	DHS-II	1991-92	6.0	6.2	6.5	6.5	6.4	6.3	6.0	15,882
Peru	DHS-III	1996	6.1	6.7	7.1	7.4	7.6	7.4	7.4	28,951
Peru	DHS-IV	2000	5.6	6.2	6.7	7.1	7.3	7.2	7.2	27,843
Peru	DHS-V	2003-08	5.1	5.7	6.2	6.7	7.0	7.2	7.3	40,552
Peru	DHS-VI	2009	4.8	5.4	6.0	6.4	6.7	7.0	7.1	24,213
Peru	DHS-VI	2010	4.8	5.4	5.9	6.5	6.7	7.1	7.2	22,947
Peru	DHS-VI	2011	4.6	5.0	5.9	6.4	6.7	7.1	7.0	22,517

Figure 3.8 Distribution of mean parity of mothers of respondents by age of respondents, according to survey round, Demographic and Health Surveys 1990-2013



In the nationally representative DHS surveys, respondents are sampled in such a way that the survey sample represents the population (women age 15-49) of the country. In the sisterhood method, it is assumed that the reported sisters also constitute a representative sample of the population of the country and that it is possible to calculate unbiased estimates of maternal mortality indicators from these data. So, naturally it is expected that the age distribution of the DHS respondents and their siblings of reproductive age will be similar. We test this assumption by comparing the age distributions of the respondents with the age distributions of reported surviving sisters. The distributions are shown in Table 3.7. A consistent pattern emerges for a large majority of countries: the proportions of youngest (15-19) and oldest (45-49) siblings (sisters) are lower than the proportions of youngest and oldest respondents. Stated differently, the two groups of siblings in the age below 20 and above 45 are underrepresented in the sibling data set. This problem may be due to age displacement during age reporting or a shift in the observation window of the birth cohort between respondents and siblings. However, it should be noted that the data on siblings are collected from respondents age 15-49 only, which by the study design truncates the siblings in extreme age groups in the reproductive period. A respondent of age 15 is unlikely to have a sibling above age 45, and similarly a respondent of 49 is unlikely to have a sibling below 20. As a result, the siblings in the age range below 20 or above 45 may not be captured adequately from the DHS survey respondents. Therefore, it is difficult to assess age truncation or underreporting of adult sisters in these two extreme age groups from sibling survival history data.

However, this problem is unlikely to affect the maternal mortality estimates in DHS surveys. During estimation, DHS surveys perform the age-standardization of the maternal mortality rates (MMRates) to match the age-distribution of sisters to the age distribution of the respondents. The age-standardization procedure washes out any effect of imbalance between the age-distributions of the survey respondents and their sisters.

Table 3.7 Percent distribution of age of female respondents and their sisters, Demographic and Health Surveys 1990-2013

Country	DHS survey round	Year of survey	Respondents/ sisters	Age of female respondents/sisters							Median year of birth	Number
				15-19	20-24	25-29	30-34	35-39	40-44	45-49		
Sub-Saharan Africa												
Benin	DHS-III	1996	Respondents	19.6	18.6	17.5	14.0	12.6	9.6	8.1	1968	5,491
	DHS-III		Sisters	16.4	19.6	19.2	17.3	13.1	9.3	5.2	1970	17,468
Benin	DHS-V	2006	Respondents	17.2	17.9	20.5	15.7	11.9	9.0	7.9	1978	17,794
	DHS-V		Sisters	14.9	19.5	20.1	17.8	13.3	9.1	5.3	1979	63,586
Burkina Faso	DHS-III	1998-99	Respondents	22.4	18.0	16.4	13.2	12.9	9.4	7.7	1971	6,445
	DHS-III		Sisters	18.3	20.5	19.8	16.2	12.3	8.2	4.7	1974	20,035
Burkina Faso	DHS-IV	2003	Respondents	22.3	18.2	16.6	12.7	12.2	9.6	8.4	1975	12,477
	DHS-IV		Sisters	16.9	20.4	19.4	16.3	12.7	9.0	5.3	1978	41,397
Burkina Faso	DHS-VI	2010	Respondents	19.4	19.4	17.3	15.1	11.7	9.6	7.5	1982	17,087
	DHS-VI		Sisters	14.8	19.4	20.2	18.0	13.6	8.9	5.1	1984	62,824
Burundi	DHS-VI	2010-11	Respondents	25.1	19.5	17.1	11.3	11.4	7.9	7.6	1984	9,389
	DHS-VI		Sisters	18.1	21.6	20.0	16.1	11.1	8.1	5.0	1986	33,478
CAR	DHS-III	1994-95	Respondents	21.9	19.1	17.5	14.4	12.0	7.8	7.2	1967	5,884
	DHS-III		Sisters	16.4	20.7	20.8	17.8	12.2	8.0	4.1	1969	19,229
Cameroon	DHS-III	1998	Respondents	23.3	20.5	16.7	13.0	11.2	8.7	6.5	1972	5,501
	DHS-III		Sisters	18.0	20.9	19.5	16.5	12.3	8.4	4.4	1973	19,676

(Continued...)

Table 3.7 – *Continued*

Country	DHS survey round	Year of survey	Respon-dents/ sisters	Age of female respondents/sisters 15-19	20-24	25-29	30-34	35-39	40-44	45-49	Median year of birth	Number
Sub-Saharan Africa												
Cameroon	DHS-IV	2004	Respondents	25.2	21.1	16.4	12.7	10.1	7.8	6.7	1978	10,656
	DHS-IV		Sisters	17.9	21.4	19.9	16.4	11.5	8.2	4.8	1979	39,559
Cameroon	DHS-VI	2011	Respondents	23.3	20.3	17.4	12.6	10.9	8.1	7.5	1984	15,426
	DHS-VI		Sisters	15.8	20.3	20.5	17.1	12.4	8.8	5.1	1984	56,850
Chad	DHS-III	1996-97	Respondents	23.0	18.4	18.1	13.1	11.7	8.0	7.7	1970	7,454
	DHS-III		Sisters	17.1	22.1	20.1	17.3	11.6	7.8	4.0	1972	24,078
Chad	DHS-IV	2004	Respondents	22.4	17.6	18.7	12.9	10.8	8.6	9.0	1978	6,085
	DHS-IV		Sisters	16.1	21.8	19.1	17.6	11.9	8.4	5.1	1980	21,141
Congo (Brazzaville)	DHS-V	2005	Respondents	22.2	21.2	17.6	13.2	11.8	7.8	6.2	1978	7,051
	DHS-V		Sisters	14.2	18.6	20.4	18.5	13.7	9.4	5.1	1978	27,148
Congo (Brazzaville)	DHS-VI	2011-12	Respondents	20.3	18.8	18.7	14.4	12.6	8.4	6.9	1983	10,819
	DHS-VI		Sisters	12.8	17.3	19.5	18.0	15.2	10.9	6.4	1983	38,585
Congo Democratic Republic	DHS-V	2007	Respondents	20.3	22.7	16.6	13.4	10.4	9.1	7.4	1980	9,995
	DHS-V		Sisters	15.7	19.1	18.9	17.2	13.8	9.1	6.2	1980	35,948
Côte d'Ivoire	DHS-III	1994	Respondents	24.2	19.4	18.0	14.7	9.9	7.7	6.1	1968	8,099
	DHS-III		Sisters	18.7	20.9	20.8	16.5	12.1	7.1	3.9	1970	28,151
Côte d'Ivoire	DHS-V	2005	Respondents	23.8	21.8	17.6	13.2	9.7	7.8	6.1	1979	5,183
	DHS-V		Sisters	17.1	20.8	20.4	16.4	12.7	8.1	4.5	1980	17,761
Côte d'Ivoire	DHS-VI	2011-12	Respondents	20.1	19.4	19.1	15.0	11.2	8.5	6.7	1984	10,060
	DHS-VI		Sisters	14.8	19.5	20.9	17.6	13.4	8.7	5.1	1984	37,727
Ethiopia	DHS-IV	2000	Respondents	24.1	18.6	16.8	12.0	11.2	9.1	8.2	1965	15,367
	DHS-IV		Sisters	17.6	21.2	18.8	15.9	12.5	8.8	5.3	1967	48,750
Ethiopia	DHS-IV	2005	Respondents	23.2	18.1	17.9	12.8	11.4	8.4	8.1	1971	14,070
	DHS-IV		Sisters	17.2	21.0	19.2	16.7	12.5	8.5	5.1	1972	47,449
Ethiopia	DHS-VI	2011	Respondents	24.3	17.7	19.1	12.4	11.6	7.6	7.2	1977	16,515
	DHS-VI		Sisters	16.4	21.1	19.8	17.3	12.3	8.4	4.7	1977	57,742
Gabon	DHS-III	2000-01	Respondents	25.7	20.4	15.8	14.0	10.8	8.0	5.4	1974	6,183
	DHS-III		Sisters	18.3	20.3	20.1	16.8	12.5	8.0	3.9	1976	23,138
Gabon	DHS-VI	2012	Respondents	21.2	19.4	17.6	14.4	11.7	8.9	6.8	1984	8,422
	DHS-VI		Sisters	15.0	18.9	19.8	16.6	13.4	9.8	6.4	1984	31,518
Guinea	DHS-III	1999	Respondents	19.6	16.1	18.5	14.3	14.0	9.2	8.4	1971	6,753
	DHS-III		Sisters	15.2	19.1	19.2	18.1	13.8	9.6	5.1	1973	19,358
Guinea	DHS-IV	2005	Respondents	20.7	14.5	15.8	14.1	14.7	10.3	9.9	1975	7,954
	DHS-IV		Sisters	14.0	18.6	18.7	17.9	14.3	10.4	6.1	1977	23,739
Guinea	DHS-VI	2012	Respondents	22.1	17.9	17.6	12.8	12.3	9.5	7.8	1984	9,142
	DHS-VI		Sisters	15.7	19.7	19.4	17.5	13.1	9.1	5.5	1986	27,699
Kenya	DHS-III	1998	Respondents	23.5	19.6	17.4	12.5	12.6	8.1	6.3	1971	7,881
	DHS-III		Sisters	16.0	19.3	20.0	17.2	13.3	9.0	5.0	1971	34,762
Kenya	DHS-IV	2003	Respondents	22.6	20.6	16.9	13.3	10.6	9.6	6.4	1976	8,195
	DHS-IV		Sisters	15.7	19.6	19.6	17.0	13.4	9.3	5.5	1976	35,510
Kenya	DHS-V	2008-09	Respondents	20.8	20.3	17.2	14.3	10.4	9.1	7.8	1981	8,444
	DHS-V		Sisters	13.5	18.6	19.6	17.9	14.0	10.1	6.3	1981	35,149

(Continued...)

Table 3.7 – *Continued*

Country	DHS survey round	Year of survey	Respon-dents/ sisters	Age of female respondents/sisters 15-19	20-24	25-29	30-34	35-39	40-44	45-49	Median year of birth	Number
Sub-Saharan Africa												
Lesotho	DHS-IV	2004-05	Respondents	24.1	20.6	14.7	11.5	10.3	10.4	8.3	1978	7,095
	DHS-IV		Sisters	16.9	19.9	19.7	15.6	12.1	9.8	6.0	1978	20,992
Lesotho	DHS-V	2009-10	Respondents	23.4	20.4	16.3	12.9	10.0	8.6	8.4	1983	7,624
	DHS-V		Sisters	15.4	20.6	21.0	16.9	11.9	8.3	5.9	1983	21,095
Liberia	DHS-V	2006-07	Respondents	18.5	19.2	16.4	13.5	13.5	9.4	9.5	1978	7,092
	DHS-V		Sisters	13.4	17.7	19.0	17.0	14.9	11.1	7.0	1979	21,822
Madagascar	DHS-II	1992	Respondents	22.7	20.2	16.4	14.5	12.0	8.8	5.4	1965	6,260
	DHS-II		Sisters	16.5	19.9	19.5	17.8	13.2	8.5	4.5	1966	25,719
Madagascar	DHS-III	1997	Respondents	22.0	18.8	16.9	14.3	12.0	9.2	6.8	1970	7,060
	DHS-III		Sisters	15.5	19.5	19.5	17.3	13.7	9.5	5.0	1971	30,708
Madagascar	DHS-IV	2003-04	Respondents	19.2	17.5	17.0	14.5	11.8	11.7	8.2	1975	7,949
	DHS-IV		Sisters	13.1	17.6	18.6	17.8	14.8	11.3	6.9	1975	31,832
Madagascar	DHS-V	2008-09	Respondents	22.8	16.2	15.9	14.4	12.3	10.0	8.5	1980	17,375
	DHS-V		Sisters	14.3	17.5	18.5	17.4	14.5	10.9	7.0	1981	70,457
Malawi	DHS-II	1992	Respondents	22.3	19.4	16.0	13.6	11.1	10.5	7.1	1965	4,849
	DHS-II		Sisters	16.3	19.7	18.2	17.3	12.9	9.9	5.7	1967	15,808
Malawi	DHS-IV	2000	Respondents	21.7	22.4	18.2	11.8	10.8	8.0	7.2	1974	13,220
	DHS-IV		Sisters	17.5	21.6	19.9	16.2	11.6	8.4	4.7	1976	43,811
Malawi	DHS-IV	2004-05	Respondents	20.4	24.5	18.4	12.6	9.5	8.0	6.4	1978	11,698
	DHS-IV		Sisters	17.7	21.8	21.0	16.1	11.1	7.7	4.6	1979	37,684
Malawi	DHS-V	2010	Respondents	21.7	19.8	19.1	14.1	11.0	7.5	6.8	1983	23,020
	DHS-V		Sisters	16.1	19.9	20.6	18.0	12.6	8.1	4.8	1984	77,384
Mali	DHS-III	1995-96	Respondents	19.4	16.4	17.5	15.7	14.0	9.2	7.8	1967	9,704
	DHS-III		Sisters	15.7	20.1	19.5	17.7	13.4	8.9	4.8	1970	31,051
Mali	DHS-IV	2001	Respondents	20.0	18.2	17.2	14.8	12.6	9.7	7.5	1973	12,849
	DHS-IV		Sisters	16.3	19.9	19.2	16.9	13.3	9.1	5.3	1975	42,141
Mali	DHS-V	2006	Respondents	21.3	18.4	18.0	13.5	11.6	9.3	8.0	1979	14,583
	DHS-V		Sisters	16.9	21.0	19.3	17.2	12.1	8.7	4.7	1980	50,147
Mali	DHS-VI	2012-13	Respondents	18.1	17.7	19.9	16.0	12.8	8.8	6.6	1984	10,424
	DHS-VI		Sisters	14.5	20.2	20.7	19.1	12.8	8.5	4.2	1986	31,283
Mozambique	DHS-III	1997	Respondents	20.9	18.9	18.1	13.6	11.7	8.3	8.4	1970	8,779
	DHS-III		Sisters	16.4	20.1	20.1	16.8	12.9	8.9	4.7	1971	26,106
Mozambique	DHS-IV	2003-04	Respondents	19.8	19.8	17.9	14.4	11.4	9.1	7.7	1976	12,418
	DHS-IV		Sisters	14.9	19.6	20.5	17.5	13.6	8.9	5.1	1977	40,014
Mozambique	DHS-VI	2011	Respondents	22.3	17.9	16.6	14.5	12.4	8.4	8.0	1984	13,745
	DHS-VI		Sisters	15.5	18.3	20.1	17.5	13.9	9.0	5.7	1984	39,493
Namibia	DHS-II	1992	Respondents	23.2	20.6	16.4	13.3	10.5	9.3	6.6	1966	5,421
	DHS-II		Sisters	17.4	20.7	19.9	16.3	12.3	8.4	5.2	1967	20,714
Namibia	DHS-IV	2000	Respondents	22.2	19.8	16.4	15.0	11.1	9.4	6.2	1973	6,755
	DHS-IV		Sisters	15.1	19.3	19.9	17.0	13.6	9.4	5.7	1973	25,741
Namibia	DHS-V	2006-07	Respondents	22.9	18.9	16.6	14.5	10.7	9.5	7.0	1979	9,804
	DHS-V		Sisters	14.6	18.4	19.9	17.5	13.7	9.8	6.1	1979	34,655

(Continued...)

Table 3.6 – *Continued*

Country	DHS survey round	Year of survey	Respon-dents/ sisters	Age of female respondents/sisters 15-19	20-24	25-29	30-34	35-39	40-44	45-49	Median year of birth	Number
Sub-Saharan Africa												
Niger	DHS-II	1992	Respondents	21.2	18.3	19.7	15.0	11.5	8.1	6.2	1965	6,503
	DHS-II		Sisters	16.0	20.7	19.9	17.9	12.5	8.3	4.7	1966	20,893
Niger	DHS-V	2006	Respondents	18.6	17.9	19.4	14.7	12.6	9.6	7.1	1979	9,223
	DHS-V		Sisters	15.3	19.8	18.9	17.5	13.5	9.6	5.4	1980	32,981
Niger	DHS-VI	2012	Respondents	16.4	17.8	20.4	16.6	12.9	8.9	7.0	1984	11,160
	DHS-VI		Sisters	15.4	19.5	19.4	17.5	13.4	9.3	5.5	1985	42,277
Nigeria	DHS-III	1999	Respondents	34.4	15.5	15.5	11.6	10.1	7.1	5.8	1974	9,810
	DHS-III		Sisters	21.1	21.6	19.2	15.2	11.2	7.5	4.2	1975	27,483
Nigeria	DHS-V	2008	Respondents	19.4	18.4	18.9	13.9	11.7	9.1	8.6	1981	33,385
	DHS-V		Sisters	14.8	20.0	20.2	17.8	13.1	8.9	5.2	1982	118,971
Rwanda	DHS-IV	2000	Respondents	25.1	18.3	15.3	12.2	11.5	10.2	7.4	1974	10,421
	DHS-IV		Sisters	17.2	19.6	17.7	16.4	13.3	9.9	5.9	1975	34,042
Rwanda	DHS-IV	2005	Respondents	22.8	20.8	15.4	12.9	10.0	10.0	8.0	1978	11,321
	DHS-IV		Sisters	17.2	21.2	18.7	15.2	12.6	9.1	6.0	1979	38,268
Rwanda	DHS-VI	2010-11	Respondents	21.5	19.6	18.2	13.3	10.6	8.5	8.1	1983	13,671
	DHS-VI		Sisters	14.0	20.4	20.8	17.2	12.3	9.2	6.2	1984	48,299
São Tomé and Príncipe	DHS-V	2008-09	Respondents	21.2	17.6	17.3	15.2	9.9	10.8	8.1	1980	2,615
	DHS-V		Sisters	12.9	18.5	19.2	16.9	14.1	11.5	7.0	1980	11,300
Senegal	DHS-II	1992-93	Respondents	22.6	19.0	16.5	14.0	12.7	9.3	5.9	1965	6,310
	DHS-II		Sisters	17.2	19.8	19.5	17.2	13.3	8.4	4.6	1968	20,643
Senegal	DHS-IV	2005	Respondents	24.4	19.5	16.3	13.4	11.0	8.6	6.9	1979	14,602
	DHS-IV		Sisters	16.8	20.5	19.3	16.2	12.6	9.2	5.4	1979	55,257
Senegal	DHS-VI	2010-11	Respondents	21.9	20.5	17.5	13.7	11.6	8.8	6.1	1984	15,688
	DHS-VI		Sisters	14.9	20.3	20.3	18.1	12.6	8.9	4.9	1984	56,885
Sierra Leone	DHS-V	2008	Respondents	16.2	16.1	22.3	14.1	15.3	8.8	7.0	1980	7,374
	DHS-V		Sisters	14.3	18.8	19.6	18.2	14.3	9.2	5.6	1980	18,624
South Africa	DHS-III	1998	Respondents	19.2	17.7	15.8	14.1	13.9	11.0	8.3	1969	11,735
	DHS-III		Sisters	11.6	15.6	18.4	17.7	16.5	12.3	7.8	1968	35,120
Swaziland	DHS-V	2006-07	Respondents	25.5	21.0	14.6	12.3	10.1	8.8	7.7	1980	4,987
	DHS-V		Sisters	17.4	21.1	19.4	15.8	12.4	8.6	5.2	1981	16,832
Tanzania	DHS-III	1996	Respondents	21.3	20.6	17.7	13.8	10.9	8.4	7.2	1969	8,120
	DHS-III		Sisters	16.2	20.3	19.6	17.3	12.8	8.9	4.9	1971	30,682
Tanzania	DHS-IV	2004-05	Respondents	21.7	19.4	18.3	14.9	10.2	8.1	7.4	1977	10,329
	DHS-IV		Sisters	14.6	19.4	19.9	18.1	13.3	9.3	5.4	1978	40,390
Tanzania	DHS-V	2009-10	Respondents	21.4	18.8	16.5	14.0	12.7	9.2	7.3	1982	10,139
	DHS-V		Sisters	14.7	18.1	18.8	17.3	14.5	10.1	6.5	1982	38,125
Togo	DHS-III	1998	Respondents	20.9	17.1	18.0	15.7	12.5	8.4	7.4	1970	8,569
	DHS-III		Sisters	15.6	19.2	19.6	17.3	13.8	9.2	5.3	1971	30,471
Uganda	DHS-III	1995	Respondents	22.7	22.0	18.0	13.8	11.1	7.1	5.4	1969	7,070
	DHS-III		Sisters	17.9	21.9	21.7	17.1	11.3	6.7	3.5	1970	27,005
Uganda	DHS-IV	2000-01	Respondents	22.3	20.8	18.5	13.6	11.2	7.9	5.8	1974	7,246
	DHS-IV		Sisters	16.2	20.3	20.1	17.6	13.1	8.6	4.2	1975	27,699

(Continued...)

Table 3.6 – *Continued*

Country	DHS survey round	Year of survey	Respon-dents/ sisters	Age of female respondents/sisters 15-19	20-24	25-29	30-34	35-39	40-44	45-49	Median year of birth	Number
Sub-Saharan Africa												
Uganda	DHS-V	2006	Respondents	22.7	20.0	16.6	14.3	11.0	8.6	6.8	1979	8,531
	DHS-V		Sisters	15.9	20.0	19.7	17.2	13.3	8.8	5.1	1980	32,314
Uganda	DHS-VI	2011	Respondents	23.6	18.8	18.1	12.5	11.8	8.4	6.8	1984	8,674
	DHS-VI		Sisters	16.8	19.6	19.1	16.3	13.1	9.2	5.9	1986	33,055
Zambia	DHS-III	1996-97	Respondents	25.0	22.8	16.0	13.5	9.5	7.1	6.2	1970	8,021
	DHS-III		Sisters	17.5	22.7	20.0	16.4	11.7	7.6	4.1	1972	31,539
Zambia	DHS-IV	2001-02	Respondents	23.7	21.7	18.0	12.7	10.0	7.9	6.1	1975	7,658
	DHS-IV		Sisters	17.0	21.0	21.2	16.8	11.8	7.7	4.5	1976	29,468
Zambia	DHS-V	2007	Respondents	22.0	19.2	19.1	14.8	10.5	7.9	6.6	1980	7,146
	DHS-V		Sisters	15.1	19.8	20.0	18.1	13.4	8.6	5.0	1981	26,640
Zimbabwe	DHS-III	1994	Respondents	24.0	20.7	14.9	14.2	10.8	8.7	6.6	1968	6,128
	DHS-III		Sisters	15.8	19.4	19.0	17.6	13.5	9.3	5.4	1968	25,418
Zimbabwe	DHS-IV	1999	Respondents	24.5	21.9	17.5	11.3	10.8	7.9	6.1	1973	5,907
	DHS-IV		Sisters	17.4	19.5	19.8	16.1	12.8	9.1	5.4	1973	23,456
Zimbabwe	DHS-V	2005-06	Respondents	24.2	21.9	16.5	13.6	9.4	7.8	6.6	1979	8,907
	DHS-V		Sisters	15.0	20.9	20.9	16.6	12.8	8.4	5.5	1979	32,502
Zimbabwe	DHS-VI	2010-11	Respondents	21.2	20.1	18.4	14.1	11.5	8.0	6.8	1983	9,171
	DHS-VI		Sisters	12.6	19.2	21.9	18.6	13.3	9.0	5.4	1983	30,201
North Africa												
Jordan	DHS-III	1997	Respondents	24.8	20.2	17.6	13.7	10.2	7.7	5.8	1965	10,165
	DHS-III		Sisters	17.8	22.3	21.3	16.2	11.7	6.6	4.1	1968	59,579
Morocco	DHS-II	1992	Respondents	23.2	18.2	15.9	14.8	12.7	8.0	7.2	1964	9,256
	DHS-II		Sisters	15.8	20.1	20.1	18.4	13.2	8.2	4.3	1965	39,803
Morocco	DHS-IV	2003-04	Respondents	19.6	17.9	15.4	13.4	12.2	11.4	10.0	1975	16,798
	DHS-IV		Sisters	12.4	17.0	18.1	17.5	15.1	12.3	7.6	1974	75,406
Asia												
Cambodia	DHS-IV	2000	Respondents	23.6	12.9	13.8	14.3	14.1	12.0	9.3	1970	15,351
	DHS-IV		Sisters	16.0	14.9	17.7	18.0	16.0	10.5	6.9	1972	48,266
Cambodia	DHS-V	2005-06	Respondents	21.4	18.1	12.2	12.4	13.2	12.6	10.1	1977	16,823
	DHS-V		Sisters	15.8	20.2	15.9	14.4	14.5	11.6	7.6	1979	56,658
Cambodia	DHS-V	2010-11	Respondents	19.9	16.8	17.4	11.6	10.9	12.3	11.2	1982	18,754
	DHS-V		Sisters	13.6	19.2	20.7	15.0	12.7	10.9	7.9	1982	63,909
Indonesia	DHS-III	1994	Respondents	19.8	17.1	16.5	15.6	13.1	9.8	8.1	1961	38,334
	DHS-III		Sisters	13.5	17.7	19.7	18.0	15.2	10.1	5.7	1963	123,921
Indonesia	DHS-III	1997	Respondents	18.9	16.5	16.5	14.7	13.8	10.7	9.0	1964	38,590
	DHS-III		Sisters	11.7	16.3	19.3	18.5	16.0	11.5	6.7	1966	123,149
Indonesia	DHS-IV	2002-03	Respondents	16.6	16.8	15.9	14.7	13.6	11.9	10.6	1969	39,315
	DHS-IV		Sisters	10.3	15.1	17.6	18.3	17.2	13.2	8.3	1969	123,113
Indonesia	DHS-V	2007	Respondents	14.8	15.6	15.9	15.1	14.5	12.8	11.4	1973	42,951
	DHS-V		Sisters	8.7	13.3	17.5	17.9	18.3	14.3	10.0	1973	132,013
Indonesia	DHS-VI	2012	Respondents	15.2	13.8	15.3	15.1	15.1	13.7	11.9	1981	45,607
	DHS-VI		Sisters	8.2	12.0	15.9	18.5	18.6	15.7	11.1	1979	131,583

(Continued...)

Table 3.6 – *Continued*

Country	DHS survey round	Year of survey	Respon-dents/ sisters	Age of female respondents/sisters 15-19	20-24	25-29	30-34	35-39	40-44	45-49	Median year of birth	Number
Asia												
Nepal	DHS-III	1996	Respondents	22.1	18.9	16.5	13.7	11.2	9.2	8.3	1922	10,101
	DHS-III		Sisters	16.2	20.1	19.3	16.6	13.1	9.1	5.5	1924	30,481
Nepal	DHS-V	2006	Respondents	22.6	18.5	16.4	12.4	11.3	10.4	8.4	2035	10,793
	DHS-V		Sisters	15.5	19.6	18.8	16.7	13.8	9.7	5.9	2035	34,719
Philippines	DHS-II	1993	Respondents	21.0	17.6	16.2	14.6	12.6	10.5	7.6	1964	15,029
	DHS-II		Sisters	12.6	17.9	19.6	17.8	15.3	10.3	6.5	1964	65,525
Philippines	DHS-III	1998	Respondents	20.9	16.4	15.8	14.7	13.2	10.6	8.4	1969	13,983
	DHS-III		Sisters	12.3	16.1	18.8	17.5	16.1	11.8	7.5	1968	58,946
Timor-Leste	DHS-VI	2009-10	Respondents	23.9	17.8	14.4	11.7	12.8	10.6	8.7	1982	13,137
	DHS-VI		Sisters	18.4	20.5	18.4	13.5	12.6	9.8	6.7	1985	39,312
Latin America and Caribbean												
Bolivia	DHS-III	1993-94	Respondents	21.0	17.9	15.6	14.8	12.5	9.8	8.3	1965	8,603
	DHS-III		Sisters	15.2	19.1	19.4	16.0	14.6	9.3	6.3	1967	27,614
Bolivia	DHS-IV	2003-04	Respondents	21.9	17.7	15.1	14.0	12.1	10.7	8.4	1975	17,654
	DHS-IV		Sisters	14.7	18.8	18.8	15.7	14.5	10.3	7.1	1976	59,858
Bolivia	DHS-V	2008	Respondents	20.8	16.2	16.2	13.9	12.7	10.6	9.7	1979	16,939
	DHS-V		Sisters	14.3	17.7	19.0	16.1	14.9	10.4	7.7	1979	56,611
Brazil	DHS-III	1996	Respondents	19.5	15.0	15.4	15.2	13.7	11.7	9.4	1966	12,612
	DHS-III		Sisters	11.6	16.1	18.1	17.6	16.3	12.0	8.3	1965	51,576
Dominican Republic	DHS-IV	2002	Respondents	19.5	17.7	15.5	14.1	13.6	10.3	9.4	1973	23,384
	DHS-IV		Sisters	10.8	16.1	17.3	17.8	16.5	12.6	8.8	1971	47,295
Dominican Republic	DHS-V	2007	Respondents	20.5	16.6	14.6	13.9	13.4	11.6	9.4	1978	27,195
	DHS-V		Sisters	9.8	14.1	16.3	17.3	17.2	14.6	10.7	1974	100,098
Guatemala	DHS-III	1995	Respondents	23.7	18.4	14.4	13.0	12.4	10.0	8.2	1968	12,403
	DHS-III		Sisters	16.0	19.1	17.6	16.3	14.2	10.4	6.4	1969	45,937
Haiti	DHS-IV	2000	Respondents	23.1	18.9	15.9	12.8	11.3	9.5	8.6	1972	10,159
	DHS-IV		Sisters	15.5	19.2	18.8	16.6	13.7	10.3	5.9	1973	34,669
Haiti	DHS-V	2005-06	Respondents	25.1	18.6	16.4	11.6	10.8	8.7	8.7	1979	10,757
	DHS-V		Sisters	16.5	20.4	18.9	16.0	12.7	9.6	5.9	1979	36,878
Peru	DHS-II	1991-92	Respondents	21.9	19.3	16.1	13.3	12.1	9.7	7.5	1964	15,882
	DHS-II		Sisters	15.3	19.6	19.7	16.5	13.6	9.2	6.1	1965	58,446
Peru	DHS-III	1996	Respondents	21.2	18.2	15.8	14.3	12.5	10.3	7.6	1968	28,951
	DHS-III		Sisters	13.9	18.7	19.0	16.8	14.8	10.1	6.8	1969	111,036
Peru	DHS-IV	2000	Respondents	20.3	17.0	15.2	14.6	12.5	11.2	9.1	1971	27,843
	DHS-IV		Sisters	12.3	17.4	18.6	17.0	15.7	11.4	7.6	1972	105,508
Peru	DHS-V	2003-08	Respondents	18.6	15.7	14.8	14.3	13.3	12.4	10.9	1976	40,552
	DHS-V		Sisters	10.6	15.7	17.3	17.3	16.7	13.1	9.3	1976	147,952
Peru	DHS-VI	2011	Respondents	18.3	15.3	14.6	14.2	14.2	12.6	10.8	1980	22,517
	DHS-VI		Sisters	10.1	14.6	16.8	17.3	17.3	13.8	10.2	1979	79,250

4. Quality of Maternal Mortality Data

In this section, we present the results pertaining to reporting of events (deaths) and pregnancy status at the time of death (during pregnancy, at delivery, or in the postpartum period) that are used for classifying women's deaths as *maternal* or *non-maternal* deaths. Any errors in the reporting of these variables (misclassification, missing response, misreporting) will directly affect and bias the maternal mortality estimates.

4.1. Timing of Maternal Deaths

Table 4.1 shows the percentage of adult female deaths with missing data on timing of death in relation to the pregnancy—during pregnancy, at delivery, in the postpartum period—by duration of recall period (age 0-6 or 7-13). In most DHS surveys, the postpartum period for maternal mortality estimates refers to two months after delivery.

In many DHS surveys, the extent of missing responses on the pregnancy status at the time of death was substantially high (>10%). Because of the possibility of recall bias, it was expected that the percentage of missingness would be higher in the more distant period (7-13 years) than in the recent period (0-6 years). However, the results show that the problem is similar in both periods (Figure 4.1). In case of higher recall problems in the distant period, compared with the recent period, we would expect most points above the diagonal line.

Table 4.1 Percentage of adult female deaths with missing data on timing of maternal deaths, Demographic and Health Surveys 1990-2013

			0-6 years before survey		7-13 years before survey	
Country	DHS survey round	Year of survey	Percentage missing	No. of deaths	Percentage missing	No. of deaths
Sub-Saharan Africa						
Benin	DHS-III	1996	5.7	165	5.3	112
Benin	DHS-V	2006	11.1	674	10.7	409
Burkina Faso	DHS-III	1998-99	11.8	280	14.7	145
Burkina Faso	DHS-VI	2010	3.8	732	2.5	516
Burundi	DHS-VI	2010-11	3.1	406	3.9	492
CAR	DHS-III	1994-95	4.8	493	3.3	211
Cameroon	DHS-III	1998	12.6	232	9.3	102
Cameroon	DHS-IV	2004	11.5	795	6.7	300
Cameroon	DHS-VI	2011	4.9	1,151	6.3	706
Chad	DHS-III	1996-97	3.6	344	3.9	175
Chad	DHS-IV	2004	5.1	402	6.8	214
Congo (Brazzaville)	DHS-V	2005	10.4	594	7.4	480
Congo (Brazzaville)	DHS-VI	2011-12	7.2	686	4.9	618
Congo Democratic Republic	DHS-V	2007	7.2	715	6.0	391
Côte d'Ivoire	DHS-III	1994	7.0	400	5.3	192
Côte d'Ivoire	DHS-V	2005	8.9	381	8.9	181
Côte d'Ivoire	DHS-VI	2011-12	17.1	711	10.5	532
Ethiopia	DHS-IV	2000	2.7	1,039	3.4	674
Ethiopia	DHS-IV	2005	8.3	925	6.7	664
Ethiopia	DHS-VI	2011	4.7	732	6.2	816

(Continued...)

Table 4.1 – *Continued*

Country	DHS survey round	Year of survey	0-6 years before survey: Percentage missing	0-6 years before survey: No. of deaths	7-13 years before survey: Percentage missing	7-13 years before survey: No. of deaths
Sub-Saharan Africa						
Gabon	DHS-III	2000-01	16.8	307	14.4	136
Gabon	DHS-VI	2012	15.3	404	22.8	309
Guinea	DHS-III	1999	21.9	209	13.7	163
Guinea	DHS-IV	2005	8.0	431	5.1	262
Guinea	DHS-VI	2012	7.2	418	5.6	296
Kenya	DHS-III	1998	3.9	529	6.5	161
Kenya	DHS-IV	2003	4.5	759	6.4	262
Kenya	DHS-V	2008-09	9.2	677	7.1	365
Lesotho	DHS-IV	2004-05	9.7	880	7.1	176
Lesotho	DHS-V	2009-10	18.9	1,017	25.4	378
Liberia	DHS-V	2006-07	22.7	359	21.5	152
Madagascar	DHS-III	1997	10.2	414	9.3	254
Madagascar	DHS-IV	2003-04	18.6	351	12.5	211
Madagascar	DHS-V	2008-09	15.0	923	11.9	613
Malawi	DHS-II	1992	17.4	335	11.9	104
Malawi	DHS-IV	2000	7.3	1,597	7.1	501
Malawi	DHS-IV	2004-05	6.9	1,376	7.0	536
Malawi	DHS-V	2010	8.0	2,134	6.2	1,671
Mali	DHS-III	1995-96	6.4	375	2.5	267
Mali	DHS-IV	2001	14.1	625	14.8	349
Mali	DHS-V	2006	22.7	601	19.8	440
Mali	DHS-VI	2012-13	0.0	239	0.7	161
Mozambique	DHS-III	1997	24.4	313	25.2	224
Mozambique	DHS-IV	2003-04	6.5	769	9.4	289
Mozambique	DHS-VI	2011	10.8	715	13.2	469
Namibia	DHS-II	1992	35.5	211	34.3	113
Namibia	DHS-IV	2000	31.3	458	34.2	127
Namibia	DHS-V	2006-07	12.5	1,133	12.9	396
Niger	DHS-II	1992	13.2	306	7.4	231
Niger	DHS-V	2006	12.4	433	12.3	299
Niger	DHS-VI	2012	6.6	503	6.3	351
Nigeria	DHS-III	1999	35.5	177	39.7	74
Nigeria	DHS-V	2008	19.2	1,699	16.0	928
Rwanda	DHS-IV	2000	5.0	2,498	4.7	567
Rwanda	DHS-IV	2005	9.4	950	8.3	2,118
Rwanda	DHS-VI	2010-11	3.3	539	3.0	859
São Tomé and Príncipe	DHS-V	2008-09	41.6	95	28.1	65
Senegal	DHS-II	1992-93	11.1	199	6.8	133
Senegal	DHS-IV	2005	18.1	512	12.7	255
Senegal	DHS-VI	2010-11	0.0	543	0.0	284
Sierra Leone	DHS-V	2008	25.8	358	23.4	186
South Africa	DHS-III	1998	22.5	348	29.2	172

(Continued...)

Table 4.1 – *Continued*

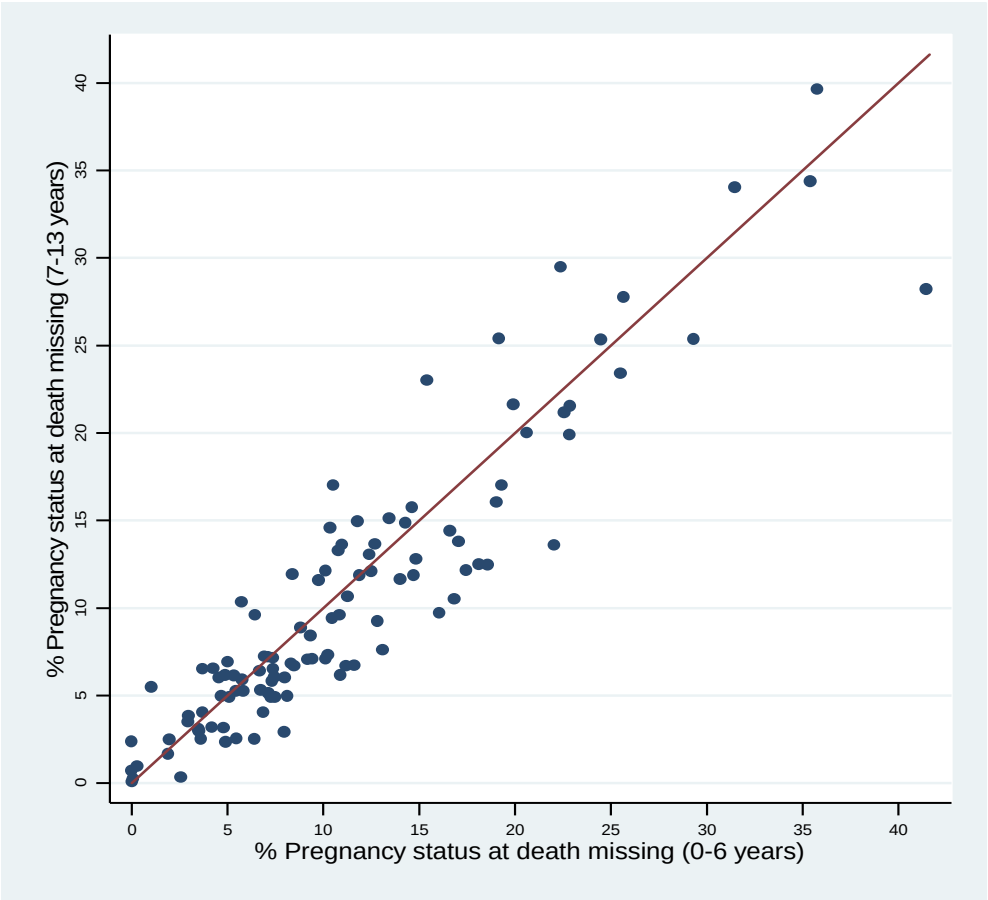
Country	DHS survey round	Year of survey	0-6 years before survey: Percentage missing	0-6 years before survey: No. of deaths	7-13 years before survey: Percentage missing	7-13 years before survey: No. of deaths
Sub-Saharan Africa						
Swaziland	DHS-V	2006-07	10.3	841	14.6	186
Tanzania	DHS-III	1996	7.4	441	7.2	140
Tanzania	DHS-IV	2004-05	5.0	894	2.5	437
Tanzania	DHS-V	2009-10	4.8	646	4.9	457
Togo	DHS-III	1998	15.9	357	9.8	182
Uganda	DHS-III	1995	14.9	753	12.8	219
Uganda	DHS-IV	2000-01	11.7	794	12.1	425
Uganda	DHS-V	2006	7.3	874	5.2	685
Uganda	DHS-VI	2011	1.9	565	2.4	590
Zambia	DHS-III	1996-97	7.6	1,129	6.5	316
Zambia	DHS-IV	2001-02	6.9	1,412	5.2	547
Zambia	DHS-V	2007	7.1	1,153	4.1	638
Zimbabwe	DHS-III	1994	8.7	333	6.6	119
Zimbabwe	DHS-IV	1999	13.4	677	15.3	135
Zimbabwe	DHS-V	2005-06	10.0	1,467	12.2	478
Zimbabwe	DHS-VI	2010-11	5.9	1,174	10.4	636
North Africa						
Jordan	DHS-III	1997	0.0	115	2.3	74
Morocco	DHS-II	1992	25.0	176	34.3	166
Morocco	DHS-IV	2003-04	8.3	266	12.9	193
Asia						
Cambodia	DHS-IV	2000	5.5	546	5.8	351
Cambodia	DHS-V	2005-06	4.0	574	3.1	407
Cambodia	DHS-V	2010-11	1.8	474	1.7	426
Indonesia	DHS-III	1994	9.6	824	11.8	534
Indonesia	DHS-III	1997	5.1	609	6.1	400
Indonesia	DHS-IV	2002-03	10.6	718	16.8	416
Indonesia	DHS-V	2007	14.9	800	15.8	520
Indonesia	DHS-VI	2012	12.9	951	13.6	583
Nepal	DHS-III	1996	1.0	320	5.7	252
Nepal	DHS-V	2006	2.7	217	0.3	178
Philippines	DHS-II	1993	29.1	375	25.4	211
Philippines	DHS-III	1998	19.9	326	21.5	226
Timor-Leste	DHS-VI	2009-10	0.5	288	0.9	233
Latin America and Caribbean						
Bolivia	DHS-III	1993-94	10.8	231	13.6	157
Bolivia	DHS-IV	2003-04	10.9	386	9.8	291
Bolivia	DHS-V	2008	5.6	320	2.7	250
Brazil	DHS-III	1996	20.5	238	20.1	128
Dominican Republic	DHS-IV	2002	22.6	286	21.1	153
Dominican Republic	DHS-V	2007	10.6	605	6.2	425

(Continued...)

Table 4.1 – *Continued*

Country	DHS survey round	Year of survey	0-6 years before survey: Percentage missing	0-6 years before survey: No. of deaths	7-13 years before survey: Percentage missing	7-13 years before survey: No. of deaths
Latin America and Caribbean						
Guatemala	DHS-III	1995	25.5	233	27.6	164
Haiti	DHS-IV	2000	7.8	686	2.9	498
Haiti	DHS-V	2005-06	6.0	591	5.3	434
Peru	DHS-II	1991-92	17.1	341	13.7	256
Peru	DHS-III	1996	13.9	627	11.6	432
Peru	DHS-IV	2000	19.1	454	16.9	366
Peru	DHS-V	2003-08	3.7	595	3.1	555
Peru	DHS-VI	2011	0.1	257	0.0	257

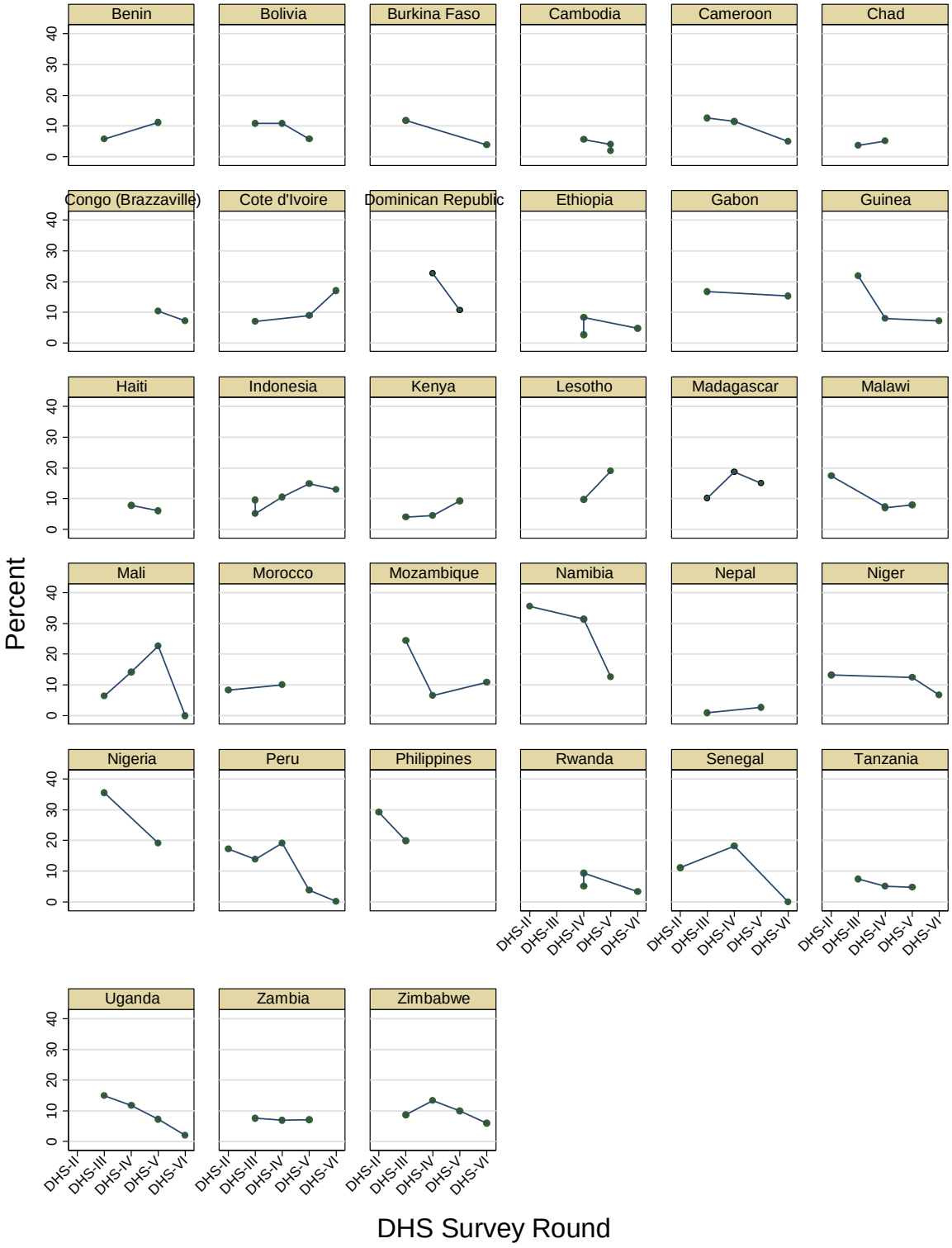
Figure 4.1 Percentage of adult female deaths with missing data on pregnancy status during the timing of death by recall period, Demographic and Health Surveys 1990-2013



Our specific interest was to examine whether the extent of missing responses to the timing of death in relationship to pregnancy—during pregnancy, at delivery, or in the postpartum period—declined in the subsequent rounds of the DHS surveys. The percentage of missing data on pregnancy status during the timing of death for sisters who died during the recent period (0-6 years before the survey) by DHS phases is shown in Figure 4.2. The examination of the countries with multiple rounds of DHS surveys suggests that the response rate improved substantially in successive rounds in most countries. A trend analysis by random-coefficient model shows that the extent of missing responses declined significantly ($p < 0.05$). A coefficient value of -1.94 (95% CI: -3.09 to -0.79) suggests that on an average, adjusted for the heterogeneity in the trend slopes at the country level, the missing response to maternal status at the time of death declined about 2% by each successive DHS survey round (detail results not shown).

However, in four countries—Benin, Cote d'Ivoire, Kenya, and Lesotho—the missing response to maternal status at death substantially increased.

Figure 4.2 Trends in missing data on pregnancy status during the timing of death for sisters who died 0-6 years before the survey, Demographic and Health Surveys 1990-2013



Clinical studies suggest that there are five major causes of maternal mortality: postpartum hemorrhage, puerperal sepsis, eclampsia, obstructed labor, and abortion. Most maternal deaths occur during the postpartum period due to hemorrhage and puerperal sepsis. Deaths during the pregnancy period are due to abortion and eclampsia. About 5%-8% of women die during delivery from obstructed labor (ruptured uterus and hemorrhage). The recent Global Burden of Disease Study 2013 (Kassebaum et al. 2014) estimated that about a quarter of maternal deaths occur during the antepartum (pregnancy) period (24.6%; 95% CI: 24.1-25.2); a quarter are intrapartum and immediate postpartum (27.7%, 95% CI: 27.1-28.2); one-third are during the subacute and delayed postpartum period (35.6%; 34.9-36.2); and 12.1% (11.9-12.5) occur during the late postpartum period.

Table 4.2 and Figure 4.3 show the distribution of timing of death in relation to pregnancy status. Contrary to expectation, in many countries maternal deaths occur mostly during the pregnancy (antepartum) period. Deaths during delivery were also very high in many countries. The high death rates during pregnancy and during delivery may be related to high levels of unsafe abortion, HIV among pregnant women, and endemic malaria in some countries. In summary, it is difficult to ascertain or explain the variability in timing of death or to assess the quality of pregnancy-related data in DHS surveys in the absence of cause of death information.

Table 4.2 Percent distribution of timing of maternal deaths (during pregnancy, during delivery, during the postpartum period), Demographic and Health Surveys 1990-2013

Country	DHS survey round	Year of survey	Timing of maternal death			No. of maternal deaths
			During pregnancy	During delivery	During the postpartum period	
Sub-Saharan Africa						
Benin	DHS-III	1996	33.0	27.3	39.7	162
Benin	DHS-V	2006	31.5	33.1	35.4	359
Burkina Faso	DHS-III	1998-99	34.7	23.4	41.9	115
Burkina Faso	DHS-VI	2010	29.8	29.0	41.2	345
Burundi	DHS-VI	2010-11	48.5	15.6	35.9	348
CAR	DHS-III	1994-95	23.1	54.8	22.1	301
Cameroon	DHS-III	1998	45.0	20.7	34.3	147
Cameroon	DHS-IV	2004	36.6	25.4	38.0	313
Cameroon	DHS-VI	2011	39.7	25.9	34.3	544
Chad	DHS-III	1996-97	47.6	34.9	17.5	320
Chad	DHS-IV	2004	32.8	35.7	31.5	375
Congo (Brazzaville)	DHS-V	2005	45.3	29.0	25.7	236
Congo (Brazzaville)	DHS-VI	2011-12	38.3	44.0	17.7	269
Congo Democratic Republic	DHS-V	2007	50.7	22.4	26.9	324
Côte d'Ivoire	DHS-III	1994	30.4	34.5	35.1	196
Côte d'Ivoire	DHS-V	2005	40.6	14.9	44.5	104
Côte d'Ivoire	DHS-VI	2011-12	28.0	31.5	40.5	287
Ethiopia	DHS-IV	2000	45.6	26.5	27.9	691
Ethiopia	DHS-IV	2005	44.2	30.3	25.6	533
Ethiopia	DHS-VI	2011	39.7	33.7	26.6	709
Gabon	DHS-III	2000-01	57.3	23.8	19.0	123
Gabon	DHS-VI	2012	50.7	22.9	26.4	115
Guinea	DHS-III	1999	42.7	33.9	23.4	203
Guinea	DHS-IV	2005	36.3	34.8	28.9	378

(Continued...)

Table 4.2 – *Continued*

Country	DHS survey round	Year of survey	Timing of maternal death			No. of maternal deaths
			During pregnancy	During delivery	During the postpartum period	
Sub-Saharan Africa						
Guinea	DHS-VI	2012	29.9	37.4	32.7	300
Kenya	DHS-III	1998	46.2	25.5	28.3	240
Kenya	DHS-IV	2003	41.1	28.9	29.9	204
Kenya	DHS-V	2008-09	32.6	37.4	30.0	205
Lesotho	DHS-IV	2004-05	30.9	18.3	50.8	131
Lesotho	DHS-V	2009-10	28.2	13.5	58.3	191
Liberia	DHS-V	2006-07	48.0	36.0	16.0	227
Madagascar	DHS-III	1997	44.1	23.4	32.6	242
Madagascar	DHS-IV	2003-04	38.2	29.0	32.9	224
Madagascar	DHS-V	2008-09	39.3	30.4	30.4	473
Malawi	DHS-II	1992	46.1	21.8	32.1	145
Malawi	DHS-IV	2000	25.8	46.2	28.0	581
Malawi	DHS-IV	2004-05	34.6	35.1	30.3	400
Malawi	DHS-V	2010	28.5	43.1	28.4	785
Mali	DHS-III	1995-96	45.4	26.4	28.3	308
Mali	DHS-IV	2001	30.6	32.6	36.8	390
Mali	DHS-V	2006	37.7	31.5	30.8	411
Mali	DHS-VI	2012-13	31.0	39.1	29.9	132
Mozambique	DHS-III	1997	57.0	13.7	29.3	177
Mozambique	DHS-IV	2003-04	51.5	18.0	30.5	273
Mozambique	DHS-VI	2011	61.5	13.6	24.9	198
Namibia	DHS-II	1992	65.9	15.3	18.8	67
Namibia	DHS-IV	2000	49.4	21.3	29.3	79
Namibia	DHS-V	2006-07	34.0	14.4	51.6	135
Niger	DHS-II	1992	30.4	44.1	25.4	306
Niger	DHS-V	2006	35.5	29.3	35.2	386
Niger	DHS-VI	2012	38.5	22.7	38.8	448
Nigeria	DHS-III	1999	53.8	25.0	21.2	80
Nigeria	DHS-V	2008	53.6	27.7	18.7	846
Rwanda	DHS-IV	2000	37.6	32.8	29.6	538
Rwanda	DHS-IV	2005	34.8	32.2	33.0	582
Rwanda	DHS-VI	2010-11	33.2	29.3	37.5	580
São Tomé and Príncipe	DHS-V	2008-09	57.1	26.6	16.3	25
Senegal	DHS-II	1992-93	48.1	30.8	21.2	156
Senegal	DHS-IV	2005	36.3	31.6	32.0	339
Senegal	DHS-VI	2010-11	35.0	32.3	32.8	326
Sierra Leone	DHS-V	2008	38.9	41.1	20.0	204
South Africa	DHS-III	1998	47.3	10.2	42.5	45
Swaziland	DHS-V	2006-07	44.8	17.9	37.3	75
Tanzania	DHS-III	1996	43.5	29.6	26.9	216
Tanzania	DHS-IV	2004-05	32.7	30.4	36.9	377
Tanzania	DHS-V	2009-10	32.7	28.4	38.9	273
Togo	DHS-III	1998	42.8	24.3	32.9	178

(Continued...)

Table 4.2 – *Continued*

Country	DHS survey round	Year of survey	Timing of maternal death: During pregnancy	Timing of maternal death: During delivery	Timing of maternal death: During the postpartum period	No. of maternal deaths
Sub-Saharan Africa						
Uganda	DHS-III	1995	49.0	28.8	22.3	221
Uganda	DHS-IV	2000-01	39.9	28.1	32.0	251
Uganda	DHS-V	2006	30.4	33.0	36.6	320
Uganda	DHS-VI	2011	31.0	36.0	33.1	367
Zambia	DHS-III	1996-97	46.1	15.7	38.2	249
Zambia	DHS-IV	2001-02	43.2	18.3	38.5	251
Zambia	DHS-V	2007	36.4	20.6	43.0	223
Zimbabwe	DHS-III	1994	30.1	42.4	27.5	108
Zimbabwe	DHS-IV	1999	46.6	21.2	32.2	115
Zimbabwe	DHS-V	2005-06	43.9	13.8	42.3	169
Zimbabwe	DHS-VI	2010-11	40.3	21.7	38.0	222
North Africa						
Jordan	DHS-III	1997	46.3	21.0	32.6	48
Morocco	DHS-II	1992	37.4	23.4	39.2	171
Morocco	DHS-IV	2003-04	28.9	24.3	46.8	222
Asia						
Cambodia	DHS-IV	2000	37.6	29.6	32.7	295
Cambodia	DHS-V	2005-06	31.6	32.4	36.0	323
Cambodia	DHS-V	2010-11	45.3	20.3	34.4	214
Indonesia	DHS-III	1994	0.0	88.3	11.7	432
Indonesia	DHS-III	1997	9.9	82.9	7.2	297
Indonesia	DHS-IV	2002-03	0.0	81.6	18.4	287
Indonesia	DHS-V	2007	0.0	82.3	17.7	318
Indonesia	DHS-VI	2012	33.7	40.7	25.6	334
Nepal	DHS-III	1996	36.7	15.1	48.2	298
Nepal	DHS-V	2006	39.5	21.5	39.0	181
Philippines	DHS-II	1993	52.2	26.0	21.7	141
Philippines	DHS-III	1998	41.2	33.7	25.1	147
Timor-Leste	DHS-VI	2009-10	23.7	54.0	22.3	326
Latin America and Caribbean						
Bolivia	DHS-III	1993-94	58.0	23.2	18.8	138
Bolivia	DHS-IV	2003-04	67.2	15.1	17.7	229
Bolivia	DHS-V	2008	40.5	41.2	18.3	227
Brazil	DHS-III	1996	45.3	31.0	23.8	106
Dominican Republic	DHS-IV	2002	51.1	24.0	24.8	109
Dominican Republic	DHS-V	2007	57.4	14.6	28.0	176
Guatemala	DHS-III	1995	55.3	26.8	17.9	129
Haiti	DHS-IV	2000	28.1	22.5	49.4	289
Haiti	DHS-V	2005-06	23.9	35.0	41.1	257
Peru	DHS-II	1991-92	35.8	64.2	0.0	132
Peru	DHS-III	1996	60.0	23.4	16.6	367
Peru	DHS-IV	2000	51.1	36.1	12.8	274

(Continued...)

Table 4.2 – *Continued*

Country	DHS survey round	Year of survey	Timing of maternal death: During pregnancy	Timing of maternal death: During delivery	Timing of maternal death: During the postpartum period	No. of maternal deaths
Latin America and Caribbean						
Peru	DHS-V	2003-08	49.6	34.8	15.6	452
Peru	DHS-VI	2011	55.0	26.2	18.9	197

Figure 4.4 shows the per cent distribution of timing of death in each country by survey rounds. In Indonesia, deaths during pregnancy and delivery were combined in the early rounds. With few exceptions (Kenya, Zimbabwe), the distribution patterns are similar for most countries.

When the percent distribution patterns were compared by duration of recall periods—recent (0-6 years) and distant (7-13 years)—we did not detect any systematic shifts in the distribution patterns (Table 4.3 and Figure 4.5).

Figure 4.3 Distribution of timing of maternal deaths (during pregnancy, during delivery, during the postpartum period), Demographic and Health Surveys 1990-2013

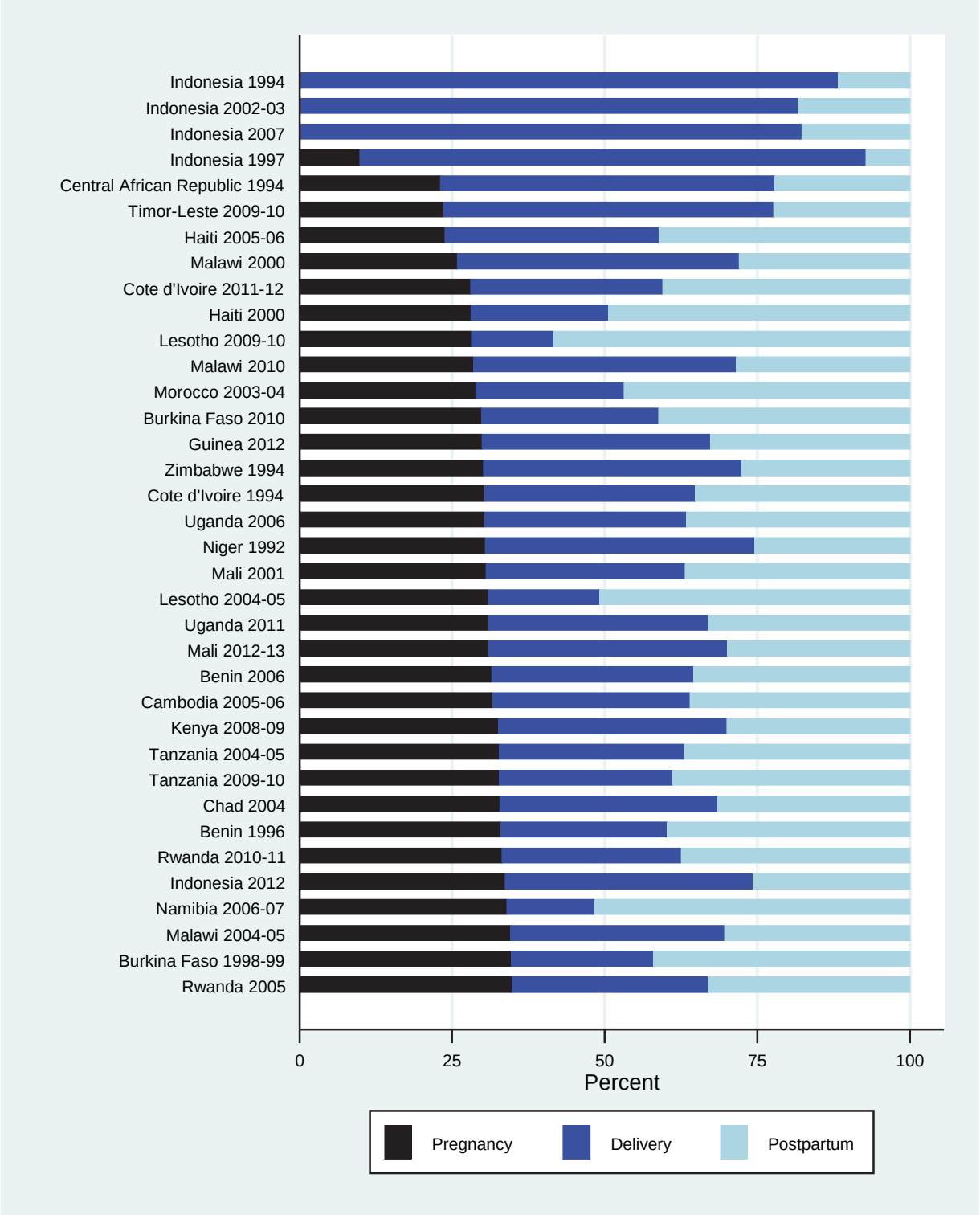


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Figure 4.3 – *Continued*

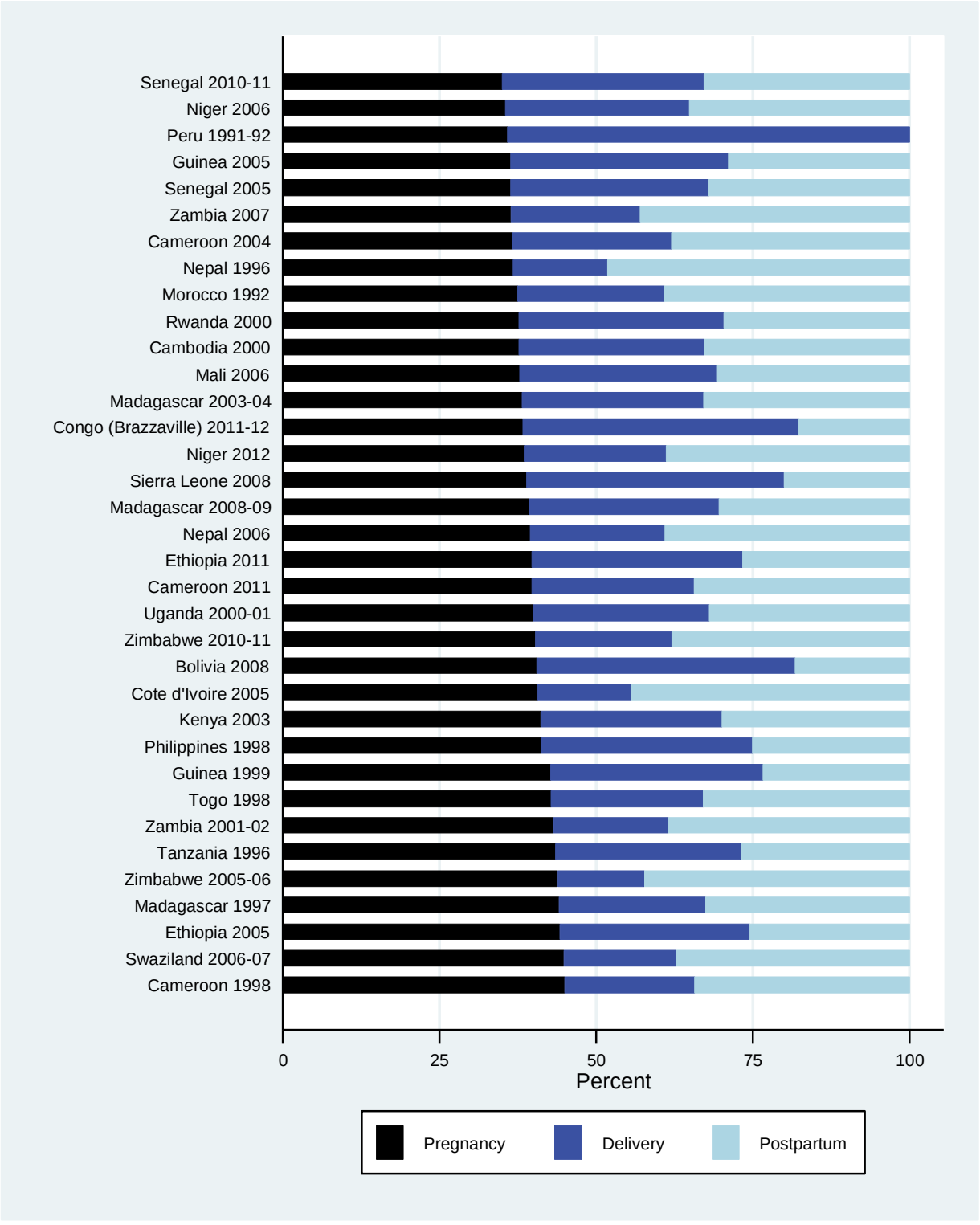

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Figure 4.3 – *Continued*

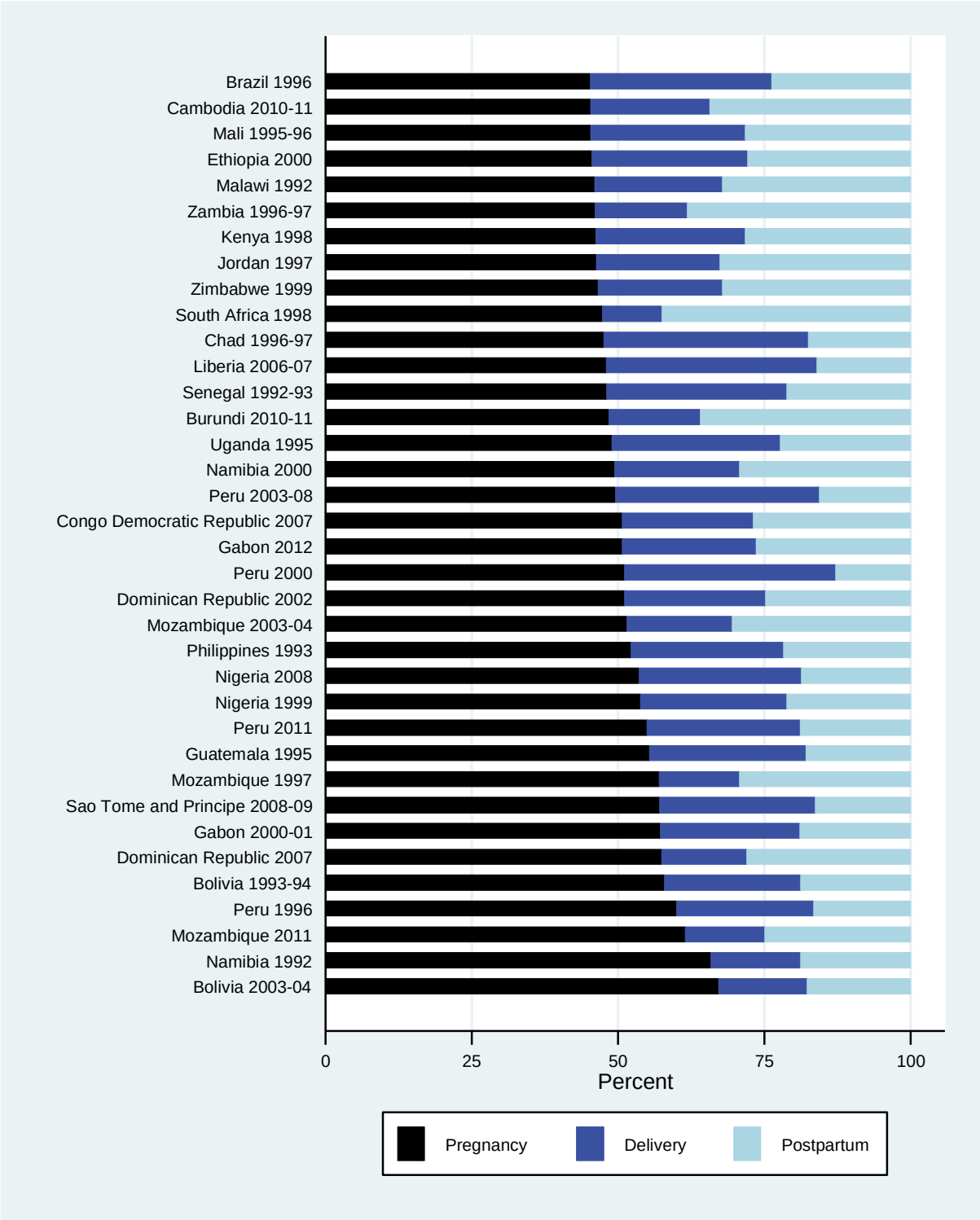

Figure 4.4 Distribution of the timing of maternal deaths by DHS survey rounds, Demographic and Health Surveys 1990-2013

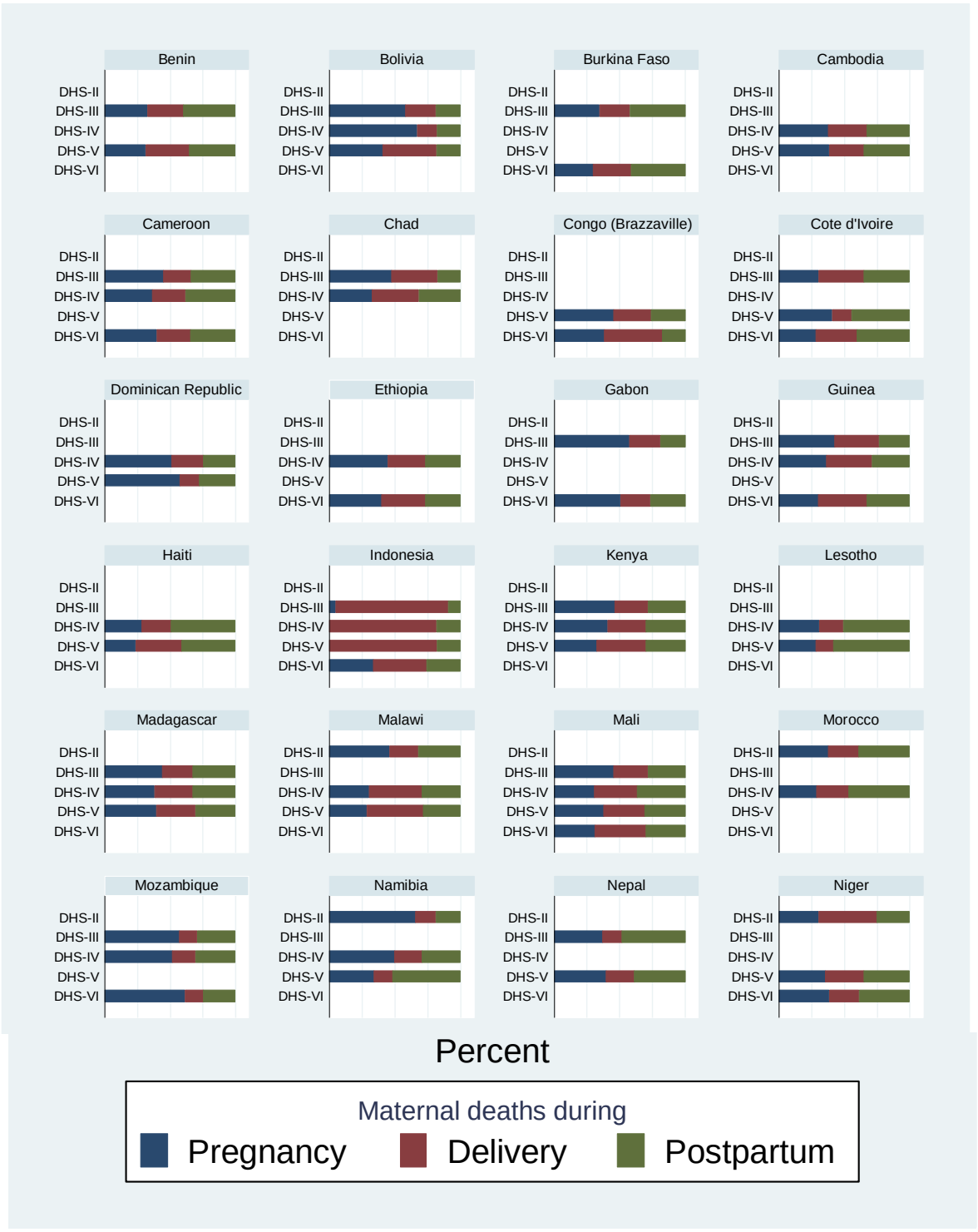

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Figure 4.4 – *Continued*

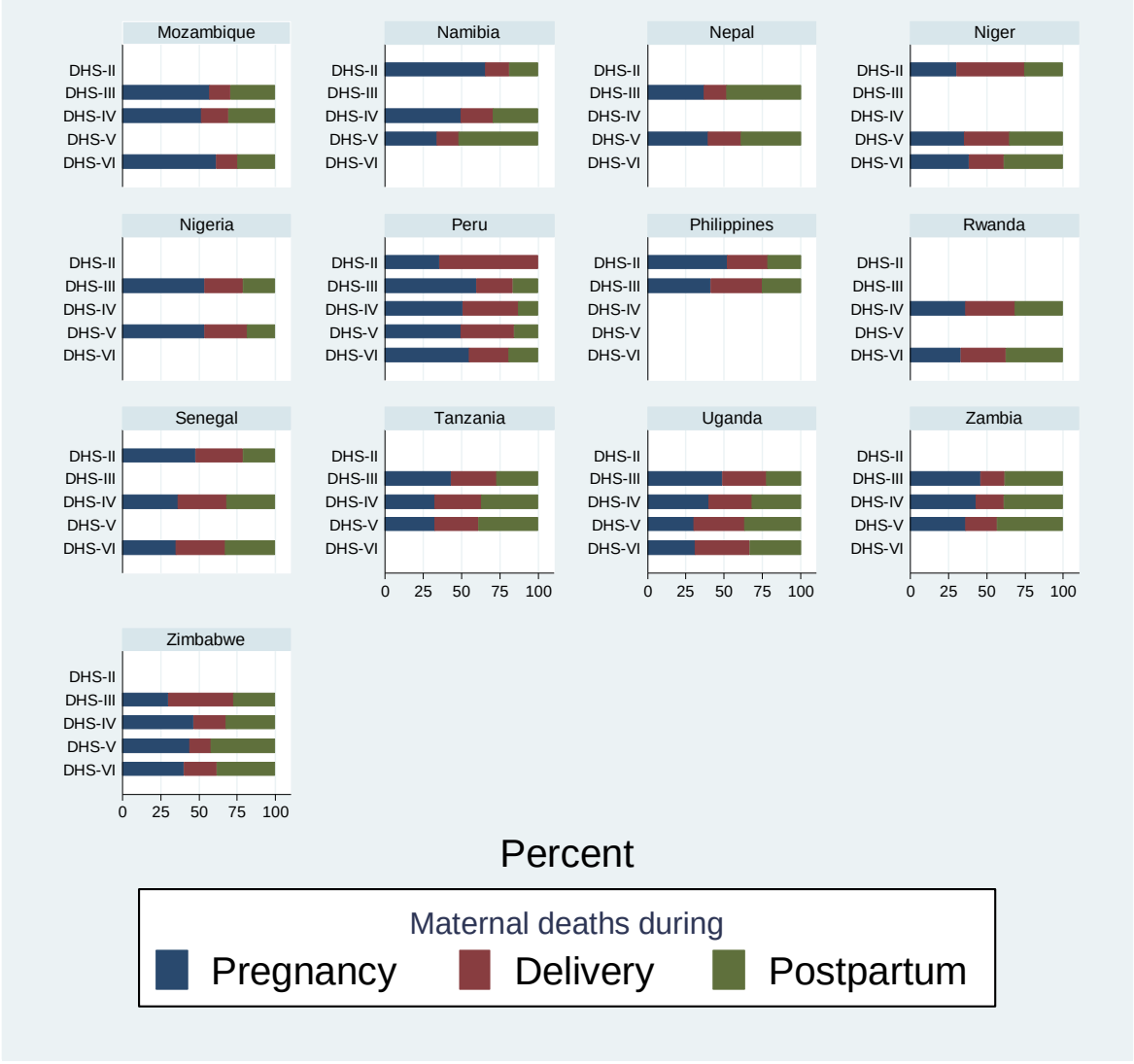


Table 4.3 Percent distribution of timing of maternal deaths (during pregnancy, during delivery, during the postpartum period) according to two recall periods before survey (recent: 0-6 years; distant: 7-13 years), Demographic and Health Surveys 1990-2013

Country	DHS survey round	Year of survey	Years before survey	Timing of maternal deaths			No. of maternal deaths
				During pregnancy	During delivery	During the postpartum period	
Sub-Saharan Africa							
Benin	DHS-III	1996	0-6 years	27.9	27.0	45.1	59
	DHS-III		7-13 years	32.6	22.4	45.0	33
Benin	DHS-V	2006	0-6 years	31.1	36.8	32.1	160
	DHS-V		7-13 years	32.6	30.9	36.6	108
Burkina Faso	DHS-III	1998-99	0-6 years	28.7	24.9	46.4	62
	DHS-III		7-13 years	38.6	13.3	48.2	22
Burkina Faso	DHS-VI	2010	0-6 years	26.2	26.7	47.1	137
	DHS-VI		7-13 years	32.6	21.4	46.0	88
Burundi	DHS-VI	2010-11	0-6 years	40.1	21.6	38.3	102
	DHS-VI		7-13 years	50.5	12.7	36.8	121
CAR	DHS-III	1994-95	0-6 years	21.1	53.8	25.1	160
	DHS-III		7-13 years	21.9	55.2	23.0	69
Cameroon	DHS-III	1998	0-6 years	47.8	16.8	35.4	61
	DHS-III		7-13 years	36.2	34.5	29.3	28
Cameroon	DHS-IV	2004	0-6 years	34.7	24.1	41.3	154
	DHS-IV		7-13 years	44.5	17.3	38.2	80
Cameroon	DHS-VI	2011	0-6 years	39.7	22.8	37.5	252
	DHS-VI		7-13 years	34.3	29.4	36.3	129
Chad	DHS-III	1996-97	0-6 years	45.1	34.5	20.4	140
	DHS-III		7-13 years	43.9	41.6	14.5	78
Chad	DHS-IV	2004	0-6 years	28.4	42.7	28.8	176
	DHS-IV		7-13 years	41.3	25.4	33.3	84
Congo (Brazzaville)	DHS-V	2005	0-6 years	45.1	31.0	23.9	114
	DHS-V		7-13 years	51.3	22.8	25.9	64
Congo (Brazzaville)	DHS-VI	2011-12	0-6 years	39.6	47.1	13.3	96
	DHS-VI		7-13 years	41.6	34.7	23.7	77
Congo Democratic Republic	DHS-V	2007	0-6 years	47.6	24.4	28.0	129
	DHS-V		7-13 years	40.7	26.1	33.2	90
Côte d'Ivoire	DHS-III	1994	0-6 years	30.2	30.1	39.8	101
	DHS-III		7-13 years	35.0	31.5	33.5	46
Côte d'Ivoire	DHS-V	2005	0-6 years	42.8	13.0	44.2	49
	DHS-V		7-13 years	35.6	19.4	45.0	39
Côte d'Ivoire	DHS-VI	2011-12	0-6 years	28.8	34.3	37.0	125
	DHS-VI		7-13 years	28.7	21.5	49.8	98
Ethiopia	DHS-IV	2000	0-6 years	45.6	25.6	28.8	267
	DHS-IV		7-13 years	40.0	31.4	28.5	179
Ethiopia	DHS-IV	2005	0-6 years	39.5	32.3	28.2	199
	DHS-IV		7-13 years	46.0	30.4	23.7	158
Ethiopia	DHS-VI	2011	0-6 years	44.6	31.9	23.5	220
	DHS-VI		7-13 years	34.2	31.1	34.8	210

(Continued...)

Table 4.3 – *Continued*

Country	DHS survey round	Year of survey	Years before survey	Timing of maternal deaths: During pregnancy	Timing of maternal deaths: During delivery	Timing of maternal deaths: During the postpartum period	No. of maternal deaths
Sub-Saharan Africa							
Gabon	DHS-III	2000-01	0-6 years	48.6	30.1	21.3	60
	DHS-III		7-13 years	59.8	12.4	27.8	31
Gabon	DHS-VI	2012	0-6 years	42.1	21.5	36.4	43
	DHS-VI		7-13 years	65.0	15.6	19.4	33
Guinea	DHS-III	1999	0-6 years	29.6	37.6	32.8	62
	DHS-III		7-13 years	44.3	38.3	17.4	61
Guinea	DHS-IV	2005	0-6 years	38.0	32.3	29.7	161
	DHS-IV		7-13 years	27.9	42.4	29.7	106
Guinea	DHS-VI	2012	0-6 years	30.2	35.5	34.3	116
	DHS-VI		7-13 years	28.5	39.4	32.1	89
Kenya	DHS-III	1998	0-6 years	48.0	23.4	28.6	144
	DHS-III		7-13 years	48.4	22.6	29.0	40
Kenya	DHS-IV	2003	0-6 years	39.8	31.0	29.2	106
	DHS-IV		7-13 years	50.2	16.1	33.7	46
Kenya	DHS-V	2008-09	0-6 years	29.4	37.2	33.4	99
	DHS-V		7-13 years	36.3	31.1	32.6	60
Lesotho	DHS-IV	2004-05	0-6 years	31.8	17.0	51.3	83
	DHS-IV		7-13 years	31.5	29.3	39.2	21
Lesotho	DHS-V	2009-10	0-6 years	27.4	10.5	62.1	111
	DHS-V		7-13 years	29.7	6.1	64.1	47
Liberia	DHS-V	2006-07	0-6 years	52.6	38.0	9.5	128
	DHS-V		7-13 years	40.3	37.8	21.9	56
Madagascar	DHS-III	1997	0-6 years	48.4	18.7	32.9	99
	DHS-III		7-13 years	40.9	26.5	32.6	80
Madagascar	DHS-IV	2003-04	0-6 years	28.2	31.1	40.7	95
	DHS-IV		7-13 years	54.2	18.7	27.1	64
Madagascar	DHS-V	2008-09	0-6 years	40.5	29.9	29.6	191
	DHS-V		7-13 years	38.0	32.5	29.5	127
Malawi	DHS-II	1992	0-6 years	40.7	31.3	28.1	71
	DHS-II		7-13 years	46.1	12.0	41.9	37
Malawi	DHS-IV	2000	0-6 years	22.7	46.4	30.9	348
	DHS-IV		7-13 years	29.1	55.0	15.9	98
Malawi	DHS-IV	2004-05	0-6 years	33.1	36.2	30.7	243
	DHS-IV		7-13 years	22.0	42.3	35.7	91
Malawi	DHS-V	2010	0-6 years	25.5	47.6	27.0	345
	DHS-V		7-13 years	28.2	41.4	30.4	261
Mali	DHS-III	1995-96	0-6 years	46.9	24.7	28.4	125
	DHS-III		7-13 years	44.5	26.1	29.4	91
Mali	DHS-IV	2001	0-6 years	31.1	33.6	35.3	179
	DHS-IV		7-13 years	28.9	22.8	48.3	94
Mali	DHS-V	2006	0-6 years	40.1	23.8	36.1	170
	DHS-V		7-13 years	35.3	35.7	29.0	127

(Continued...)

Table 4.3 – *Continued*

Country	DHS survey round	Year of survey	Years before survey	Timing of maternal deaths: During pregnancy	Timing of maternal deaths: During delivery	Timing of maternal deaths: During the postpartum period	No. of maternal deaths
Sub-Saharan Africa							
Mali	DHS-VI	2012-13	0-6 years	32.5	34.4	33.1	76
	DHS-VI		7-13 years	28.0	50.9	21.0	38
Mozambique	DHS-III	1997	0-6 years	56.9	28.4	14.7	50
	DHS-III		7-13 years	43.6	3.3	53.1	77
Mozambique	DHS-IV	2003-04	0-6 years	52.6	18.6	28.8	121
	DHS-IV		7-13 years	61.4	13.9	24.7	60
Mozambique	DHS-VI	2011	0-6 years	60.0	11.6	28.4	106
	DHS-VI		7-13 years	55.4	15.6	29.0	47
Namibia	DHS-II	1992	0-6 years	78.8	11.2	10.0	31
	DHS-II		7-13 years	45.0	31.5	23.5	12
Namibia	DHS-IV	2000	0-6 years	63.0	11.2	25.8	43
	DHS-IV		7-13 years	36.9	28.8	34.3	26
Namibia	DHS-V	2006-07	0-6 years	33.9	10.7	55.4	71
	DHS-V		7-13 years	23.8	25.9	50.3	33
Niger	DHS-II	1992	0-6 years	26.6	45.3	28.0	103
	DHS-II		7-13 years	30.1	47.5	22.4	106
Niger	DHS-V	2006	0-6 years	34.6	28.5	36.9	180
	DHS-V		7-13 years	34.7	26.6	38.7	111
Niger	DHS-VI	2012	0-6 years	44.8	18.4	36.8	194
	DHS-VI		7-13 years	30.3	29.7	40.0	113
Nigeria	DHS-III	1999	0-6 years	65.8	23.8	10.4	42
	DHS-III		7-13 years	32.5	31.6	35.9	16
Nigeria	DHS-V	2008	0-6 years	51.0	28.8	20.2	403
	DHS-V		7-13 years	53.1	24.0	22.9	238
Rwanda	DHS-IV	2000	0-6 years	40.7	29.3	30.0	351
	DHS-IV		7-13 years	32.4	37.4	30.2	127
Rwanda	DHS-IV	2005	0-6 years	24.0	36.7	39.3	179
	DHS-IV		7-13 years	42.2	26.5	31.3	293
Rwanda	DHS-VI	2010-11	0-6 years	24.7	27.4	47.9	129
	DHS-VI		7-13 years	30.5	34.9	34.6	160
São Tomé and Príncipe	DHS-V	2008-09	0-6 years	64.1	0.0	35.9	7
	DHS-V		7-13 years	71.5	14.7	13.8	11
Senegal	DHS-II	1992-93	0-6 years	45.3	31.3	23.4	64
	DHS-II		7-13 years	48.9	35.6	15.6	45
Senegal	DHS-IV	2005	0-6 years	39.3	33.9	26.8	121
	DHS-IV		7-13 years	37.6	28.5	33.9	81
Senegal	DHS-VI	2010-11	0-6 years	29.4	34.9	35.8	149
	DHS-VI		7-13 years	35.7	30.2	34.1	71
Sierra Leone	DHS-V	2008	0-6 years	34.6	42.5	22.9	99
	DHS-V		7-13 years	42.5	38.7	18.8	55
South Africa	DHS-III	1998	0-6 years	48.1	4.1	47.8	19
	DHS-III		7-13 years	39.0	16.2	44.8	16

(Continued...)

Table 4.3 – *Continued*

Country	DHS survey round	Year of survey	Years before survey	Timing of maternal deaths: During pregnancy	Timing of maternal deaths: During delivery	Timing of maternal deaths: During the postpartum period	No. of maternal deaths
Sub-Saharan Africa							
Swaziland	DHS-V	2006-07	0-6 years	40.5	18.6	40.9	48
	DHS-V		7-13 years	57.4	27.7	14.9	13
Tanzania	DHS-III	1996	0-6 years	41.5	28.0	30.5	122
	DHS-III		7-13 years	44.1	28.0	27.9	37
Tanzania	DHS-IV	2004-05	0-6 years	33.8	25.7	40.6	156
	DHS-IV		7-13 years	31.9	27.9	40.2	104
Tanzania	DHS-V	2009-10	0-6 years	33.3	25.5	41.1	115
	DHS-V		7-13 years	31.0	24.5	44.4	87
Togo	DHS-III	1998	0-6 years	39.1	19.6	41.3	70
	DHS-III		7-13 years	45.9	28.0	26.1	48
Uganda	DHS-III	1995	0-6 years	53.0	28.0	19.0	112
	DHS-III		7-13 years	32.4	30.7	36.9	66
Uganda	DHS-IV	2000-01	0-6 years	34.6	29.6	35.8	120
	DHS-IV		7-13 years	39.1	25.2	35.7	66
Uganda	DHS-V	2006	0-6 years	32.9	32.6	34.5	105
	DHS-V		7-13 years	31.2	23.5	45.3	107
Uganda	DHS-VI	2011	0-6 years	31.7	29.9	38.5	109
	DHS-VI		7-13 years	29.1	31.1	39.8	88
Zambia	DHS-III	1996-97	0-6 years	45.7	13.6	40.6	149
	DHS-III		7-13 years	55.0	16.6	28.4	53
Zambia	DHS-IV	2001-02	0-6 years	43.6	16.2	40.2	148
	DHS-IV		7-13 years	35.5	22.6	41.9	62
Zambia	DHS-V	2007	0-6 years	29.7	22.2	48.1	106
	DHS-V		7-13 years	38.8	15.1	46.1	68
Zimbabwe	DHS-III	1994	0-6 years	34.2	43.8	22.0	50
	DHS-III		7-13 years	25.1	27.7	47.2	16
Zimbabwe	DHS-IV	1999	0-6 years	49.3	16.8	33.8	78
	DHS-IV		7-13 years	28.6	30.3	41.1	16
Zimbabwe	DHS-V	2005-06	0-6 years	46.4	13.5	40.1	101
	DHS-V		7-13 years	38.4	22.0	39.7	44
Zimbabwe	DHS-VI	2010-11	0-6 years	38.8	21.7	39.4	139
	DHS-VI		7-13 years	37.9	18.6	43.4	48
North Africa							
Jordan	DHS-III	1997	0-6 years	32.1	36.6	31.3	9
	DHS-III		7-13 years	43.2	25.9	30.8	11
Morocco	DHS-II	1992	0-6 years	36.8	24.6	38.6	57
	DHS-II		7-13 years	27.4	25.8	46.8	62
Morocco	DHS-IV	2003-04	0-6 years	28.0	17.2	54.8	59
	DHS-IV		7-13 years	39.7	20.2	40.1	48
Asia							
Cambodia	DHS-IV	2000	0-6 years	38.7	32.1	29.2	101
	DHS-IV		7-13 years	34.4	29.9	35.7	68

(Continued...)

Table 4.3 – *Continued*

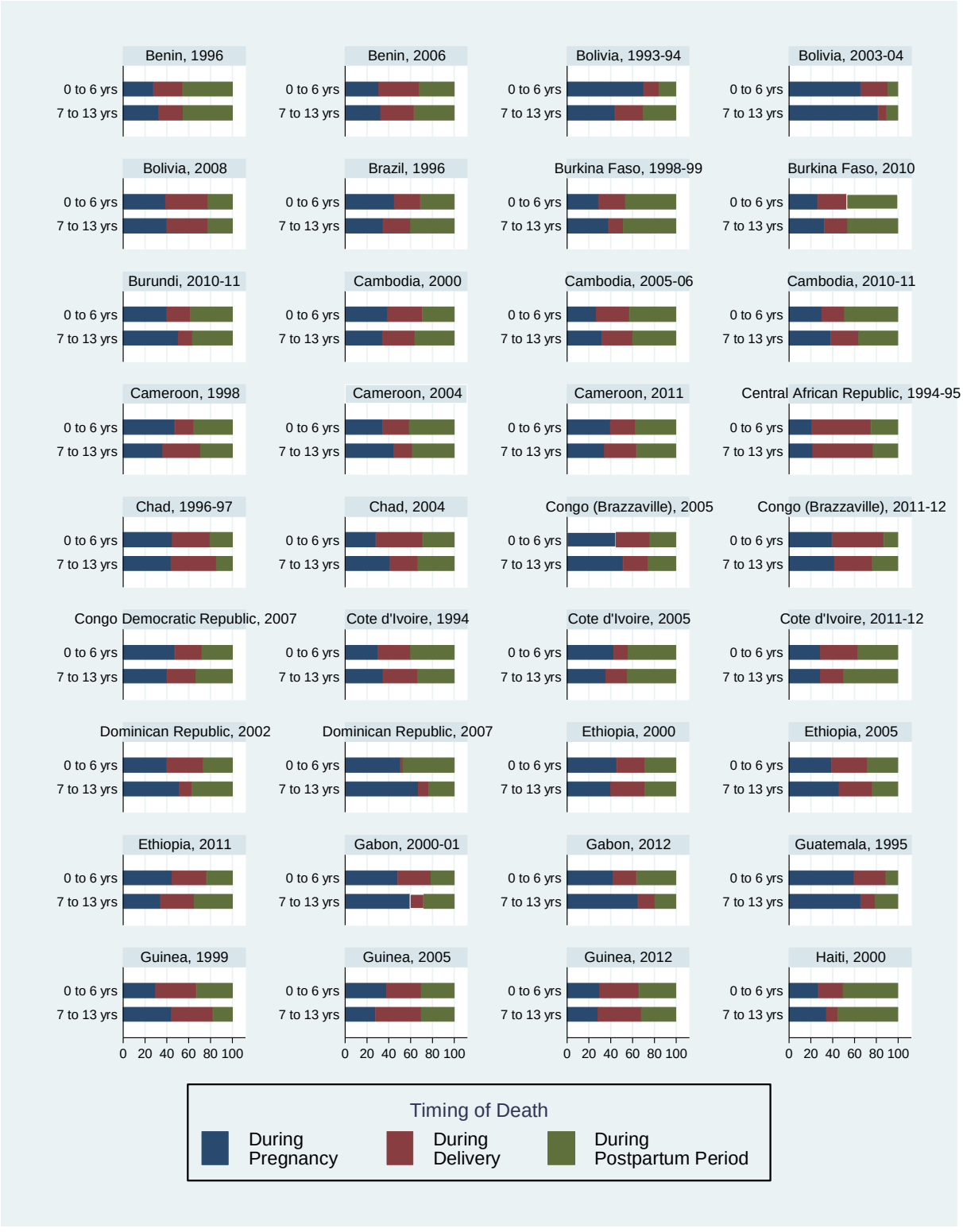
Country	DHS survey round	Year of survey	Years before survey	Timing of maternal deaths: During pregnancy	Timing of maternal deaths: During delivery	Timing of maternal deaths: During the postpartum period	No. of maternal deaths
Asia							
Cambodia	DHS-V	2005-06	0-6 years	26.6	30.6	42.8	99
	DHS-V		7-13 years	32.1	28.1	39.7	68
Cambodia	DHS-V	2010-11	0-6 years	30.1	20.7	49.3	45
	DHS-V		7-13 years	38.3	25.7	36.1	61
Indonesia	DHS-III	1994	0-6 years	0.0	87.2	12.8	164
	DHS-III		7-13 years	0.0	88.3	11.7	117
Indonesia	DHS-III	1997	0-6 years	8.3	89.7	2.1	109
	DHS-III		7-13 years	6.7	80.5	12.7	87
Indonesia	DHS-IV	2002-03	0-6 years	0.0	82.6	17.4	106
	DHS-IV		7-13 years	0.0	73.4	26.6	76
Indonesia	DHS-V	2007	0-6 years	0.0	86.7	13.3	79
	DHS-V		7-13 years	0.0	79.2	20.8	101
Indonesia	DHS-VI	2012	0-6 years	39.9	35.4	24.7	113
	DHS-VI		7-13 years	31.4	37.9	30.7	64
Nepal	DHS-III	1996	0-6 years	44.8	13.8	41.4	87
	DHS-III		7-13 years	28.3	7.4	64.3	81
Nepal	DHS-V	2006	0-6 years	33.5	23.9	42.6	39
	DHS-V		7-13 years	38.3	29.6	32.1	39
Philippines	DHS-II	1993	0-6 years	49.7	18.1	32.2	52
	DHS-II		7-13 years	47.5	35.4	17.1	46
Philippines	DHS-III	1998	0-6 years	35.9	23.8	40.3	44
	DHS-III		7-13 years	43.9	36.7	19.4	51
Timor-Leste	DHS-VI	2009-10	0-6 years	22.6	55.7	21.7	122
	DHS-VI		7-13 years	21.5	46.7	31.8	98
Latin America and Caribbean							
Bolivia	DHS-III	1993-94	0-6 years	70.4	14.1	15.5	50
	DHS-III		7-13 years	44.4	25.1	30.5	34
Bolivia	DHS-IV	2003-04	0-6 years	65.8	24.4	9.8	56
	DHS-IV		7-13 years	81.8	7.5	10.8	63
Bolivia	DHS-V	2008	0-6 years	38.7	38.7	22.6	60
	DHS-V		7-13 years	40.2	37.2	22.6	61
Brazil	DHS-III	1996	0-6 years	45.3	24.1	30.6	29
	DHS-III		7-13 years	35.2	25.0	39.8	20
Dominican Republic	DHS-IV	2002	0-6 years	40.3	33.3	26.4	30
	DHS-IV		7-13 years	51.5	11.6	37.0	30
Dominican Republic	DHS-V	2007	0-6 years	51.1	1.9	47.0	61
	DHS-V		7-13 years	67.0	9.6	23.3	38
Guatemala	DHS-III	1995	0-6 years	59.8	29.1	11.1	40
	DHS-III		7-13 years	65.9	13.0	21.1	32
Haiti	DHS-IV	2000	0-6 years	27.4	22.4	50.2	96
	DHS-IV		7-13 years	34.4	10.6	55.0	97

(Continued...)

Table 4.3 – *Continued*

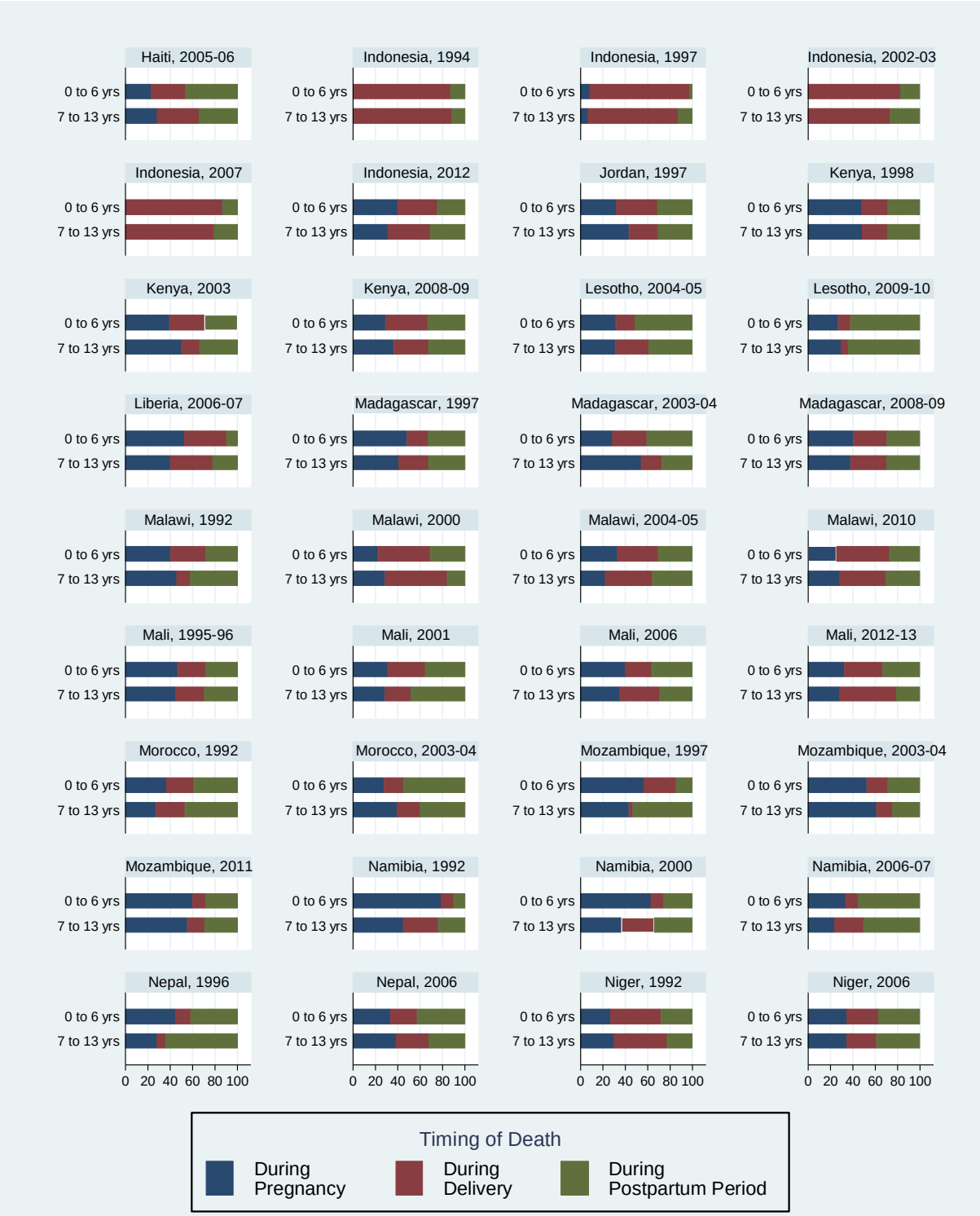
Country	DHS survey round	Year of survey	Years before survey	Timing of maternal deaths: During pregnancy	Timing of maternal deaths: During delivery	Timing of maternal deaths: During the postpartum period	No. of maternal deaths
Latin America and Caribbean							
Haiti	DHS-V	2005-06	0-6 years	23.1	30.7	46.2	104
	DHS-V		7-13 years	28.4	37.7	33.9	72
Peru	DHS-II	1991-92	0-6 years	48.0	52.0	0.0	40
	DHS-II		7-13 years	33.5	66.5	0.0	37
Peru	DHS-III	1996	0-6 years	65.6	17.9	16.6	113
	DHS-III		7-13 years	55.5	27.2	17.3	89
Peru	DHS-IV	2000	0-6 years	50.9	27.1	22.0	63
	DHS-IV		7-13 years	53.8	43.2	3.0	67
Peru	DHS-V	2003-08	0-6 years	53.6	29.4	17.0	85
	DHS-V		7-13 years	47.5	39.8	12.7	101
Peru	DHS-VI	2011	0-6 years	56.0	34.0	10.0	36
	DHS-VI		7-13 years	59.7	16.4	23.9	47

Figure 4.5 Distribution of timing of maternal deaths (during pregnancy, during delivery, during the postpartum period) by recall periods: recent (0-6 years) and distant (7-13 years), Demographic and Health Surveys 1990-2013



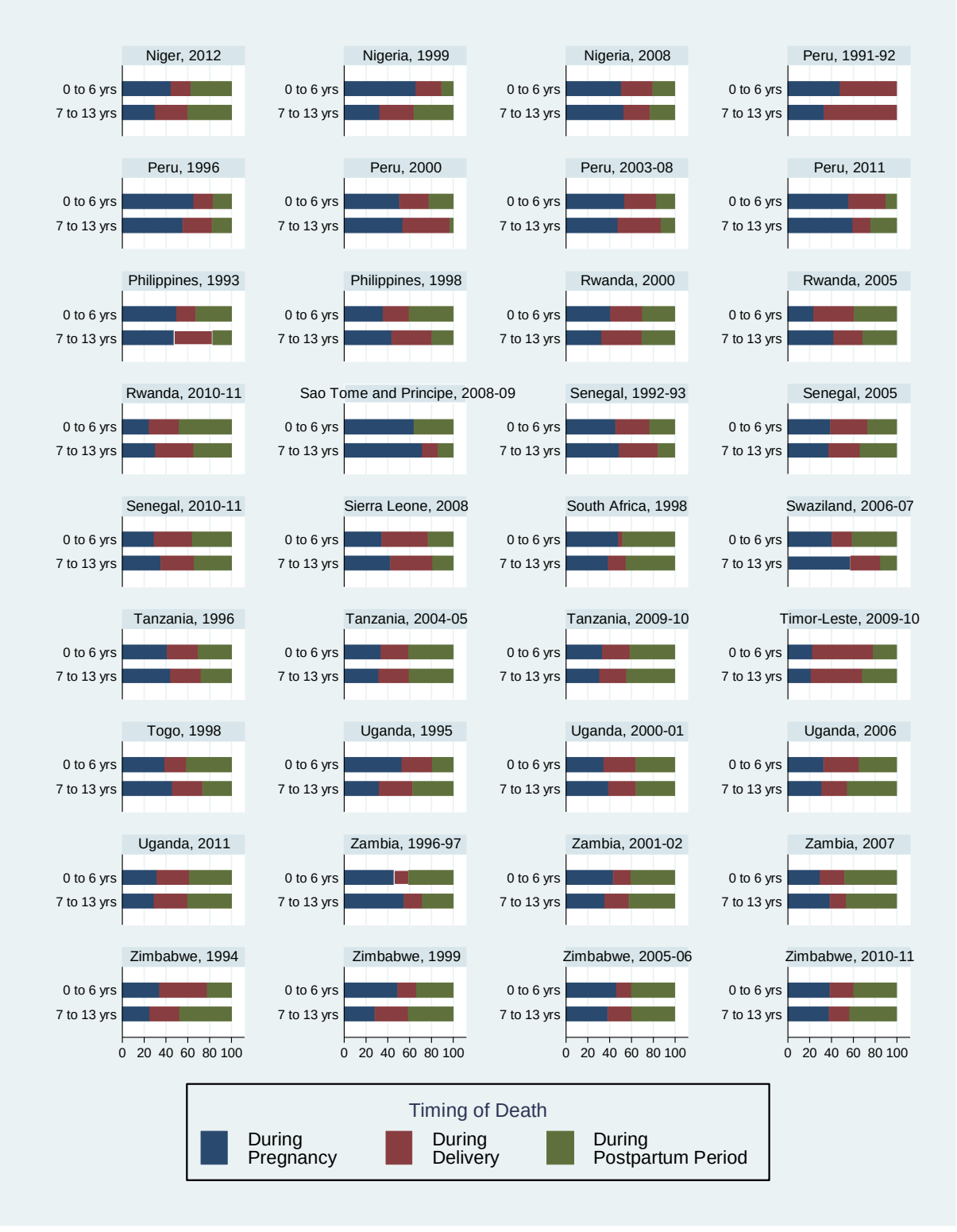
(Continued...)

Figure 4.5 – *Continued*



(Continued...)

Figure 4.5 – *Continued*



4.2. Maternal Mortality Estimates

In DHS survey reports, only deaths that are reported to have occurred during pregnancy, delivery, or the postpartum period (2 months in recent DHS surveys; 6 weeks in some earlier DHS surveys) are considered maternal deaths. Deaths with unknown status about pregnancy—i.e., missing or not sure response to the questions: Was the sibling pregnant (when died)? Did she die during childbirth? Did she die within two months after the end of a pregnancy or childbirth?—are classified as non-maternal.

It is possible that respondents may be unware of the pregnancy status of sisters who died, especially in the first trimester, or they may deliberately underreport pregnancy status—for example, if a sister died from abortion-related complications in a setting where abortion is illegal or socially unacceptable. In summary, all deaths lacking pregnancy status are not necessarily non-maternal deaths. We consider that DHS may underestimate maternal mortality in areas with high non-response rates for the timing of death variable.

Table 4.4 shows the maternal mortality rate (maternal deaths per 1,000 woman-years of exposure) and maternal mortality ratio (deaths per 100,000 live births) with 95% confidence intervals based on standard DHS practice based on 7 years of recall (observation) period from the survey date. Confidence intervals were estimated using the jackknife method.

Confidence interval of MMR estimates was quite large in most DHS surveys. This was not unexpected. Maternal deaths are rare events in the statistical sense. The estimation of maternal mortality indicators with a reasonably small margin-of-error requires a very large sample size, which is beyond the scope of DHS surveys. The relative margin-of-error of MMR (RME: margin-of-error divided by MMR), shown in Figure 4.6, varied between 20% and 40% in most (71.3%) DHS surveys. All surveys have more than 10% RME. Countries with low MMR had higher relative margins-of-error.

Table 4.4 Estimates of maternal mortality rates (MMRates) and maternal mortality ratios (MMRs) with 95% confidence internals (CI) from 106 Demographic and Health Surveys 1990-2013

Country	DHS survey round	Year of survey	GFR	MMRate	MMR	95% CI		LTR
						LL	UL	
Sub-Saharan Africa								
Benin	DHS-III	1996	205	1.020	498	375	621	0.032
Benin	DHS-V	2006	193	0.773	400	328	472	0.023
Burkina Faso	DHS-III	1998-99	219	0.962	440	305	575	0.031
Burkina Faso	DHS-VI	2010	200	0.682	341	276	405	0.021
Burundi	DHS-VI	2010-11	194	0.972	500	379	621	0.033
Cameroon	DHS-III	1998	178	0.909	511	375	647	0.028
Cameroon	DHS-IV	2004	174	1.198	689	568	810	0.036
Cameroon	DHS-VI	2011	170	1.330	782	649	914	0.040
Central African Republic	DHS-III	1994-95	185	2.553	1380	1141	1620	0.076
Chad	DHS-III	1996-97	223	1.863	836	665	1007	0.055
Chad	DHS-IV	2004	225	2.472	1098	685	1512	0.074
Congo (Brazzaville)	DHS-V	2005	154	1.204	781	495	1068	0.036
Congo (Brazzaville)	DHS-VI	2011-12	161	0.687	426	277	575	0.021
Congo Democratic Republic	DHS-V	2007	201	1.087	542	409	674	0.034
Cote d'Ivoire	DHS-III	1994	197	1.179	597	418	777	0.036
Cote d'Ivoire	DHS-V	2005	163	0.880	539	325	754	0.026
Cote d'Ivoire	DHS-VI	2011-12	164	1.004	614	448	780	0.031
Ethiopia	DHS-IV	2000	181	1.577	872	707	1036	0.051

(Continued...)

Table 4.4 – *Continued*

Country	DHS survey round	Year of survey	GFR	MMRate	MMR	95% CI LL	95% CI UL	LTR
Sub-Saharan Africa								
Ethiopia	DHS-IV	2005	185	1.240	671	549	793	0.040
Ethiopia	DHS-VI	2011	169	1.140	675	543	808	0.036
Gabon	DHS-III	2000-01	149	0.771	519	331	707	0.023
Gabon	DHS-VI	2012	131	0.412	316	180	451	0.013
Guinea	DHS-III	1999	196	1.033	528	380	676	0.032
Guinea	DHS-IV	2005	181	2.030	1119	912	1327	0.065
Guinea	DHS-VI	2012	173	1.250	724	536	911	0.039
Kenya	DHS-III	1998	160	1.191	743	594	892	0.036
Kenya	DHS-IV	2003	165	0.834	506	400	612	0.025
Kenya	DHS-V	2008-09	157	0.818	520	348	691	0.025
Lesotho	DHS-IV	2004-05	114	1.066	936	684	1187	0.034
Lesotho	DHS-V	2009-10	108	1.347	1244	931	1558	0.041
Liberia	DHS-V	2006-07	172	1.698	990	683	1297	0.053
Madagascar	DHS-III	1997	202	0.990	490	367	614	0.030
Madagascar	DHS-IV	2003-04	172	0.887	517	348	686	0.028
Madagascar	DHS-V	2008-09	163	0.812	498	404	593	0.026
Malawi	DHS-II	1992	212	1.302	615	406	824	0.042
Malawi	DHS-IV	2000	210	2.357	1123	959	1288	0.070
Malawi	DHS-IV	2004-05	204	1.997	981	823	1138	0.058
Malawi	DHS-V	2010	197	1.331	675	571	778	0.040
Mali	DHS-III	1995-96	234	1.265	541	437	645	0.039
Mali	DHS-IV	2001	231	1.340	581	453	710	0.042
Mali	DHS-V	2006	224	1.036	462	377	548	0.032
Mali	DHS-VI	2012-13	214	0.790	368	261	476	0.024
Mozambique	DHS-III	1997	186	0.538	289	123	455	0.017
Mozambique	DHS-IV	2003-04	188	0.877	466	366	566	0.027
Mozambique	DHS-VI	2011	187	0.763	408	305	511	0.024
Namibia	DHS-II	1992	161	0.473	294	194	394	0.015
Namibia	DHS-IV	2000	134	0.442	330	203	458	0.014
Namibia	DHS-V	2006-07	114	0.580	509	360	658	0.018
Niger	DHS-II	1992	250	1.535	614	475	753	0.046
Niger	DHS-V	2006	242	1.716	708	578	838	0.052
Niger	DHS-VI	2012	264	1.411	535	427	643	0.043
Nigeria	DHS-III	1999	173	0.497	287	189	384	0.015
Nigeria	DHS-V	2008	186	1.014	545	477	614	0.032
Rwanda	DHS-IV	2000	179	2.789	1559	1324	1795	0.094
Rwanda	DHS-IV	2005	176	1.330	757	623	891	0.045
Rwanda	DHS-VI	2010-11	154	0.751	487	395	579	0.025
Sao Tome and Principe	DHS-V	2008-09	152	0.177	116	27	205	0.006
Senegal	DHS-II	1992-93	200	0.998	498	367	629	0.031
Senegal	DHS-IV	2005	166	0.666	401	314	487	0.021
Senegal	DHS-VI	2010-11	163	0.790	484	340	628	0.024
Sierra Leone	DHS-V	2008	175	1.487	849	615	1082	0.045

(Continued...)

Table 4.4 – *Continued*

Country	DHS survey round	Year of survey	GFR	MMRate	MMR	95% CI LL	95% CI UL	LTR
Sub-Saharan Africa								
South Africa	DHS-III	1998	97	0.146	150	79	222	0.005
Swaziland	DHS-V	2006-07	131	0.774	589	394	783	0.023
Tanzania	DHS-III	1996	193	1.179	612	461	764	0.036
Tanzania	DHS-IV	2004-05	185	1.119	605	476	735	0.034
Tanzania	DHS-V	2009-10	178	0.880	494	376	611	0.027
Togo	DHS-III	1998	175	0.732	417	302	532	0.023
Uganda	DHS-III	1995	235	1.245	529	401	657	0.037
Uganda	DHS-IV	2000-01	236	1.248	529	420	638	0.037
Uganda	DHS-V	2006	225	0.939	418	317	519	0.029
Uganda	DHS-VI	2011	211	0.912	433	318	548	0.028
Zambia	DHS-III	1996-97	206	1.337	649	522	777	0.040
Zambia	DHS-IV	2001-02	198	1.443	729	589	869	0.043
Zambia	DHS-V	2007	198	1.170	591	453	730	0.035
Zimbabwe	DHS-III	1994	152	0.556	365	253	477	0.017
Zimbabwe	DHS-IV	1999	140	0.904	647	476	819	0.027
Zimbabwe	DHS-V	2005-06	135	0.829	613	461	764	0.024
Zimbabwe	DHS-VI	2010-11	132	1.262	960	781	1139	0.037
North Africa								
Jordan	DHS-III	1997	145	0.051	35	8	62	0.002
Morocco	DHS-II	1992	130	0.493	378	255	501	0.017
Morocco	DHS-IV	2003-04	81	0.221	272	186	359	0.007
Asia								
Cambodia	DHS-IV	2000	127	0.554	437	328	547	0.019
Cambodia	DHS-V	2005-06	106	0.499	472	341	603	0.017
Cambodia	DHS-V	2010-11	95	0.197	206	125	287	0.006
Indonesia	DHS-III	1994	96	0.396	411	284	537	0.012
Indonesia	DHS-III	1997	91	0.262	288	137	438	0.008
Indonesia	DHS-IV	2002-03	82	0.271	331	222	440	0.009
Indonesia	DHS-V	2007	80	0.166	209	137	281	0.005
Indonesia	DHS-VI	2012	75	0.235	313	222	404	0.008
Nepal	DHS-III	1996	162	0.875	539	395	683	0.026
Nepal	DHS-V	2006	252	0.334	133	84	181	0.010
Philippines	DHS-II	1993	131	0.229	175	120	230	0.007
Philippines	DHS-III	1998	119	0.206	172	123	222	0.007
Timor-Leste	DHS-VI	2009-10	172	0.959	557	411	703	0.034
Latin America								
Bolivia	DHS-III	1993-94	160	0.577	360	218	503	0.018
Bolivia	DHS-IV	2003-04	134	0.281	210	146	274	0.009
Bolivia	DHS-V	2008	115	0.309	268	183	353	0.010
Brazil	DHS-III	1996	83	0.153	184	104	263	0.005
Dominican Republic	DHS-IV	2002	99	0.163	165	75	254	0.005
Dominican Republic	DHS-V	2007	88	0.152	173	104	242	0.005
Guatemala	DHS-III	1995	166	0.257	155	96	214	0.008

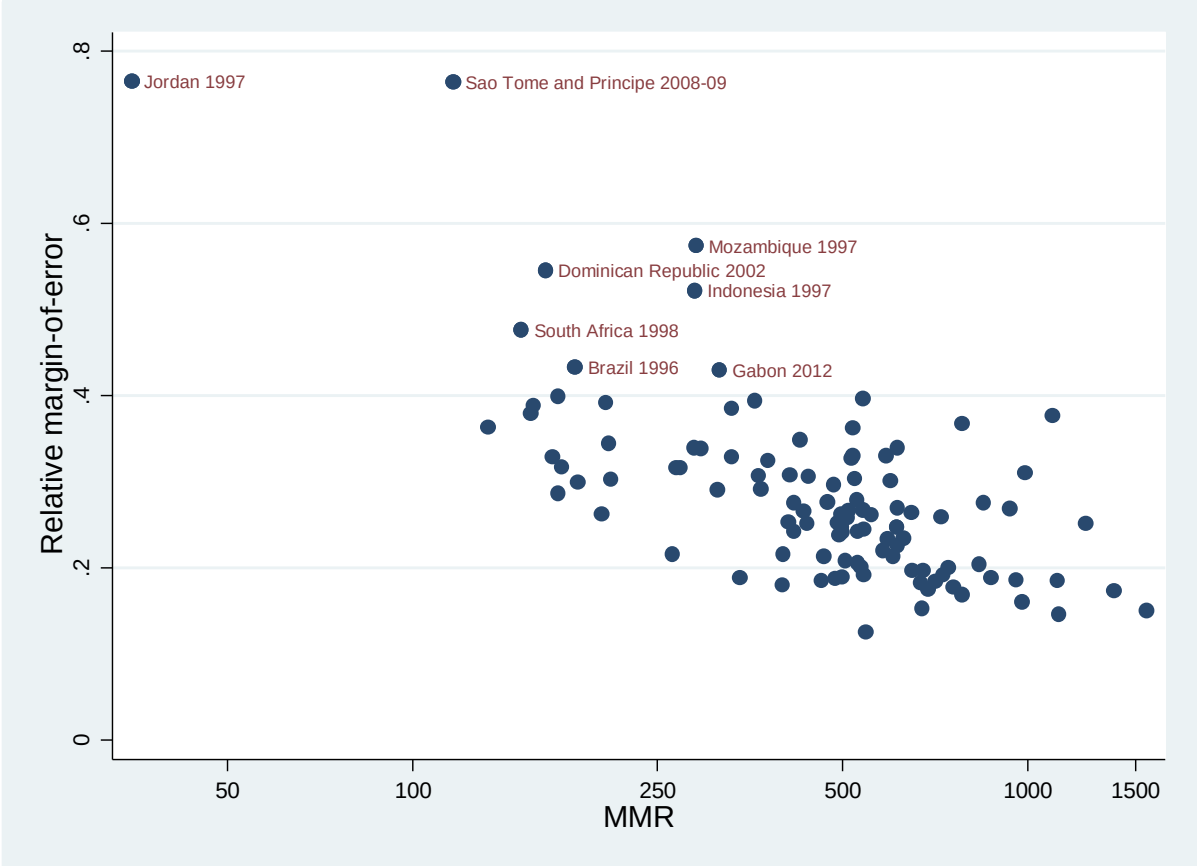
(Continued...)

Table 4.4 – *Continued*

Country	DHS survey round	Year of survey	GFR	MMRate	MMR	95% CI LL	95% CI UL	LTR
Latin America								
Haiti	DHS-IV	2000	148	0.773	523	364	682	0.026
Haiti	DHS-V	2005-06	124	0.777	628	481	776	0.026
Peru	DHS-II	1991-92	121	0.205	169	113	224	0.006
Peru	DHS-III	1996	119	0.316	265	208	322	0.010
Peru	DHS-IV	2000	99	0.183	185	130	241	0.006
Peru	DHS-V	2003-08	81	0.163	203	150	256	0.005
Peru	DHS-VI	2011	80	0.126	157	96	219	0.004

Note: Data from 4 survey rounds could not be used for MMR estimation because some standard variables were missing (e.g., imputed age, cause of death maternal).

Figure 4.6 Relative margin-of-error by MMR estimates, Demographic and Heath Surveys 1990-2013



Note: Surveys with high relative margin-of-error > 0.4 are labeled.

The extent of missingness of the variable on timing of death in relation to pregnancy status for the sisters included in the analysis (died during last 7 years) for 108 DHS surveys is shown in Table 4.5 by rank order (from lowest to highest). Almost half of the surveys have more than 10% missing responses for this variable.

There are several methods suggested in the statistical literature to handle missing data. Missing values are often handled during statistical analysis by the *complete case analysis method* in which the missing cases are dropped from the analysis. However, there are concerns that this procedure is inefficient due to sample size reduction (increases margin-of-errors and reduces statistical power) and may introduce bias.

A simple approach is the weighting method. Under an assumption that the distribution of maternal deaths among sisters with unknown pregnancy status is similar to the distribution among sisters with known pregnancy status, we may correct for missing responses by a weighting factor of $1/(1-f)$, where f is the fraction of non-response rate. It is also possible to take into account the sample characteristics in the weighting method, which is often used in longitudinal surveys for correcting drop-out rates.

A preferred simple data adjustment procedure is to perform imputation that takes *uncertainty* into account in the distribution of missingness. Two common procedures of imputation are single imputation (such as hot deck) and multiple imputation methods, such as suggested by Rubin (1987).

For assessing the extent of underestimation of MMR due to missing values in the pregnancy status during female deaths, which is used for classifying maternal mortality, we used all these three methods (complete case analysis, weighting, imputation) for estimating corrected MMRs and comparing them to DHS reported MMRs.

In case of complete case analysis, woman person-years for missing cases were excluded from the denominator of the MMRate calculation. We have used two methods of imputation: single imputation with hot deck method (Andridge and Little 2010), and multiple imputation (Rubin 1987).

Hot deck is a simple method in which the missing values are populated with the values from other values in the data set, either randomly or based on responses from similar subjects. In recent years, the multiple imputation method has superseded the single imputation method. However, multiple imputation is better implemented by individuals who are both imputers and analysts. It is difficult to distribute multiple imputed data sets for public use. On the other hand, single imputed data are convenient for distribution.

Missing values are often classified into three types: missing completely at random (MCAR), missing at random (MAR), and nonignorable (NI) missing values. We consider that the MAR is a more realistic assumption, which assumes that the missingness is related to some observed characteristics of the subjects. Our preliminary analyses suggest that the missing values were substantially related to respondents' characteristics, including age, urban/rural residence, education, and wealth quintile in several settings. For multiple imputation method, we used 10 imputations and used these variables for determining the probabilities of missing values. Multinomial logistic regressions using respondents' characteristics, including age, urban/rural residence, education, and wealth quintile, were utilized for imputing the missing values in the timing of the death.

The corrected MMR estimates with weighting are shown in the last column of Table 4.5. The mean values of MMR of the study countries with missing response in the timing of death was 531 per 100,000 live births; in case of weighted analysis, the mean value of MMR was 596. In this adjustment procedure, the extent of underestimation bias is proportional to the extent of missingness.

Side-by-side comparisons of complete case analysis and imputation methods are shown in Table 4.6. Complete case analysis results are similar to the standard DHS estimates for the MMR (mean MMR for

the study surveys with missing values: 531). Maternal deaths are rare events; so the exclusion of person-years of sisters with missing responses from denominators had negligible effects on the MMRate and thus on MMR estimates.

Imputation methods, however, increased MMR estimates substantially. Mean MMRs for h ot deck and multiple imputation methods were 605 and 609, respectively. MMR estimates corrected with weighting and two imputation methods are quite similar.

The MMR estimates from all five methods (DHS standard method, weighted with the inverse probability of missing response; complete case analysis, hot deck imputation, and multiple imputations) are shown graphically in Figure 4.7.

Table 4.5 Extent of missing responses on timing of death for ascertainment of maternal mortality in 105 Demographic and Health Surveys 1990-2013

Rank in under-estimation	Region	Country	DHS survey round	Year of survey	Percent missing timing of death (maternal or non-maternal)	MMR	MMR corrected for missing response
1	North Africa	Jordan	DHS-III	1997	0.0	35	35
2	Sub-Saharan Africa	Mali	DHS-VI	2012-13	0.0	368	368
3	Sub-Saharan Africa	Senegal	DHS-VI	2010-11	0.0	484	484
4	Latin America & Caribbean	Peru	DHS-VI	2011	0.1	157	158
5	Asia	Timor-Leste	DHS-VI	2009-10	0.5	557	560
6	Asia	Nepal	DHS-III	1996	1.0	539	544
7	Asia	Cambodia	DHS-V	2010-11	1.8	206	210
8	Sub-Saharan Africa	Uganda	DHS-VI	2011	1.9	433	441
9	Asia	Nepal	DHS-V	2006	2.7	133	136
10	Sub-Saharan Africa	Ethiopia	DHS-IV	2000	2.7	872	896
11	Sub-Saharan Africa	Burundi	DHS-VI	2010-11	3.1	500	516
12	Sub-Saharan Africa	Rwanda	DHS-VI	2010-11	3.3	487	504
13	Sub-Saharan Africa	Chad	DHS-III	1996-97	3.6	836	867
14	Latin America & Caribbean	Peru	DHS-V	2003-08	3.7	203	211
15	Sub-Saharan Africa	Burkina Faso	DHS-VI	2010	3.8	341	354
16	Sub-Saharan Africa	Kenya	DHS-III	1998	3.9	743	773
17	Asia	Cambodia	DHS-V	2005-06	4.0	472	492
18	Sub-Saharan Africa	Kenya	DHS-IV	2003	4.5	506	529
19	Sub-Saharan Africa	Ethiopia	DHS-VI	2011	4.7	675	709
20	Sub-Saharan Africa	Tanzania	DHS-V	2009-10	4.8	494	518
21	Sub-Saharan Africa	Central African Republic	DHS-III	1994-95	4.8	1,380	1,451
22	Sub-Saharan Africa	Cameroon	DHS-VI	2011	4.9	782	822
23	Sub-Saharan Africa	Tanzania	DHS-IV	2004-05	5.0	605	637
24	Sub-Saharan Africa	Rwanda	DHS-IV	2000	5.0	1,559	1,642
25	Sub-Saharan Africa	Chad	DHS-IV	2004	5.1	1,098	1,157

(Continued...)

Table 4.5 – *Continued*

Rank in under-estimation	Region	Country	DHS survey round	Year of survey	Percent missing timing of death (maternal or non-maternal)	MMR	MMR corrected for missing response
26	Asia	Indonesia	DHS-III	1997	5.1	288	303
27	Asia	Cambodia	DHS-IV	2000	5.5	437	463
28	Latin America & Caribbean	Bolivia	DHS-V	2008	5.6	268	284
29	Sub-Saharan Africa	Benin	DHS-III	1996	5.7	498	528
30	Sub-Saharan Africa	Zimbabwe	DHS-VI	2010-11	5.9	960	1,020
31	Latin America & Caribbean	Haiti	DHS-V	2005-06	6.0	628	668
32	Sub-Saharan Africa	Mali	DHS-III	1995-96	6.4	541	578
33	Sub-Saharan Africa	Mozambique	DHS-IV	2003-04	6.5	466	499
34	Sub-Saharan Africa	Niger	DHS-VI	2012	6.6	535	573
35	North Africa	Morocco	DHS-II	1992	6.8	378	406
36	Sub-Saharan Africa	Malawi	DHS-IV	2004-05	6.9	981	1,054
37	Sub-Saharan Africa	Zambia	DHS-IV	2001-02	6.9	729	784
38	Sub-Saharan Africa	Cote d'Ivoire	DHS-III	1994	7.0	597	642
39	Sub-Saharan Africa	Zambia	DHS-V	2007	7.1	591	636
40	Sub-Saharan Africa	Guinea	DHS-VI	2012	7.2	724	780
41	Sub-Saharan Africa	Congo Democratic Republic	DHS-V	2007	7.2	542	584
42	Sub-Saharan Africa	Congo (Brazzaville)	DHS-VI	2011-12	7.2	426	460
43	Sub-Saharan Africa	Malawi	DHS-IV	2000	7.3	1,123	1,212
44	Sub-Saharan Africa	Uganda	DHS-V	2006	7.3	418	451
45	Sub-Saharan Africa	Tanzania	DHS-III	1996	7.4	612	661
46	Sub-Saharan Africa	Zambia	DHS-III	1996-97	7.6	649	703
47	Latin America & Caribbean	Haiti	DHS-IV	2000	7.8	523	567
48	Sub-Saharan Africa	Guinea	DHS-IV	2005	8.0	1,119	1216
49	Sub-Saharan Africa	Malawi	DHS-V	2010	8.0	675	733
50	Sub-Saharan Africa	Ethiopia	DHS-IV	2005	8.3	671	732
51	Sub-Saharan Africa	Zimbabwe	DHS-III	1994	8.7	365	400
52	Sub-Saharan Africa	Cote d'Ivoire	DHS-V	2005	8.9	539	592
53	Sub-Saharan Africa	Kenya	DHS-V	2008-09	9.2	520	572
54	Sub-Saharan Africa	Rwanda	DHS-IV	2005	9.4	757	835
55	Asia	Indonesia	DHS-III	1994	9.6	411	455
56	Sub-Saharan Africa	Lesotho	DHS-IV	2004-05	9.7	936	1,036
57	Sub-Saharan Africa	Zimbabwe	DHS-V	2005-06	10.0	613	681
58	North Africa	Morocco	DHS-IV	2003-04	10.0	272	303

(Continued...)

Table 4.5 – *Continued*

Rank in under-estimation	Region	Country	DHS survey round	Year of survey	Percent missing timing of death (maternal or non-maternal)	MMR	MMR corrected for missing response
59	Sub-Saharan Africa	Madagascar	DHS-III	1997	10.2	490	546
60	Sub-Saharan Africa	Swaziland	DHS-V	2006-07	10.3	589	656
61	Sub-Saharan Africa	Congo (Brazzaville)	DHS-V	2005	10.4	781	872
62	Asia	Indonesia	DHS-IV	2002-03	10.6	331	370
63	Latin America & Caribbean	Dominican Republic	DHS-V	2007	10.6	173	193
64	Sub-Saharan Africa	Mozambique	DHS-VI	2011	10.8	408	457
65	Latin America & Caribbean	Bolivia	DHS-III	1993-94	10.8	360	404
66	Latin America & Caribbean	Bolivia	DHS-IV	2003-04	10.9	210	236
67	Sub-Saharan Africa	Senegal	DHS-II	1992-93	11.1	498	560
68	Sub-Saharan Africa	Benin	DHS-V	2006	11.1	400	450
69	Sub-Saharan Africa	Cameroon	DHS-IV	2004	11.5	689	779
70	Sub-Saharan Africa	Uganda	DHS-IV	2000-01	11.7	529	599
71	Sub-Saharan Africa	Burkina Faso	DHS-III	1998-99	11.8	440	499
72	Sub-Saharan Africa	Niger	DHS-V	2006	12.4	708	808
73	Sub-Saharan Africa	Namibia	DHS-V	2006-07	12.5	509	582
74	Sub-Saharan Africa	Cameroon	DHS-III	1998	12.6	511	584
75	Asia	Indonesia	DHS-VI	2012	12.9	313	359
76	Sub-Saharan Africa	Niger	DHS-II	1992	13.2	614	707
77	Sub-Saharan Africa	Zimbabwe	DHS-IV	1999	13.4	647	747
78	Latin America & Caribbean	Peru	DHS-III	1996	13.9	265	307
79	Sub-Saharan Africa	Mali	DHS-IV	2001	14.1	581	677
80	Asia	Indonesia	DHS-V	2007	14.9	209	245
81	Sub-Saharan Africa	Uganda	DHS-III	1995	14.9	529	622
82	Sub-Saharan Africa	Madagascar	DHS-V	2008-09	15.0	498	586
83	Sub-Saharan Africa	Gabon	DHS-VI	2012	15.3	316	373
84	Sub-Saharan Africa	Togo	DHS-III	1998	15.9	417	496
85	Sub-Saharan Africa	Gabon	DHS-III	2000-01	16.8	519	623
86	Sub-Saharan Africa	Cote d'Ivoire	DHS-VI	2011-12	17.1	614	740
87	Latin America & Caribbean	Peru	DHS-II	1991-92	17.1	169	204
88	Sub-Saharan Africa	Malawi	DHS-II	1992	17.4	615	744
89	Sub-Saharan Africa	Senegal	DHS-IV	2005	18.1	401	489
90	Sub-Saharan Africa	Madagascar	DHS-IV	2003-04	18.6	517	635
91	Sub-Saharan Africa	Lesotho	DHS-V	2009-10	18.9	1,244	1,535
92	Latin America & Caribbean	Peru	DHS-IV	2000	19.1	185	229

(Continued...)

Table 4.5 – *Continued*

Rank in under-estimation	Region	Country	DHS survey round	Year of survey	Percent missing timing of death (maternal or non-maternal)	MMR	MMR corrected for missing response
93	Sub-Saharan Africa	Nigeria	DHS-V	2008	19.2	545	674
94	Asia	Philippines	DHS-III	1998	19.9	172	215
95	Latin America & Caribbean	Brazil	DHS-III	1996	20.5	184	231
96	Sub-Saharan Africa	Guinea	DHS-III	1999	21.9	528	676
97	Sub-Saharan Africa	South Africa	DHS-III	1998	22.5	150	194
98	Latin America & Caribbean	Dominican Republic	DHS-IV	2002	22.6	165	213
99	Sub-Saharan Africa	Mali	DHS-V	2006	22.7	462	598
100	Sub-Saharan Africa	Liberia	DHS-V	2006-07	22.7	990	1,280
101	Sub-Saharan Africa	Mozambique	DHS-III	1997	24.4	289	382
102	Latin America & Caribbean	Guatemala	DHS-III	1995	25.5	155	209
103	Sub-Saharan Africa	Sierra Leone	DHS-V	2008	25.8	849	1,143
104	Asia	Philippines	DHS-II	1993	29.1	175	247
105	Sub-Saharan Africa	Namibia	DHS-IV	2000	31.3	330	481
106	Sub-Saharan Africa	Namibia	DHS-II	1992	35.5	294	456
107	Sub-Saharan Africa	Nigeria	DHS-III	1999	35.5	287	445
108	Sub-Saharan Africa	Sao Tome and Principe	DHS-V	2008-09	41.6	116	199

Table 4.6 Comparison of MMR estimates from imputation and complete case analysis using DHS data, Demographic and Health Surveys 1990-2013

		Hot deck imputation			Multiple imputation			Complete case analysis		
Country	**Year**	**MMR**	**LL**	**UL**	**MMR**	**LL**	**UL**	**MMR**	**LL**	**UL**
Sub-Saharan Africa										
Benin	1996	561	424	699	541	410	674	505	381	630
Benin	2006	474	397	552	458	382	534	403	331	476
Burkina Faso	1998-99	518	374	663	493	352	635	442	307	578
Burkina Faso	2010	369	302	437	359	293	425	343	279	408
Burundi	2010	515	394	637	521	399	645	500	380	621
CAR	1994-95	1481	1236	1727	1454	1211	1697	1397	1157	1638
Cameroon	1998	630	475	786	632	472	793	524	380	669
Cameroon	2004	829	699	960	803	668	939	699	578	821
Cameroon	2011	826	692	961	820	686	955	782	650	915
Chad	1996-97	853	678	1029	875	697	1055	845	670	1021
Chad	2004	1220	753	1688	1227	760	1694	1174	709	1640
Congo (Brazzaville)	2005	887	590	1185	912	598	1228	824	524	1125
Congo (Brazzaville)	2011-12	476	322	631	476	320	633	432	283	582

(Continued...)

Table 4.6 – *Continued*

		Hot deck imputation			Multiple imputation			Complete case analysis		
Country	**Year**	**MMR**	**LL**	**UL**	**MMR**	**LL**	**UL**	**MMR**	**LL**	**UL**
Sub-Saharan Africa										
Congo Democratic Republic	2007	615	476	755	633	483	784	548	414	683
Côte d'Ivoire	1994	659	476	843	637	456	820	606	427	786
Côte d'Ivoire	2005	610	387	834	605	383	828	558	341	776
Côte d'Ivoire	2011-12	770	587	954	754	572	937	615	450	781
Ethiopia	2000	907	740	1075	918	748	1089	883	718	1049
Ethiopia	2005	796	661	932	743	614	873	681	558	805
Ethiopia	2011	708	574	843	713	578	850	676	544	809
Gabon	2000	672	474	871	676	469	884	526	338	715
Gabon	2012	465	298	633	425	263	587	319	184	455
Guinea	1999	720	551	890	703	533	875	539	389	690
Guinea	2005	1257	1033	1482	1246	1025	1469	1161	947	1376
Guinea	2012	803	609	998	806	610	1002	743	554	933
Kenya	1998	786	634	939	785	632	938	744	596	893
Kenya	2003	550	435	666	560	446	675	514	406	623
Kenya	2008-09	604	427	782	595	419	773	522	351	694
Lesotho	2004	1125	842	1409	1045	782	1308	945	692	1199
Lesotho	2009	1550	1203	1898	1579	1222	1936	1256	939	1574
Liberia	2007	1265	941	1590	1277	951	1603	1002	693	1312
Madagascar	1997	560	431	690	565	436	696	492	369	616
Madagascar	2003-04	609	435	784	635	444	828	520	351	690
Madagascar	2008-09	618	509	728	604	499	710	503	409	598
Malawi	1992	679	466	893	742	522	963	618	409	828
Malawi	2000	1243	1066	1421	1216	1047	1387	1131	966	1297
Malawi	2004	1106	942	1271	1082	916	1249	987	829	1146
Malawi	2010	740	634	847	733	626	842	675	572	779
Mali	1995-96	575	466	685	591	484	700	546	442	651
Mali	2001	685	545	826	681	544	819	583	455	712
Mali	2006	631	525	738	616	512	720	474	387	562
Mozambique	1997	360	185	536	423	220	628	290	123	458
Mozambique	2003	533	424	643	525	417	635	487	382	593
Mozambique	2011	468	360	577	462	355	570	412	309	516
Namibia	1992	505	366	645	438	312	564	295	195	396
Namibia	2000	490	325	656	536	369	705	333	205	462
Namibia	2006-07	573	418	729	591	434	749	510	362	659
Niger	1992	766	593	940	809	636	982	616	477	756
Niger	2006	834	691	978	812	674	950	723	593	854

(Continued...)

Table 4.6 – *Continued*

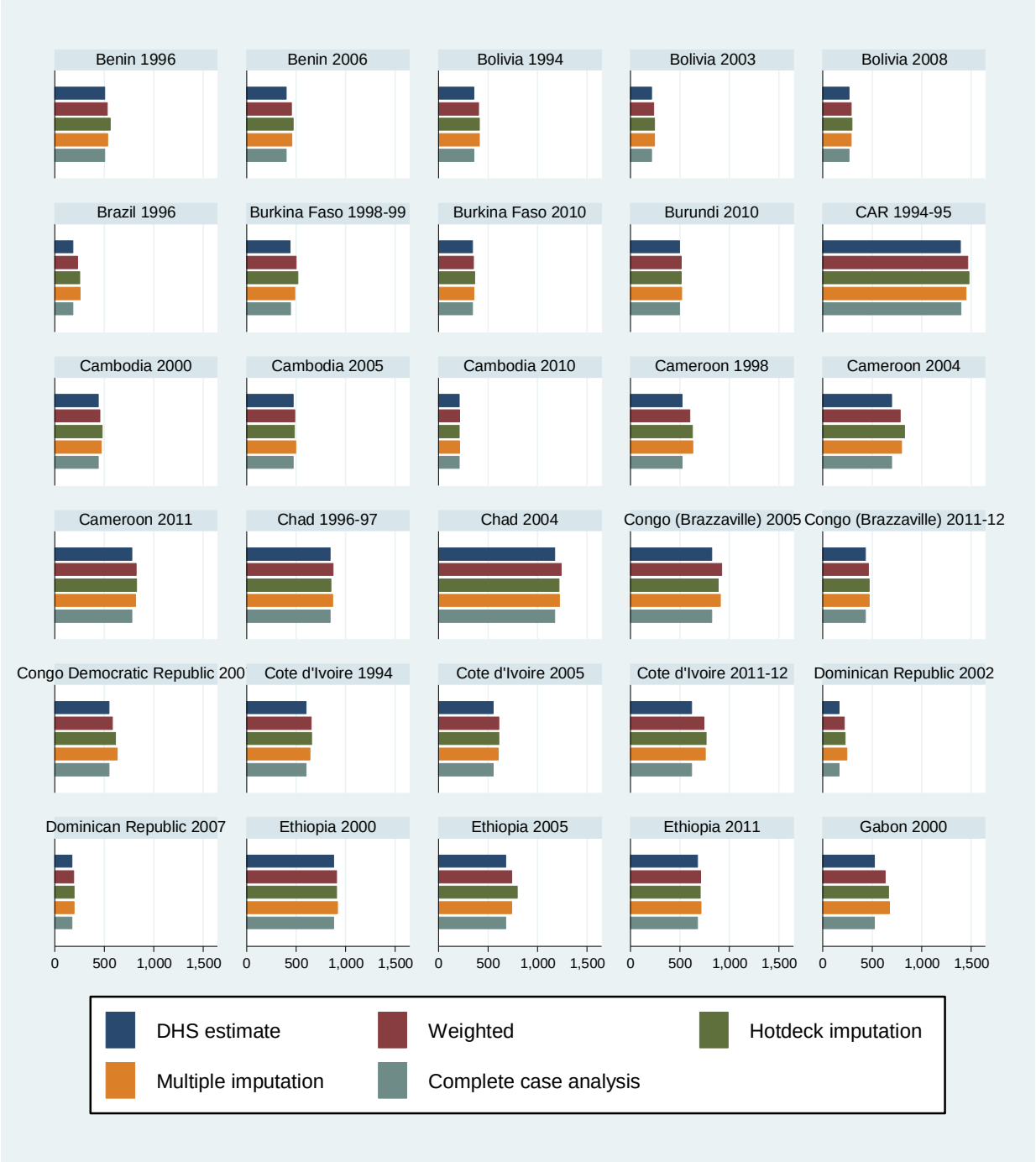
		Hot deck imputation			Multiple imputation			Complete case analysis		
Country	**Year**	**MMR**	**LL**	**UL**	**MMR**	**LL**	**UL**	**MMR**	**LL**	**UL**
Sub-Saharan Africa										
Nigeria	1999	447	325	570	464	338	590	294	196	393
Nigeria	2008	712	634	791	705	626	785	552	483	622
Rwanda	2000	1647	1406	1889	1726	1477	1977	1588	1349	1828
Rwanda	2005	847	709	986	835	695	975	760	626	895
Rwanda	2010	512	420	605	511	418	604	492	401	584
São Tomé and Príncipe	2008-09	165	65	266	290	127	453	117	29	206
Senegal	1992-93	611	468	755	625	478	773	499	368	631
Senegal	2005	560	456	665	517	417	618	417	328	507
Sierra Leone	2008	1173	909	1438	1242	966	1518	903	667	1140
South Africa	1998	179	103	256	201	116	287	151	80	223
Swaziland	2006-07	686	477	896	680	469	892	593	398	789
Tanzania	1996	682	525	840	674	516	833	616	465	768
Tanzania	2004-05	629	497	762	657	522	793	613	484	743
Tanzania	2010	563	438	689	545	423	668	507	389	626
Togo	1998	498	377	620	485	361	610	419	304	535
Uganda	1995-96	626	489	764	643	499	788	539	410	669
Uganda	2000-01	625	504	747	636	517	757	541	432	651
Uganda	2006	442	339	546	463	357	571	424	321	528
Uganda	2011	446	330	563	447	331	564	433	318	549
Zambia	1996	695	564	827	714	581	847	652	524	781
Zambia	2001-02	807	658	957	796	649	945	733	593	874
Zambia	2007	633	492	775	643	500	787	592	454	731
Zimbabwe	1994	377	263	492	405	285	526	366	254	479
Zimbabwe	1999	766	587	946	784	596	972	649	478	821
Zimbabwe	2005-06	680	525	836	693	537	849	613	462	765
Zimbabwe	2010	995	813	1178	1007	825	1191	963	784	1143
North Africa										
Morocco	1992	513	362	665	544	400	689	379	257	502
Morocco	2003-04	321	230	413	321	229	414	273	187	360
Asia										
Cambodia	2000	481	366	597	473	360	588	438	329	548
Cambodia	2005	488	357	620	494	362	627	472	342	603
Cambodia	2010	207	127	288	211	130	293	207	127	288
Indonesia	1994	471	340	603	470	334	607	413	287	540
Indonesia	1997	345	184	507	334	175	494	315	158	473
Indonesia	2002-03	378	262	495	378	261	496	334	224	445
Indonesia	2007	258	181	336	277	197	358	209	138	281
Indonesia	2012	345	252	439	358	262	455	313	222	405

(Continued...)

Table 4.6 – *Continued*

		Hot deck imputation			Multiple imputation			Complete case analysis		
Country	**Year**	**MMR**	**LL**	**UL**	**MMR**	**LL**	**UL**	**MMR**	**LL**	**UL**
Asia										
Nepal	1996	546	401	692	550	405	696	539	395	684
Nepal	2006	136	88	185	139	88	190	133	85	182
Niger	2012	575	466	685	573	462	686	540	433	648
Philippines	1993	274	208	341	264	198	331	176	121	232
Philippines	1998	227	170	285	250	188	313	173	124	223
Timor-Leste	2009-10	562	416	709	561	415	708	558	412	705
Latin America and Caribbean										
Bolivia	1994	411	265	558	416	267	566	361	219	504
Bolivia	2003	248	179	318	248	178	318	211	148	275
Bolivia	2008	296	205	388	290	202	379	271	187	356
Brazil	1996	259	159	360	262	163	362	184	105	264
Dominican Republic	2002	228	130	327	244	146	343	168	79	258
Dominican Republic	2007	201	124	279	202	128	276	174	106	243
Guatemala	1995	252	167	338	238	158	319	156	97	216
Haiti	2000	531	371	692	568	389	747	524	365	684
Haiti	2005-06	649	501	798	671	518	826	630	483	778
Peru	1991-92	299	224	375	304	226	383	176	119	234
Peru	1996	329	264	395	325	261	389	269	212	327
Peru	2000	234	170	299	254	186	323	188	133	244
Peru	2004-06	221	166	277	220	165	276	207	154	261
Peru	2007-08	221	166	277	220	165	276	207	154	261
Peru	2011	159	98	221	171	102	242	158	97	220

Figure 4.7 Comparison of five methods for estimating MMR (DHS method, complete case analysis, weighting for non-response, single imputation with hot deck method, and multiple imputation method), DHS data from sub-Saharan Africa, Demographic and Health Surveys 1990-2013



(Continued...)

Figure 4.7 – *Continued*

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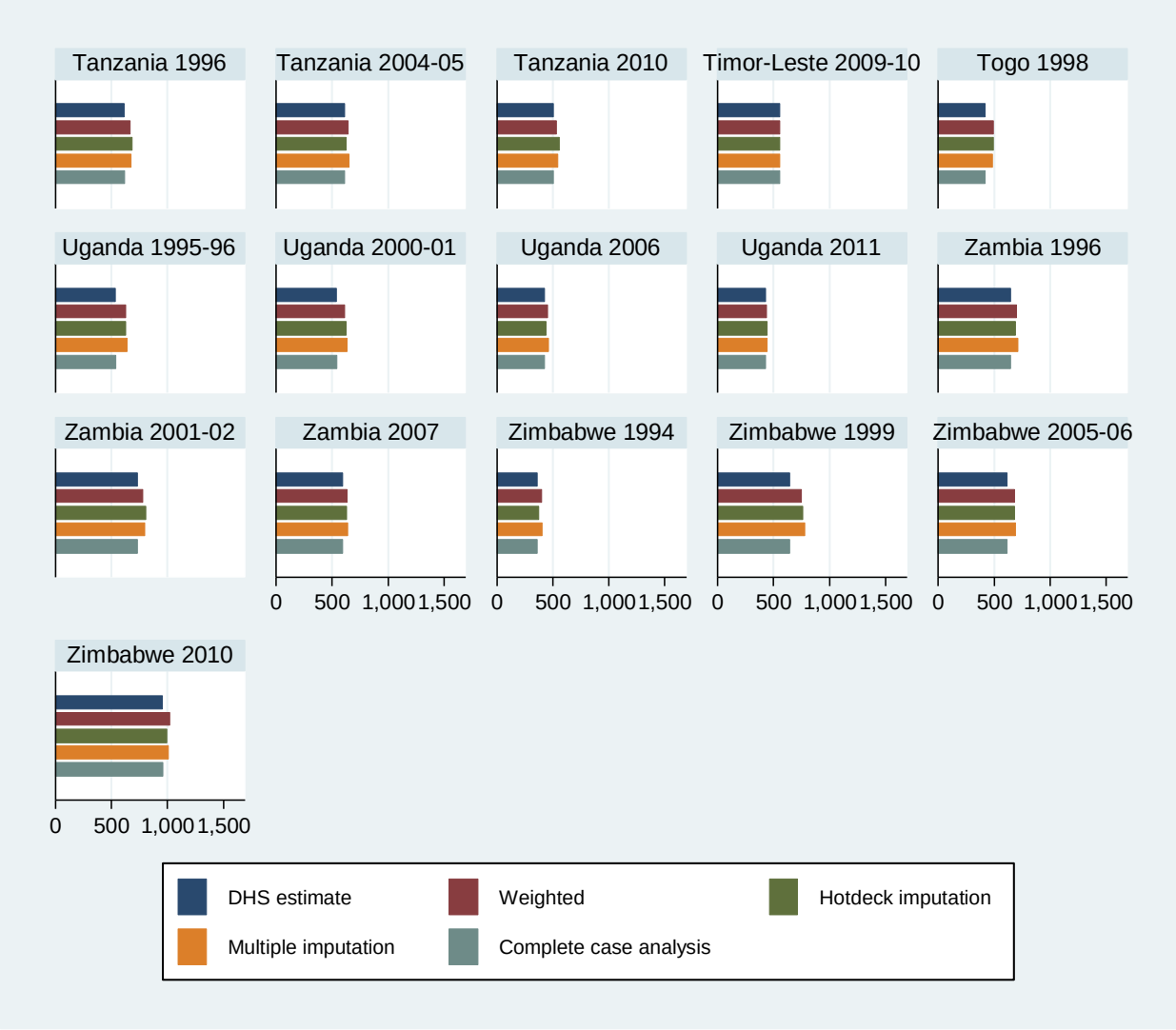
Figure 4.7 – *Continued*

(Continued...)

Figure 4.7 – *Continued*

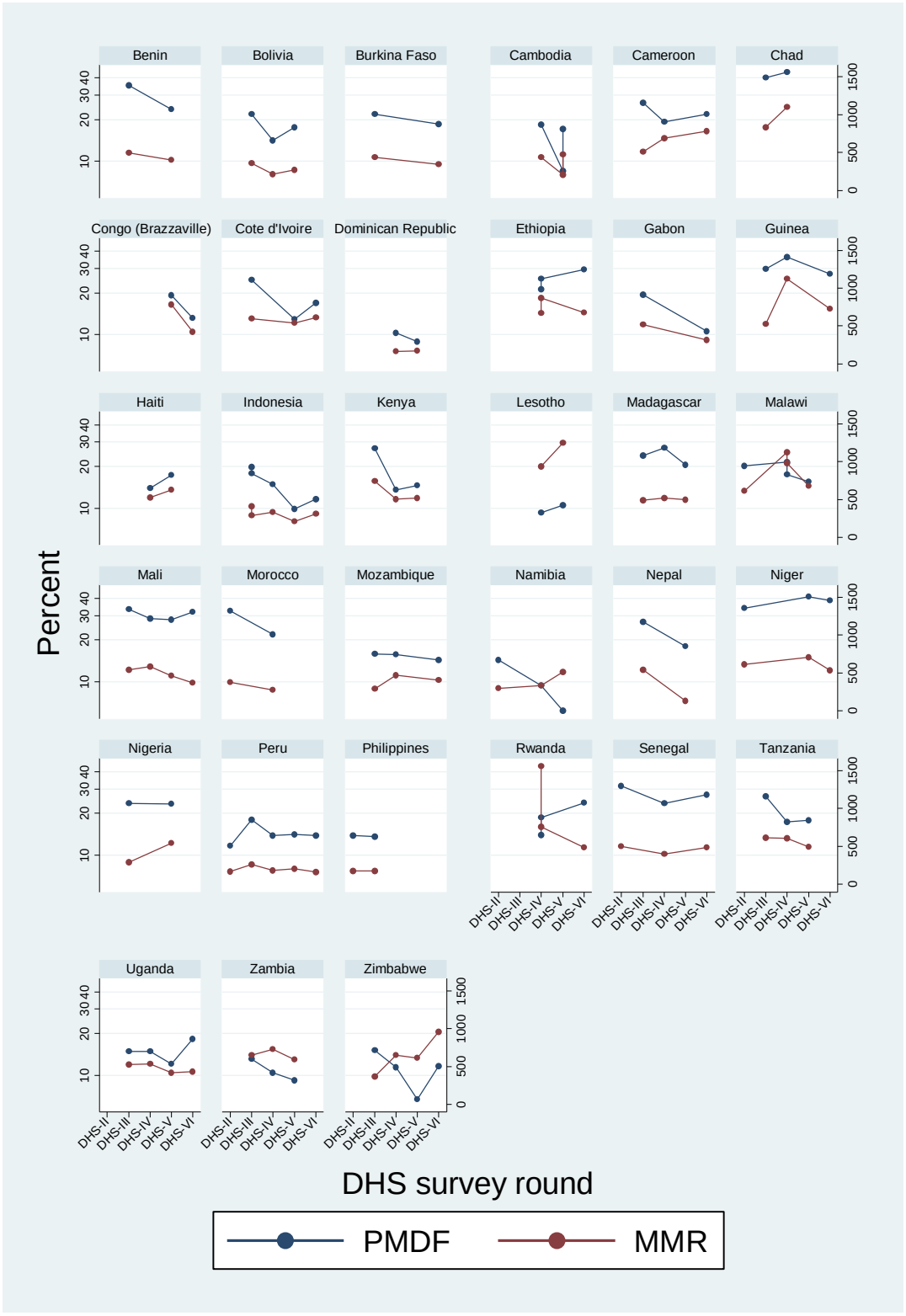


Instead of modeling maternal mortality with the MMR as done by IHME, the World Health Organization, UNICEF, UNFPA, and the World Bank use *the proportion of deaths to women age 15-49 that are maternal* (PMDF), which is considered more stable than the MMR. Age-specific maternal mortality ratio estimation also used PMDF (Nove et al. 2014).

Maternal deaths are a subset of adult female deaths , and the underestimation of adult mortality thus also underestimates maternal mortality. However, PMDF may not be affected by the underestimation of adult mortality. Hill, AbouZahr, and Wardlaw (2001) consider that PMDF is amore robust and reliable estimate from the sisterhood method than the MMR estimate. As a proportion, PMDF may be used as logit, which bounds the predicted model values between 0 and 1; this specification in m odeling guarantees that the estimated MMR is never a negative value.

Despite several advantages of using PMDF for maternal mortality estimation, the empirical relationship between PMDF and MMR is not well known. Figure 4.8 compares PMDF and MMR trend patterns for maternal deaths in DHS countries. It is difficult to draw any inference from this comparison that the PMDF is more stable than the MMR. For example, in Ethiopia, while the MMR remains about the same between the two DHS survey rounds, the PMDF increased. A comparison of global MMR estimates from PMDF and MMR may provide additional insight into the suitability or preference of one indicator over the other for estimating global maternal mortality trends.

Figure 4.8 Trends in the proportion of maternal deaths among female deaths (PMDF) and the maternal mortality ratio (MMR) by DHS survey rounds, Demographic and Health Surveys 1990-2013



4.3. Risk of Maternal Mortality Underreporting

Epidemiological studies suggest that the risk of maternal death is highest at the extreme ends of the reproductive years. Maternal mortality risk is higher at younger ages, when pelvic development is incomplete, and at older ages and higher parities, when a mother's health condition is more compromised. If this risk profile holds, it is expected that the share of maternal mortality will be higher in these age groups. A recent study of 144 countries shows a J-shaped age distribution of maternal mortality, with a slightly increased risk of mortality in adolescents compared with women in the age group 20-24 (Nove at al. 2014). Abortion-related deaths are often high in the youngest age group, so there is concern that maternal deaths may be underreported in the youngest group, especially in settings where abortions are prohibited or socially unacceptable.

It could be possible to examine the possibilities of underreporting of maternal mortality in the youngest age group or in the extreme reproductive age groups due to age-displacement by looking at age-specific MMR estimates. With high obstetrical risks, MMRs are expected to be high in the youngest and oldest age groups of reproductive period. However, the estimation of age-specific MMRs at the country level is unreliable from DHS survey data due to small sample size, especially in these two age groups. Blanc, Winfrey, and Ross (2013) combined data from 38 DHS surveys to circumvent the problems of small sample size for a reasonable analysis of maternal mortality age patterns. Similarly, the analysis by Nove at al. (2014) for age-specific MMR is also based on aggregate data. It is, however, difficult to examine underreporting of age-specific maternal mortality from aggregate data.

Instead, we examined underreporting by comparing the age-specific maternal death distribution to birth distribution. With a birth-specific constant risk at each age group, we expect a proportional covariation in these two distributions. In the presence of maternal mortality underreporting, we expect that the proportion of maternal deaths will be lower than their relative share. Table 4.7 shows the distribution of deaths and births by age distribution of the sibling sisters. The results are shown graphically in Figure 4.7. The total births are calculated by summing the expected number of births, given the current age-specific fertility rates (ASFRs) of the respondents—i.e., ASFR equals the distribution of deaths and births by age distribution of sibling sisters [respondents] × number of sisters in the age category—over the age range. In cases where deaths are proportional to births, we expect that the distribution of births and deaths will be similar. This pattern is observed in Cameroon 1998, Ethiopia 2000, Niger 2102, and Peru 1991-1992.

In the absence of maternal mortality underreporting, we expect that the proportional share of maternal deaths will be higher in the youngest and oldest age groups, compared with the corresponding distribution of births in the respective age groups.

Many DHS surveys show a disproportionately higher proportion of births in the youngest age group but a lower proportion of deaths (e.g., Côte d' Ivoire, Zambia, Zimbabwe). These survey rounds may have underreporting of maternal deaths in the youngest age group.

Although we are able to assess the indications of underestimations based on the relationship between the distribution of maternal deaths and births from the graphs (Figure 4.9) or the table (Table 4.7), it is to not possible to summarize the magnitude of the underestimation. Using an econometric method that graphically shows the concentration of inequality using the *Gini coefficient concentration index*, it may be possible to summarize the level of age-specific underestimation of maternal mortality. We show the concentration curves in the Appendix (Figure A2) for additional insights into the relationship between birth and maternal death distribution. The x-axis shows the cumulative proportion of births and the y-axis shows the cumulative proportion of deaths over the age range. A complete thick diagonal line suggests proportional distributions of maternal deaths and births. A thick curved line *above* the diagonal line (e.g., Chad 2004) suggests higher proportional deaths in the youngest group. This suggests that underreporting

of maternal deaths in these surveys may be absent or minimal. The concentration graph showing a large *downward* curve (e.g., Cambodia 2005-06, Malawi 2004-05, Swaziland 2006-07, Zambia 2007) may indicate the presence of underreporting of maternal deaths in the survey round.

Table 4.7 Percentage distribution of maternal deaths and births (expected births among sisters) by age, Demographic and Health Surveys 1990-2013

Country	DHS survey round	Year of survey	Maternal deaths/ births	Age						
				15-19	20-24	25-29	30-34	35-39	40-44	45-49
Sub-Saharan Africa										
Benin	DHS-III	1996	Deaths	11.8	18.8	19.6	32.4	8.0	7.5	2.0
	DHS-III		Births	11.6	27.6	26.7	19.2	11.0	3.3	0.6
Benin	DHS-V	2006	Deaths	7.0	13.7	25.3	28.4	17.8	6.2	1.6
	DHS-V		Births	11.7	28.8	28.2	18.8	9.1	2.7	0.7
Burkina Faso	DHS-III	1998-99	Deaths	20.8	36.0	14.7	7.1	13.4	6.0	1.9
	DHS-IV		Births	13.9	29.1	24.7	17.8	10.1	3.7	0.8
Burkina Faso	DHS-VI	2010	Deaths	8.5	23.1	21.0	19.7	17.2	7.0	3.5
	DHS-VI		Births	13.2	28.2	25.9	19.0	10.1	3.1	0.4
Burundi	DHS-VI	2010-11	Deaths	13.8	15.8	21.3	17.9	18.4	6.7	6.1
	DHS-VI		Births	7.7	30.1	27.2	19.6	10.9	3.9	0.7
Cameroon	DHS-III	1998	Deaths	10.1	31.5	26.6	18.3	10.4	3.0	0.0
	DHS-III		Births	16.8	30.4	25.8	15.9	8.2	2.5	0.4
Cameroon	DHS-IV	2004	Deaths	17.3	14.8	26.6	22.8	7.0	8.2	3.3
	DHS-IV		Births	18.0	30.3	25.3	16.3	7.4	2.3	0.4
Cameroon	DHS-VI	2011	Deaths	11.1	25.4	22.3	21.1	11.4	5.2	3.4
	DHS-VI		Births	15.1	30.0	27.3	16.9	8.1	2.2	0.4
Central African Republic	DHS-III	1994-95	Deaths	14.0	18.7	23.4	18.2	14.6	9.3	1.6
	DHS-III		Births	18.1	30.4	25.2	16.6	7.0	2.3	0.4
Chad	DHS-III	1996-97	Deaths	18.1	24.5	12.1	26.2	12.8	5.4	0.9
	DHS-III		Births	18.5	30.4	26.3	16.0	6.9	1.7	0.2
Chad	DHS-IV	2004	Deaths	30.6	23.2	20.8	16.6	3.9	3.4	1.6
	DHS-IV		Births	18.9	29.0	24.3	17.2	8.2	2.1	0.2
Congo (Brazzaville)	DHS-V	2005	Deaths	8.8	27.6	22.5	16.7	15.1	9.0	0.3
	DHS-V		Births	15.8	28.2	25.1	17.9	9.7	2.8	0.5
Congo (Brazzaville)	DHS-VI	2011-12	Deaths	10.6	15.1	14.7	26.9	24.0	3.4	5.3
	DHS-VI		Births	14.8	25.4	25.7	20.0	11.1	2.6	0.3
Congo Democratic Republic	DHS-V	2007	Deaths	12.0	18.2	26.3	21.6	6.7	11.5	3.6
	DHS-V		Births	12.1	26.1	25.8	20.8	10.5	3.9	0.7
Côte d'Ivoire	DHS-III	1994	Deaths	8.9	16.0	28.1	20.0	9.8	12.7	4.7
	DHS-III		Births	17.1	29.2	25.4	16.9	8.6	2.5	0.3
Côte d'Ivoire	DHS-V	2005	Deaths	12.4	24.4	20.9	14.4	11.8	13.0	3.1
	DHS-V		Births	17.1	29.7	24.6	16.6	9.0	2.5	0.4
Côte d'Ivoire	DHS-VI	2011-12	Deaths	8.5	18.9	19.7	18.3	21.4	7.7	5.4
	DHS-VI		Births	14.8	28.3	26.6	18.0	8.9	2.9	0.6
Ethiopia	DHS-IV	2000	Deaths	12.0	23.9	21.3	23.4	12.9	4.6	1.9
	DHS-IV		Births	12.6	27.8	25.4	19.3	10.8	3.7	0.6
Ethiopia	DHS-IV	2005	Deaths	7.7	22.1	26.9	22.8	17.8	2.1	0.6
	DHS-IV		Births	13.1	28.3	25.6	19.1	9.7	3.5	0.7

(Continued...)

Table 4.7 – *Continued*

Country	DHS survey round	Year of survey	Maternal deaths/ births	Age 15-19	20-24	25-29	30-34	35-39	40-44	45-49
Sub-Saharan Africa										
Ethiopia	DHS-VI	2011	Deaths	9.4	17.9	17.3	32.0	13.5	7.6	2.2
	DHS-VI		Births	12.0	29.1	28.1	17.9	9.3	3.0	0.6
Gabon	DHS-III	2000-01	Deaths	12.1	22.8	35.9	12.0	7.9	7.2	2.1
	DHS-III		Births	21.3	28.5	22.9	17.1	8.2	1.8	0.2
Gabon	DHS-VI	2012	Deaths	34.5	11.0	21.2	6.7	17.8	7.0	1.8
	DHS-VI		Births	17.0	25.7	25.3	18.1	10.4	3.3	0.3
Guinea	DHS-III	1999	Deaths	4.3	18.7	29.5	23.0	16.5	6.2	1.9
	DHS-III		Births	16.4	26.4	25.1	19.4	8.9	3.1	0.7
Guinea	DHS-IV	2005	Deaths	15.4	18.0	16.5	19.6	18.5	8.7	3.4
	DHS-IV		Births	15.5	26.1	24.6	19.0	10.7	3.6	0.5
Guinea	DHS-VI	2012	Deaths	18.5	21.9	18.9	18.3	15.7	4.6	2.1
	DHS-VI		Births	17.0	26.5	25.5	17.9	9.2	3.2	0.6
Kenya	DHS-III	1998	Deaths	11.0	27.6	24.5	17.9	11.1	7.5	0.4
	DHS-III		Births	13.4	31.6	27.1	17.6	7.6	2.4	0.3
Kenya	DHS-IV	2003	Deaths	10.3	24.6	23.5	21.8	15.1	3.3	1.4
	DHS-IV		Births	13.4	31.6	26.1	17.5	8.3	2.6	0.5
Kenya	DHS-V	2008-09	Deaths	8.1	16.6	21.2	16.8	24.8	6.5	6.0
	DHS-V		Births	12.5	30.7	26.1	18.4	9.2	2.8	0.4
Lesotho	DHS-IV	2004-05	Deaths	6.6	13.1	22.9	19.2	21.1	16.3	0.7
	DHS-IV		Births	14.6	30.8	24.8	15.7	10.2	3.5	0.5
Lesotho	DHS-V	2009-10	Deaths	5.4	18.5	32.1	21.7	13.4	6.5	2.2
	DHS-V		Births	14.8	33.1	25.3	15.5	8.5	2.7	0.3
Liberia	DHS-V	2006-07	Deaths	16.5	12.8	19.5	20.4	13.9	12.5	4.4
	DHS-V		Births	13.9	26.7	24.0	18.7	11.6	4.0	1.1
Madagascar	DHS-III	1997	Deaths	12.5	21.2	24.0	17.3	18.5	4.2	2.4
	DHS-III		Births	16.2	28.7	24.1	17.4	9.8	3.4	0.4
Madagascar	DHS-IV	2003-04	Deaths	6.6	33.4	13.9	13.7	18.1	13.1	1.1
	DHS-IV		Births	14.8	27.9	25.1	18.0	10.2	3.5	0.5
Madagascar	DHS-V	2008-09	Deaths	18.0	17.4	20.4	18.6	14.8	7.7	3.1
	DHS-V		Births	15.5	27.7	24.1	17.9	10.6	3.6	0.5
Malawi	DHS-II	1992	Deaths	19.2	7.6	22.4	21.3	17.7	5.2	6.6
	DHS-II		Births	14.7	27.1	24.5	17.1	10.8	4.4	1.4
Malawi	DHS-IV	2000	Deaths	3.9	23.1	21.7	22.9	12.8	12.6	3.1
	DHS-IV		Births	16.4	32.2	24.0	15.1	8.3	3.1	0.9
Malawi	DHS-IV	2004-05	Deaths	3.3	21.6	26.5	20.9	13.5	9.1	5.1
	DHS-IV		Births	17.4	33.4	23.6	14.6	7.5	2.8	0.7
Malawi	DHS-V	2010	Deaths	8.4	15.3	23.6	18.9	18.9	10.4	4.4
	DHS-V		Births	16.3	30.9	25.3	16.0	8.1	2.8	0.6
Mali	DHS-III	1995-96	Deaths	14.2	22.4	21.6	17.3	13.3	9.4	1.8
	DHS-III		Births	16.6	28.4	25.0	17.4	9.5	2.8	0.4
Mali	DHS-IV	2001	Deaths	17.8	20.7	20.4	19.2	11.8	7.7	2.4
	DHS-IV		Births	17.2	27.3	23.6	17.6	10.2	3.6	0.6

(Continued...)

Table 4.7 – *Continued*

Country	DHS survey round	Year of survey	Maternal deaths/ births	Age 15-19	20-24	25-29	30-34	35-39	40-44	45-49
Sub-Saharan Africa										
Mali	DHS-V	2006	Deaths	15.6	22.7	24.8	18.7	13.4	3.7	1.1
	DHS-V		Births	18.1	28.7	24.6	16.8	8.7	2.8	0.3
Mali	DHS-VI	2012-13	Deaths	12.2	13.9	21.6	35.3	10.1	5.4	1.5
	DHS-VI		Births	16.4	29.0	26.6	16.9	8.2	2.3	0.6
Mozambique	DHS-III	1997	Deaths	22.4	47.5	9.4	5.4	5.9	9.3	0.1
	DHS-III		Births	18.1	31.0	25.0	15.0	7.6	2.9	0.4
Mozambique	DHS-IV	2003-04	Deaths	8.5	20.2	21.9	21.9	17.3	10.2	0.0
	DHS-IV		Births	18.4	29.0	24.4	15.9	8.6	2.8	0.9
Mozambique	DHS-VI	2011	Deaths	14.0	27.9	26.3	13.2	9.7	4.5	4.4
	DHS-VI		Births	16.0	28.3	24.2	17.4	10.0	3.4	0.8
Namibia	DHS-II	1992	Deaths	6.7	20.4	19.0	6.7	22.2	17.6	7.4
	DHS-II		Births	12.7	26.4	26.4	18.0	11.3	4.3	0.9
Namibia	DHS-IV	2000	Deaths	7.6	18.8	34.8	23.2	12.1	3.5	0.0
	DHS-IV		Births	12.0	26.2	25.7	19.2	11.5	4.3	1.2
Namibia	DHS-V	2006-07	Deaths	9.6	16.9	19.0	24.6	10.1	7.9	11.9
	DHS-V		Births	11.7	27.6	25.9	19.7	11.3	3.4	0.4
Niger	DHS-II	1992	Deaths	10.4	28.5	24.1	17.8	11.9	6.8	0.5
	DHS-II		Births	19.3	28.3	25.1	16.3	7.9	2.6	0.6
Niger	DHS-V	2006	Deaths	15.6	23.6	19.2	17.1	11.7	10.8	1.9
	DHS-V		Births	17.7	27.7	23.5	17.6	9.7	3.2	0.7
Niger	DHS-VI	2012	Deaths	15.4	26.8	18.3	21.1	10.7	5.9	1.8
	DHS-VI		Births	16.5	27.4	24.5	17.6	10.0	3.2	0.8
Nigeria	DHS-III	1999	Deaths	24.0	23.4	21.3	11.4	12.8	5.0	1.9
	DHS-III		Births	16.3	29.5	25.6	17.5	8.1	2.6	0.4
Nigeria	DHS-V	2008	Deaths	15.7	22.2	19.0	23.7	11.8	6.3	1.3
	DHS-V		Births	13.2	26.5	27.5	19.4	9.2	3.3	0.9
Rwanda	DHS-IV	2000	Deaths	4.9	18.6	19.0	24.1	18.7	11.7	3.1
	DHS-IV		Births	6.2	26.2	27.3	21.8	12.8	4.9	0.8
Rwanda	DHS-IV	2005	Deaths	4.3	19.9	19.5	24.7	15.8	13.1	2.7
	DHS-IV		Births	5.4	27.2	27.7	20.9	12.8	5.2	0.8
Rwanda	DHS-VI	2010-11	Deaths	4.3	15.7	25.5	23.8	17.6	10.2	2.9
	DHS-VI		Births	5.0	26.6	30.3	20.9	11.8	4.8	0.6
São Tomé and Príncipe	DHS-V	2008-09	Deaths	0.0	0.0	12.4	33.7	8.4	45.6	0.0
	DHS-V		Births	12.1	28.3	23.4	19.2	12.6	4.1	0.2
Senegal	DHS-II	1992-93	Deaths	14.3	20.6	17.5	11.1	27.0	9.5	0.0
	DHS-II		Births	13.7	27.1	25.8	19.2	10.5	3.0	0.6
Senegal	DHS-IV	2005	Deaths	13.6	23.8	18.3	14.0	20.2	8.5	1.7
	DHS-IV		Births	12.2	26.6	26.8	19.8	10.8	3.3	0.5
Senegal	DHS-VI	2010-11	Deaths	8.7	20.7	22.3	28.9	12.8	5.7	0.9
	DHS-VI		Births	11.6	27.5	28.2	19.5	10.0	3.0	0.3
Sierra Leone	DHS-V	2008	Deaths	21.5	19.8	19.7	24.6	9.3	3.9	1.2
	DHS-V		Births	16.9	26.9	24.9	17.5	9.9	3.3	0.7

(Continued...)

Table 4.7 – *Continued*

Country	DHS survey round	Year of survey	Maternal deaths/ births	Age 15-19	20-24	25-29	30-34	35-39	40-44	45-49
Sub-Saharan Africa										
South Africa	DHS-III	1998	Deaths	8.6	29.7	25.1	21.9	10.5	4.1	0.0
	DHS-III		Births	12.0	25.7	26.8	20.4	11.3	3.2	0.6
Swaziland	DHS-V	2006-07	Deaths	3.3	19.4	18.6	22.9	23.7	12.2	0.0
	DHS-V		Births	17.3	30.3	23.8	17.8	8.8	1.8	0.1
Tanzania	DHS-III	1996	Deaths	12.1	27.9	20.7	17.1	12.4	4.9	5.0
	DHS-III		Births	14.2	29.3	25.4	17.1	9.9	3.2	0.8
Tanzania	DHS-IV	2004-05	Deaths	7.5	23.3	24.9	20.7	13.2	7.2	3.2
	DHS-IV		Births	13.9	29.7	25.9	18.0	9.2	2.9	0.4
Tanzania	DHS-V	2009-10	Deaths	5.1	20.5	18.5	27.9	14.9	11.3	1.8
	DHS-V		Births	13.6	28.2	24.4	18.9	10.9	3.4	0.6
Togo	DHS-III	1998	Deaths	7.2	8.9	23.2	14.4	23.5	17.4	5.4
	DHS-III		Births	10.3	26.8	27.2	19.4	11.5	3.9	0.8
Uganda	DHS-III	1995	Deaths	10.8	19.2	24.3	30.6	9.8	2.8	2.4
	DHS-III		Births	17.8	31.0	26.5	15.5	6.8	2.1	0.4
Uganda	DHS-IV	2000-01	Deaths	5.3	15.0	35.2	26.1	12.3	5.2	0.9
	DHS-IV		Births	16.5	30.5	24.9	17.0	8.5	2.1	0.5
Uganda	DHS-V	2006	Deaths	11.5	19.7	27.1	22.9	11.0	4.6	3.1
	DHS-V		Births	14.4	29.1	25.7	17.9	9.5	2.9	0.5
Uganda	DHS-VI	2011	Deaths	6.2	23.9	12.1	28.6	13.5	9.8	5.9
	DHS-VI		Births	13.9	29.8	25.8	17.6	9.4	2.9	0.5
Zambia	DHS-III	1996-97	Deaths	12.2	23.1	29.2	20.9	10.7	2.1	1.8
	DHS-III		Births	16.8	30.7	24.3	16.8	8.6	2.4	0.4
Zambia	DHS-IV	2001-02	Deaths	11.2	19.4	34.7	18.1	7.9	8.4	0.3
	DHS-IV		Births	16.9	30.2	24.5	16.6	8.5	2.7	0.5
Zambia	DHS-V	2007	Deaths	4.5	13.0	22.1	30.5	19.8	6.9	3.2
	DHS-V		Births	14.6	28.2	25.7	18.2	9.8	3.0	0.5
Zimbabwe	DHS-III	1994	Deaths	7.1	23.4	26.6	33.5	3.8	1.7	3.7
	DHS-III		Births	13.4	28.2	25.6	18.8	10.2	3.3	0.5
Zimbabwe	DHS-IV	1999	Deaths	7.6	25.1	23.3	23.9	12.8	7.3	0.0
	DHS-IV		Births	15.0	30.8	24.7	16.5	9.6	3.0	0.5
Zimbabwe	DHS-V	2005-06	Deaths	8.0	10.7	20.5	24.1	22.0	11.4	3.2
	DHS-V		Births	15.5	33.1	25.0	15.6	7.6	2.7	0.4
Zimbabwe	DHS-VI	2010-11	Deaths	8.6	20.3	28.9	18.4	14.7	6.1	3.0
	DHS-VI		Births	14.2	33.0	26.9	15.9	7.7	2.0	0.5
North Africa										
Jordan	DHS-III	1997	Deaths	0.0	0.0	39.5	15.4	30.5	14.6	0.0
	DHS-III		Births	6.8	29.6	32.8	20.1	8.5	2.0	0.2
Morocco	DHS-II	1992	Deaths	19.3	7.0	21.1	21.1	19.3	7.0	5.3
	DHS-II		Births	6.8	24.6	30.2	22.5	11.3	3.8	0.8
Morocco	DHS-IV	2003-04	Deaths	3.5	21.7	12.4	25.2	16.7	20.5	0.0
	DHS-IV		Births	7.0	23.8	27.9	24.1	13.2	3.6	0.3

(Continued...)

Table 4.7 – *Continued*

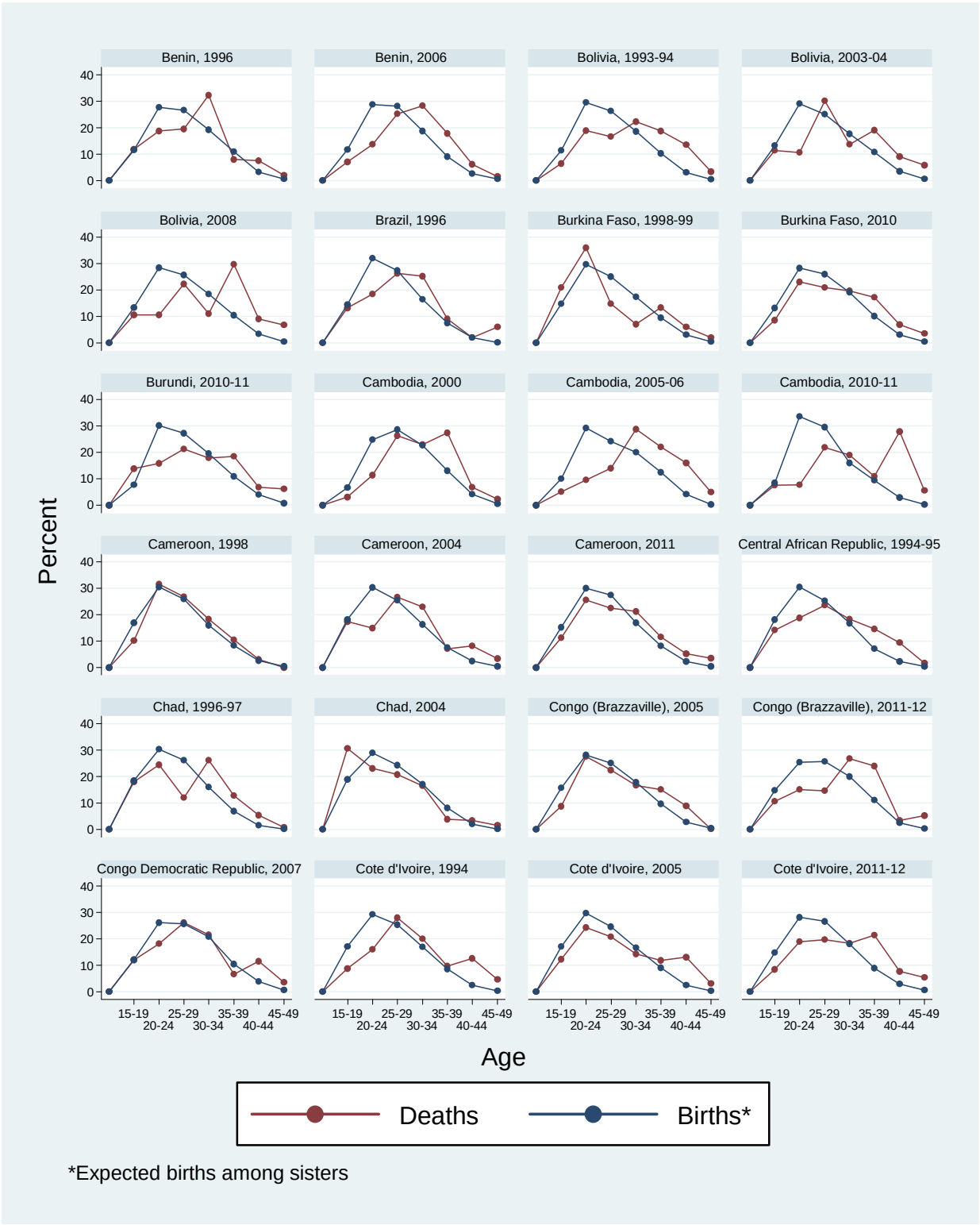
Country	DHS survey round	Year of survey	Maternal deaths/ births	Age 15-19	20-24	25-29	30-34	35-39	40-44	45-49
Asia										
Cambodia	DHS-IV	2000	Deaths	3.1	11.4	26.3	22.9	27.4	6.7	2.3
	DHS-IV		Births	6.5	24.7	28.5	22.6	13.0	4.1	0.6
Cambodia	DHS-V	2005-06	Deaths	5.0	9.5	14.0	28.7	21.9	16.0	4.9
	DHS-V		Births	10.0	29.2	24.2	19.9	12.5	4.1	0.2
Cambodia	DHS-V	2010-11	Deaths	7.5	7.7	21.9	18.8	10.9	27.8	5.5
	DHS-V		Births	8.5	33.6	29.5	15.9	9.3	2.9	0.3
Indonesia	DHS-III	1994	Deaths	15.1	20.9	26.5	10.9	18.3	7.5	0.8
	DHS-III		Births	11.5	30.6	29.0	18.3	8.3	2.1	0.2
Indonesia	DHS-III	1997	Deaths	4.5	6.4	18.8	33.6	14.1	21.4	1.3
	DHS-III		Births	10.8	28.7	29.1	20.1	8.5	2.4	0.3
Indonesia	DHS-IV	2002-03	Deaths	4.7	10.8	23.7	16.8	19.4	14.3	10.3
	DHS-IV		Births	9.2	27.4	29.9	20.5	10.5	2.2	0.3
Indonesia	DHS-V	2007	Deaths	7.9	9.9	34.3	22.5	11.3	10.7	3.5
	DHS-V		Births	7.7	25.6	28.2	23.5	11.6	2.9	0.5
Indonesia	DHS-VI	2012	Deaths	4.6	12.3	21.6	21.4	18.3	15.8	6.1
	DHS-VI		Births	6.4	23.8	29.5	23.8	13.0	3.1	0.4
Nepal	DHS-III	1996	Deaths	19.6	22.6	26.8	12.7	15.2	1.0	2.2
	DHS-III		Births	16.1	34.3	25.9	14.8	6.9	1.6	0.3
Nepal	DHS-V	2006	Deaths	20.4	15.7	12.9	29.2	11.8	9.9	0.0
	DHS-V		Births	17.8	39.0	23.2	12.7	5.7	1.6	0.1
Philippines	DHS-II	1993	Deaths	1.9	25.9	26.1	16.6	15.6	5.2	8.6
	DHS-II		Births	6.5	27.9	29.9	21.0	11.0	3.3	0.3
Philippines	DHS-III	1998	Deaths	1.1	11.9	26.6	22.7	27.4	10.4	0.0
	DHS-III		Births	6.4	26.4	30.3	21.8	11.5	3.3	0.3
Timor-Leste	DHS-VI	2009-10	Deaths	6.4	18.7	20.4	26.5	10.4	12.5	5.1
	DHS-VI		Births	6.9	27.1	26.2	20.2	13.5	5.0	1.2
Latin America and Caribbean										
Bolivia	DHS-III	1993-94	Deaths	6.4	18.9	16.6	22.4	18.7	13.6	3.4
	DHS-III		Births	11.4	29.6	26.4	18.7	10.4	3.1	0.4
Bolivia	DHS-IV	2003-04	Deaths	11.4	10.7	30.3	13.7	19.0	9.1	5.8
	DHS-IV		Births	13.2	29.1	25.1	17.8	10.8	3.5	0.6
Bolivia	DHS-V	2008	Deaths	10.6	10.6	22.3	11.0	29.7	9.1	6.7
	DHS-V		Births	13.3	28.4	25.7	18.4	10.4	3.3	0.4
Brazil	DHS-III	1996	Deaths	13.2	18.4	26.2	25.2	9.0	1.9	6.0
	DHS-III		Births	14.5	32.0	27.4	16.4	7.5	2.0	0.2
Dominican Republic	DHS-IV	2002	Deaths	8.2	9.9	48.4	29.6	2.5	1.3	0.0
	DHS-IV		Births	17.6	34.0	26.7	14.9	5.8	0.9	0.1
Dominican Republic	DHS-V	2007	Deaths	16.8	11.6	22.3	30.2	12.9	5.1	1.1
	DHS-V		Births	16.1	31.0	28.4	15.7	7.3	1.4	0.1
Guatemala	DHS-III	1995	Deaths	16.5	30.1	17.5	13.5	14.8	4.2	3.4
	DHS-III		Births	14.7	30.3	24.9	17.4	9.6	2.8	0.3

(Continued...)

Table 4.7 – *Continued*

Country	DHS survey round	Year of survey	Maternal deaths/ births	Age 15-19	20-24	25-29	30-34	35-39	40-44	45-49
Latin America and Caribbean										
Haiti	DHS-IV	2000	Deaths	2.9	16.3	32.5	22.2	15.5	7.7	2.8
	DHS-IV		Births	9.8	25.1	25.0	22.8	12.5	4.3	0.5
Haiti	DHS-V	2005-06	Deaths	2.1	19.2	16.7	25.5	22.9	12.2	1.3
	DHS-V		Births	11.2	26.3	25.3	20.4	12.1	4.2	0.5
Peru	DHS-II	1991-92	Deaths	17.6	27.5	21.7	20.6	0.0	12.5	0.0
	DHS-II		Births	11.1	30.3	27.5	18.5	9.2	2.8	0.5
Peru	DHS-III	1996	Deaths	17.4	20.5	13.4	13.6	17.9	13.5	3.6
	DHS-III		Births	11.5	30.0	25.6	18.9	10.6	3.2	0.3
Peru	DHS-IV	2000	Deaths	20.1	20.8	13.4	11.2	21.2	12.7	0.6
	DHS-IV		Births	11.2	28.2	26.0	20.0	11.1	3.2	0.4
Peru	DHS-V	2003-08	Deaths	12.3	13.6	17.8	26.9	13.2	12.3	4.0
	DHS-V		Births	10.7	26.5	26.3	20.1	12.4	3.6	0.4
Peru	DHS-VI	2011	Deaths	15.9	7.4	19.7	19.6	24.7	12.6	0.0
	DHS-VI		Births	10.2	25.2	25.8	21.7	12.8	3.9	0.4

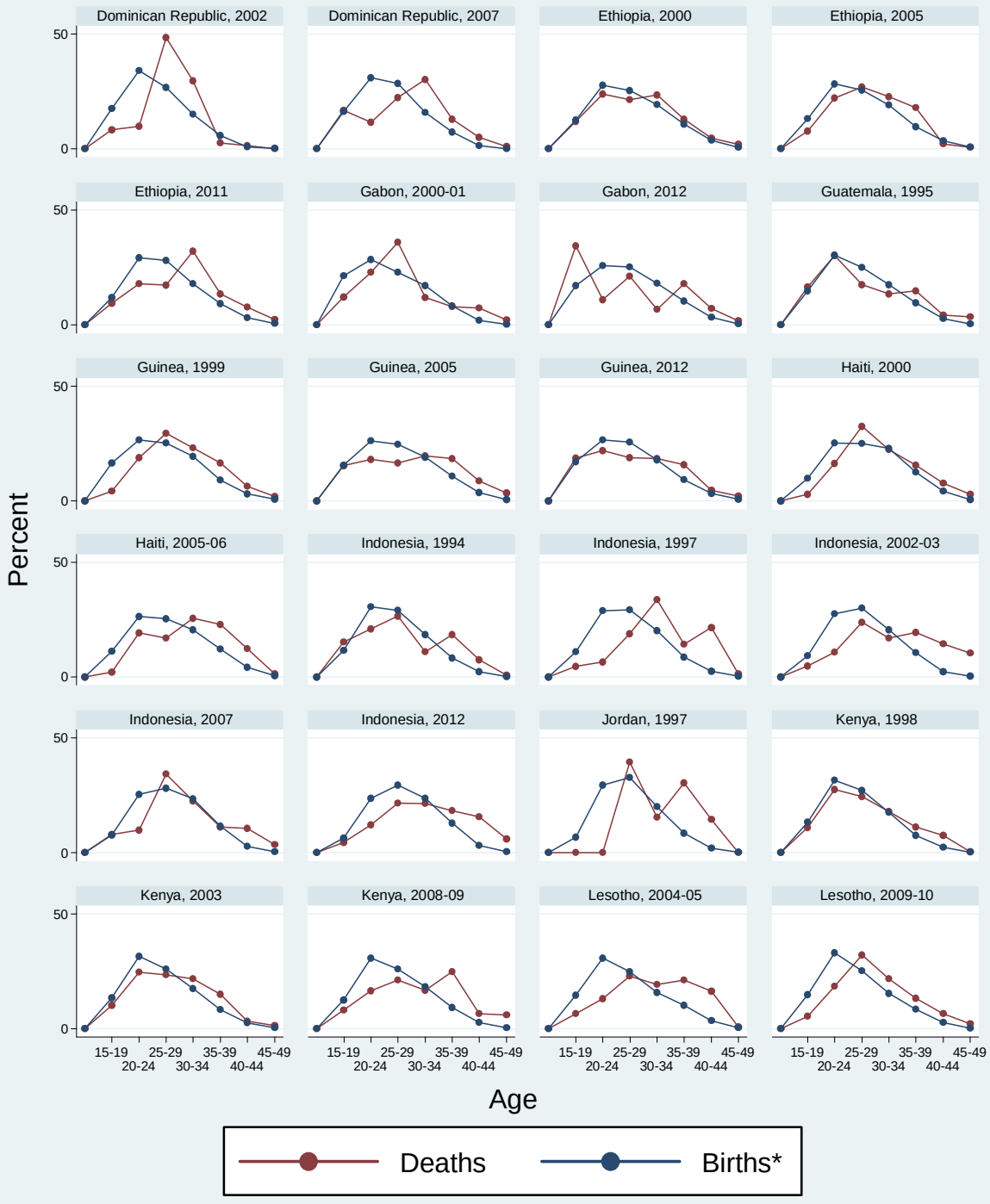
Figure 4.9 Percentage distribution of maternal deaths and births (expected births among sisters) by age, Demographic and Health Surveys 1990-2013



*Expected births among sisters

(Continued...)

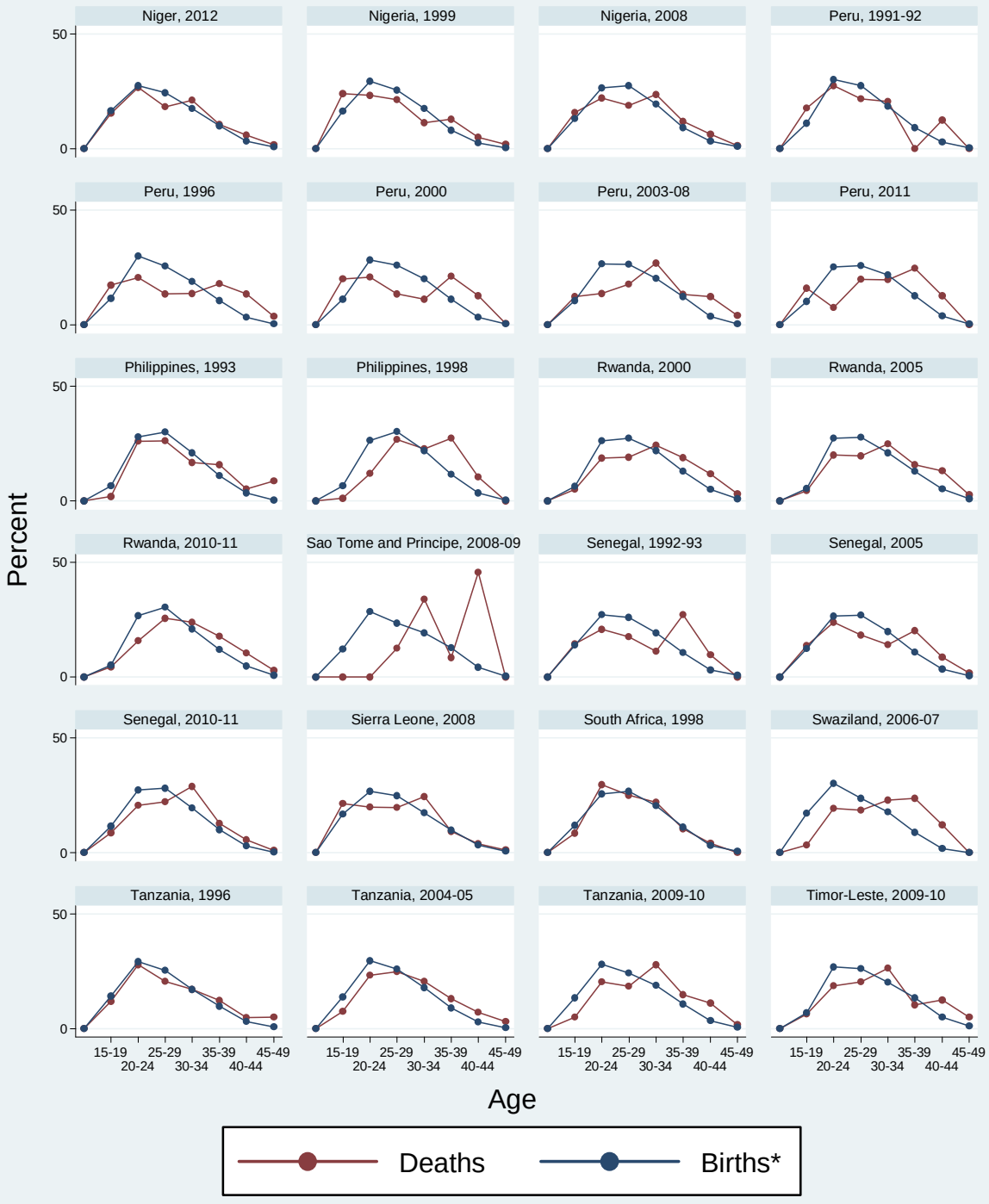
Figure 4.9 – *Continued*



*Expected births among sisters

(Continued...)

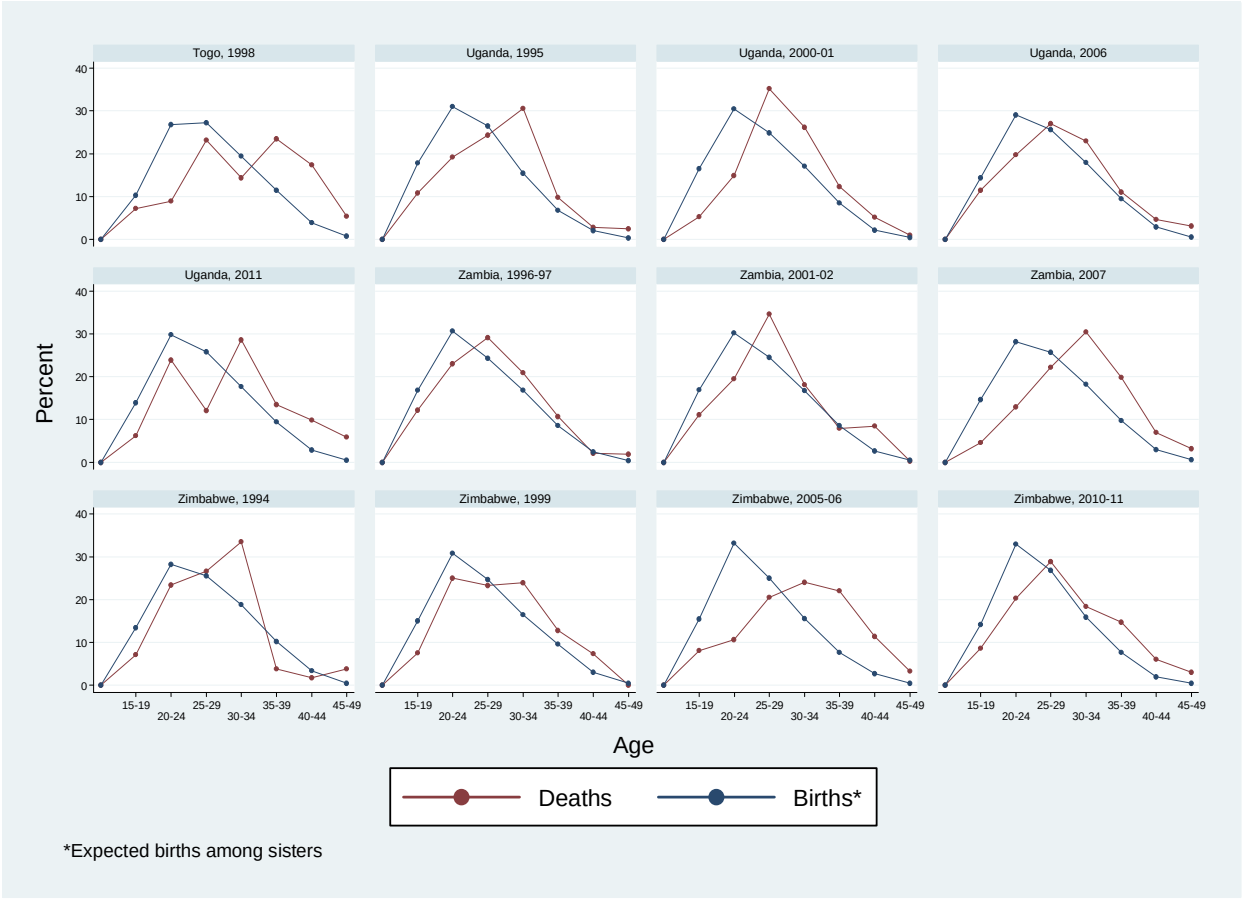
Figure 4.9 – *Continued*



*Expected births among sisters

(Continued...)

Figure 4.9 – *Continued*



4.4. Completeness of Adult Death Reporting in Sibling History Module

Maternal deaths are a subset of all female deaths. Underreporting of adult female deaths may thus bias and underestimate maternal mortality. Reniers, Masquelier, and Gerland (2011) show that adult mortality estimates from sibling survival data are generally lower than the UN estimates.

We applied the Brass Growth Balance Method (Brass 1975), which is used for assessing completeness of death reporting in census data, to assess the extent of underestimation of adult female deaths in DHS sibling survival data (Figure 4.10). The Afghanistan Mortality Survey 2010 also applied Brass Growth Balance Method for assessing underreporting of adult deaths from sibling survival history data. We also compared the results of female deaths to reported male deaths to examine whether there was any systematic underreporting for female population. The utility or suitability of the method for use with truncated mortality survey data—e.g., young respondents may not have siblings over 50 years of age—is not well known. Moreover, instead of fitting the best-fitted line for each survey data set, we applied the fitted line at two pre-determined age values. The results should be interpreted with caution, and the analysis may require further exploration. The results suggest the possibility of underreporting. Some results are implausible but are shown here for the sake of completeness.

Figure 4.10 Death reporting completeness diagnostic plots using the Brass Growth Balance Method, Demographic and Heath Surveys 1990-2013

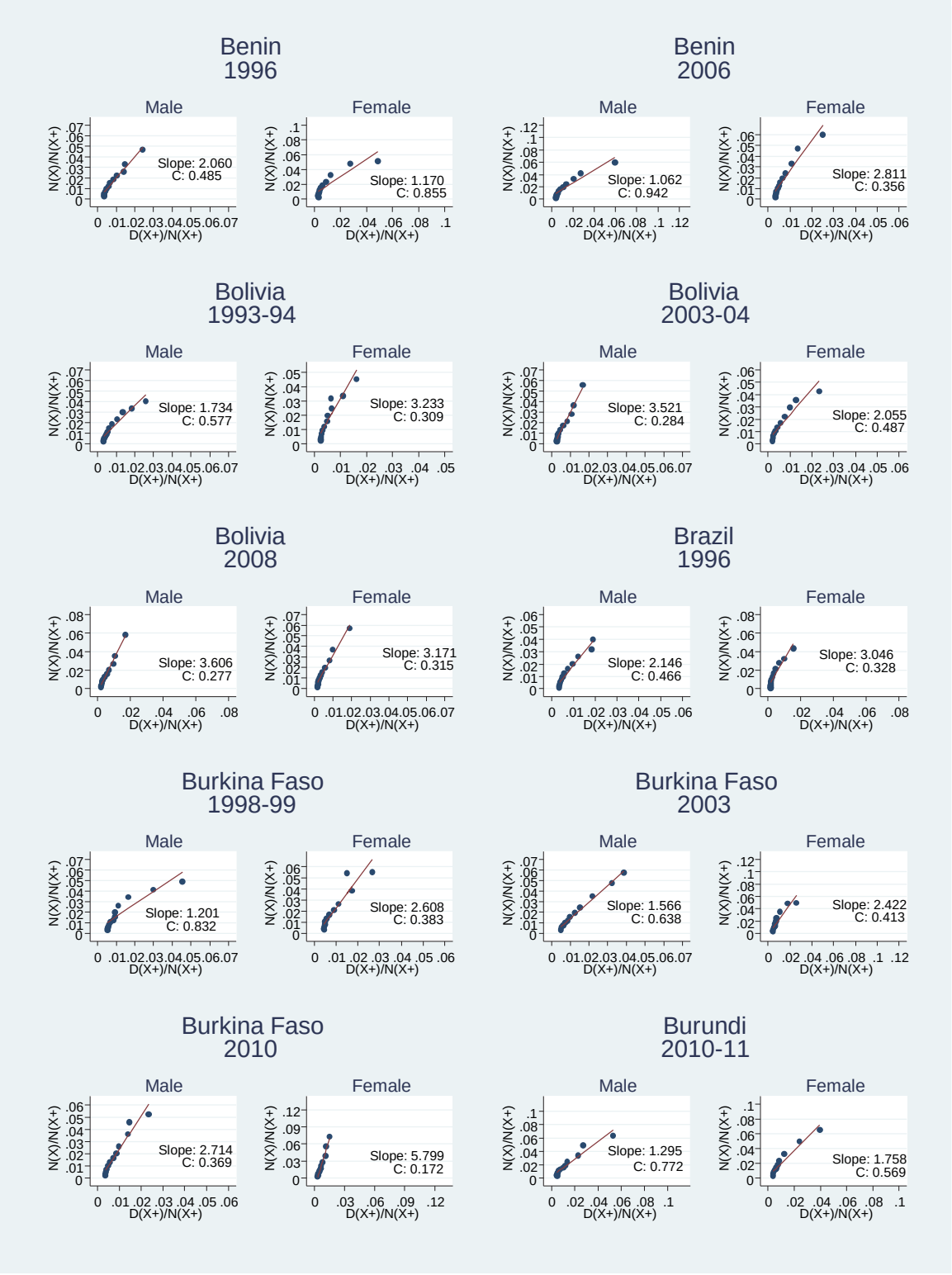


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Figure 4.10 – *Continued*

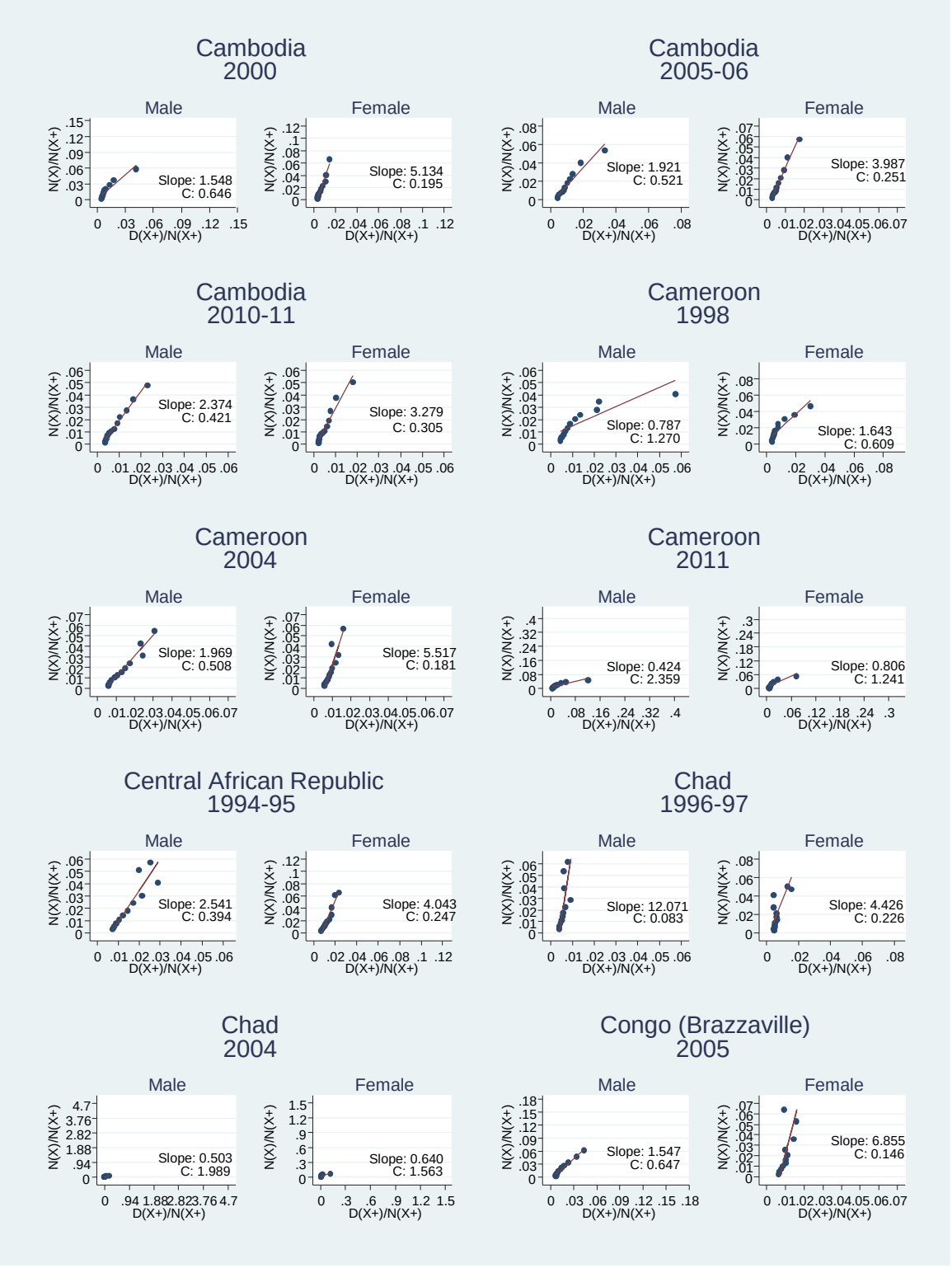

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Figure 4.10 – *Continued*

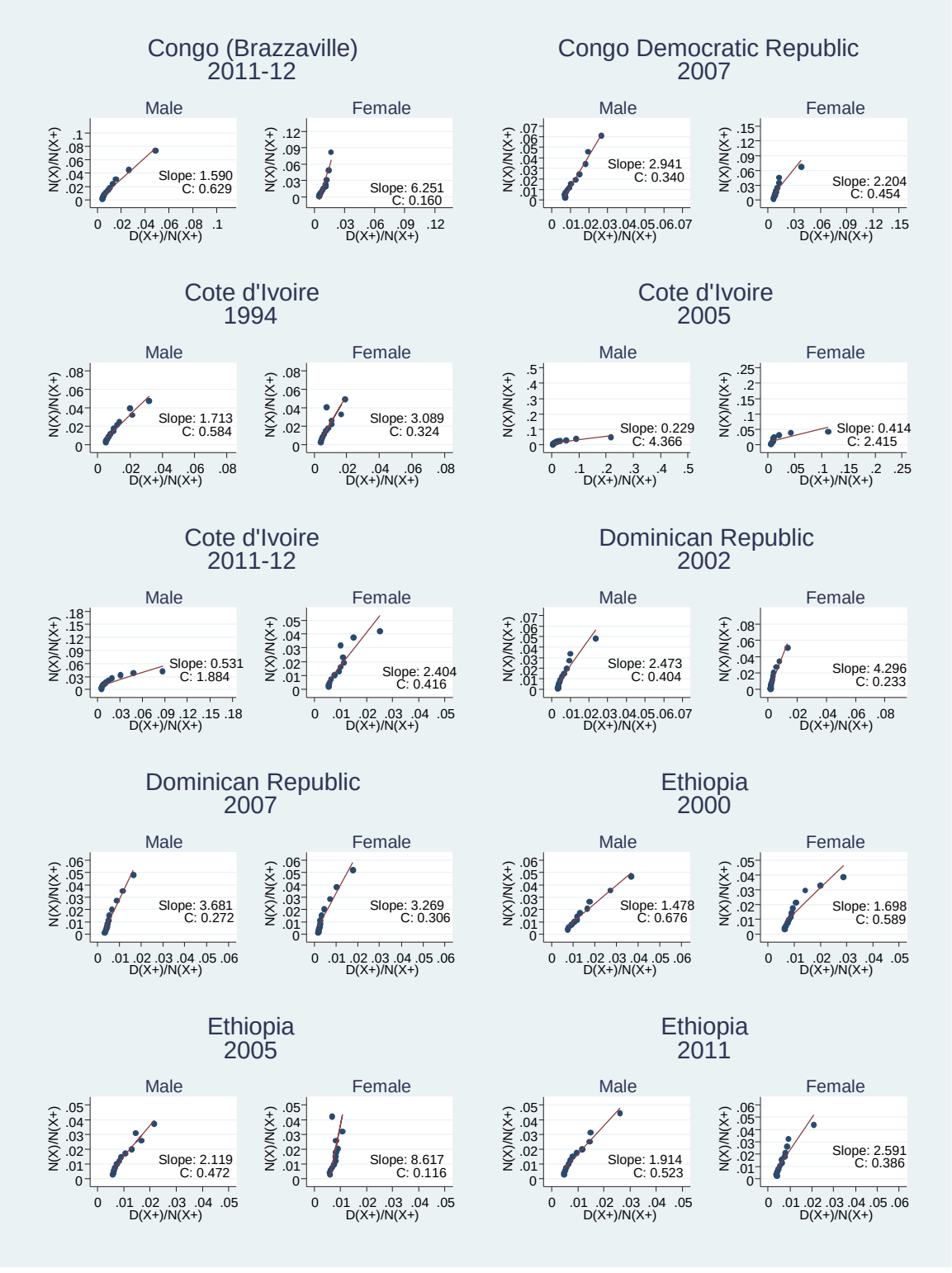

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Figure 4.10 – *Continued*

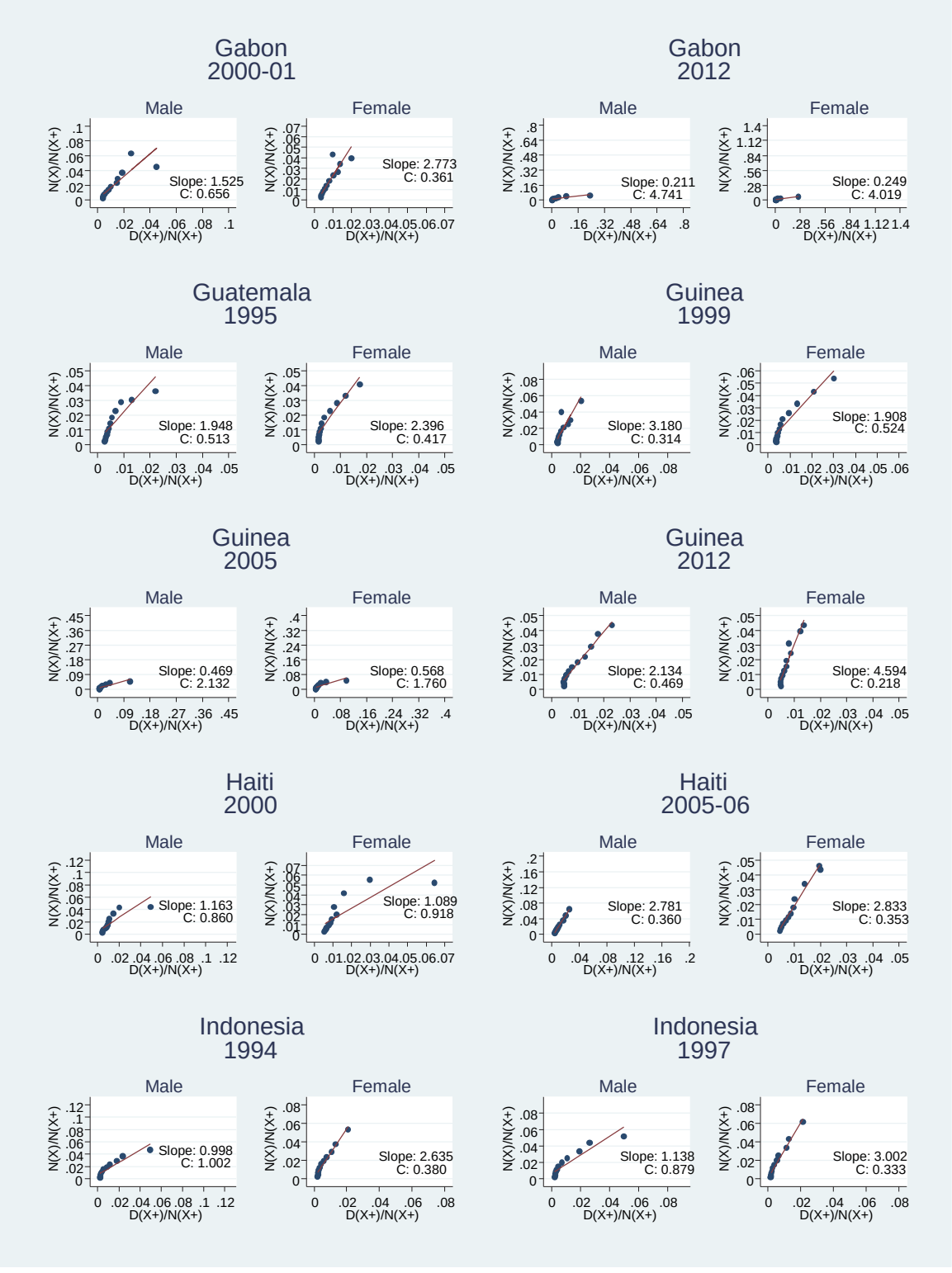

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Figure 4.10 – *Continued*

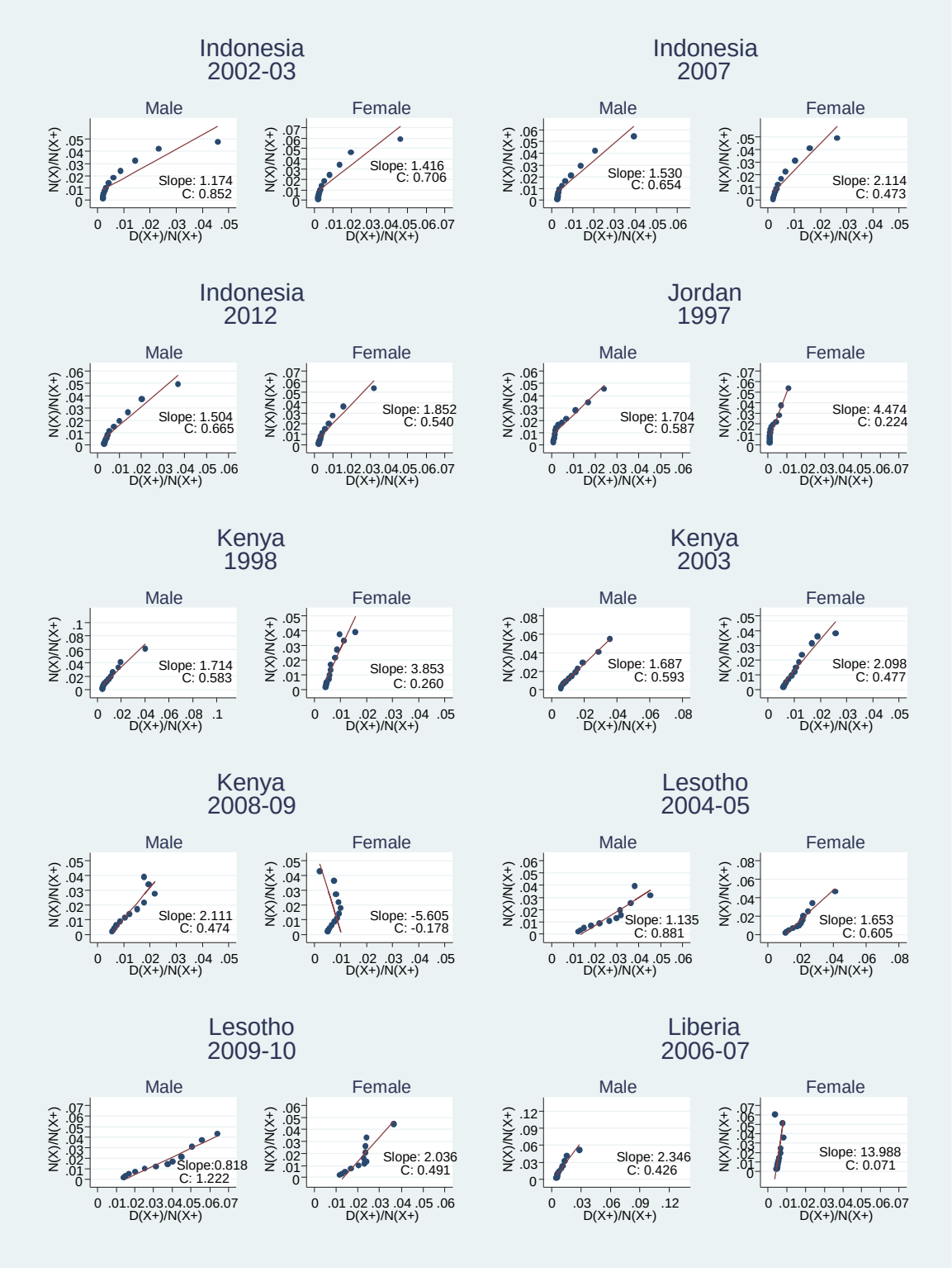

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Figure 4.10 – *Continued*

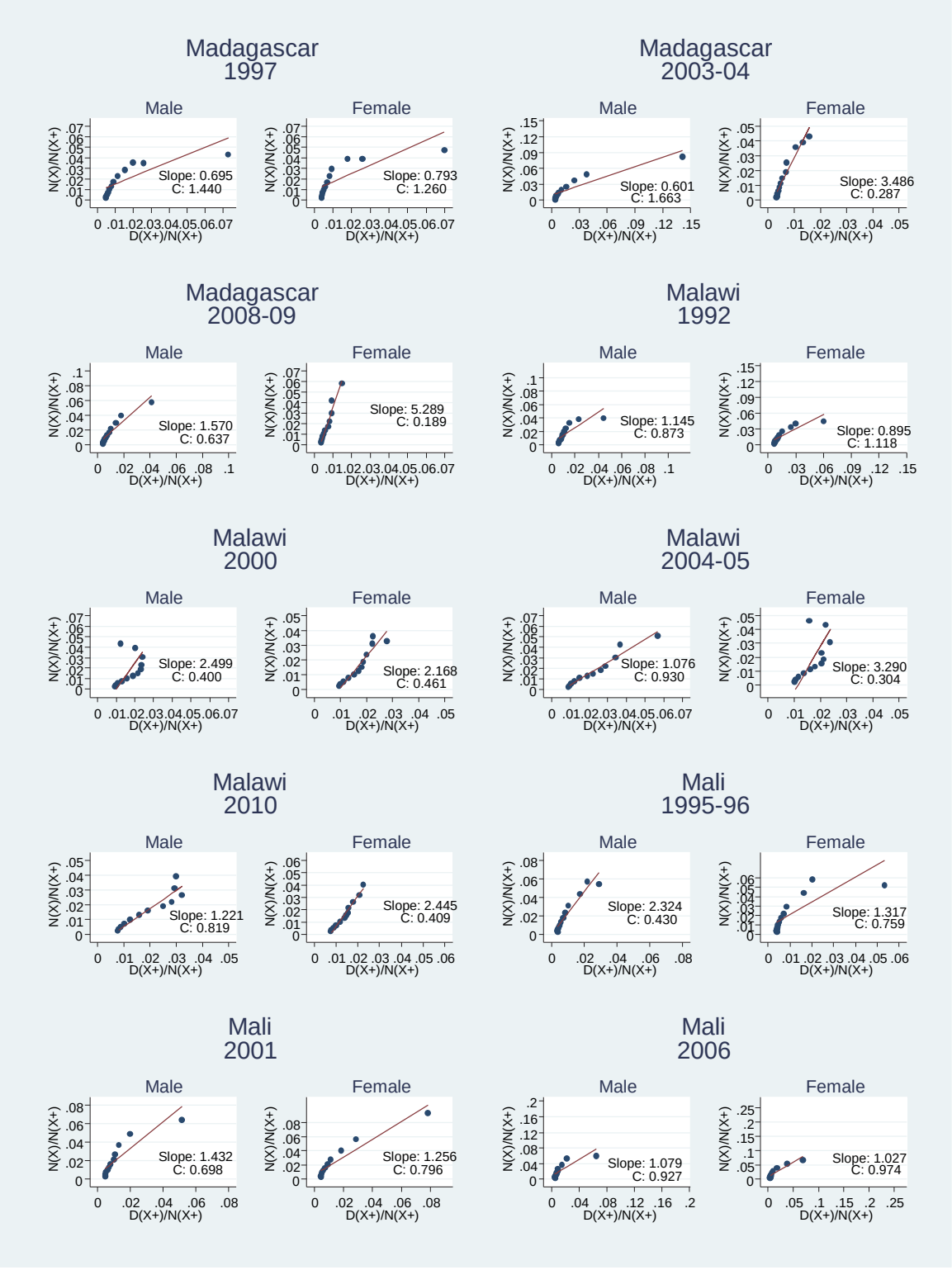

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Figure 4.10 – *Continued*

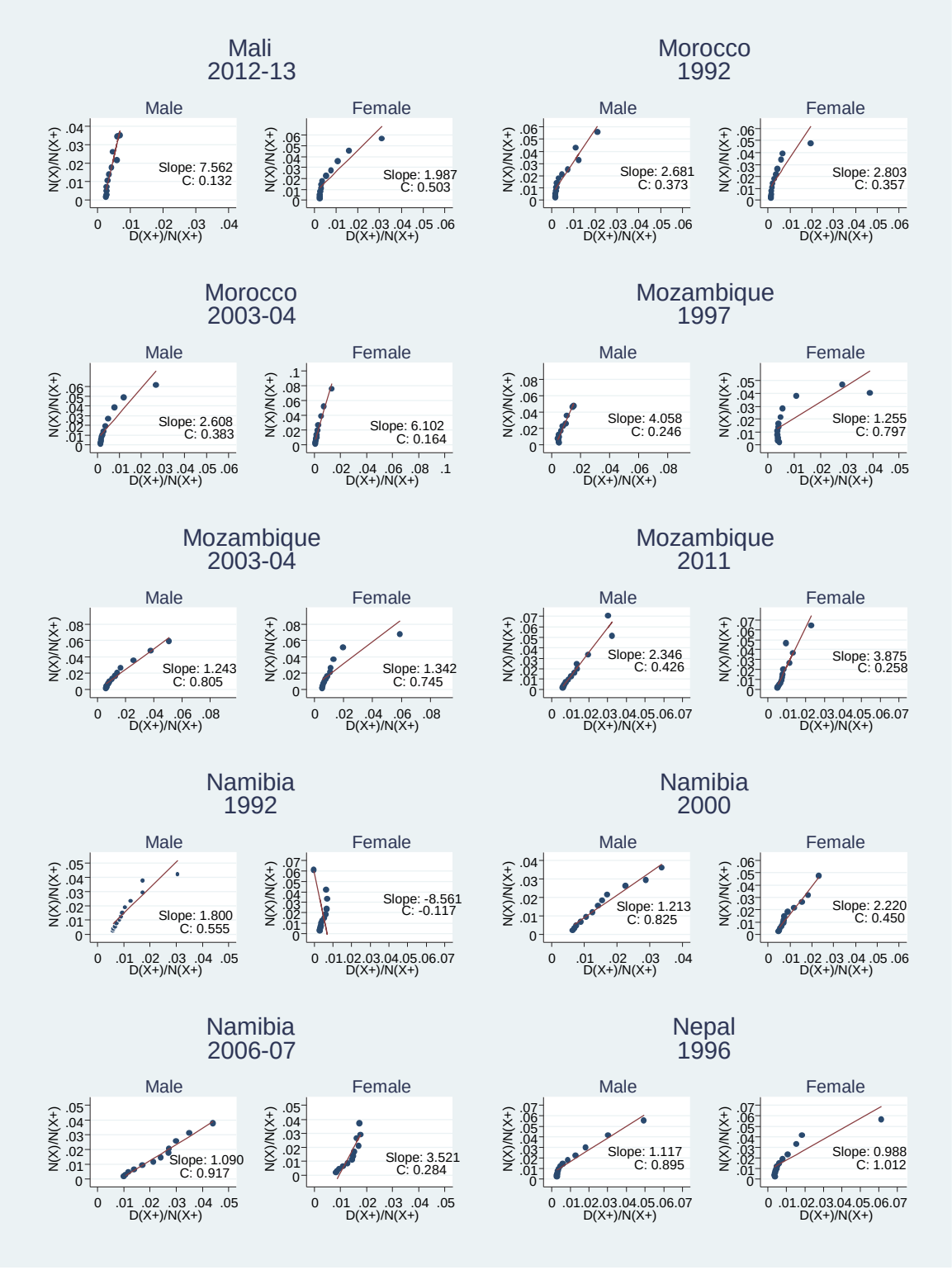

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Figure 4.10 – *Continued*

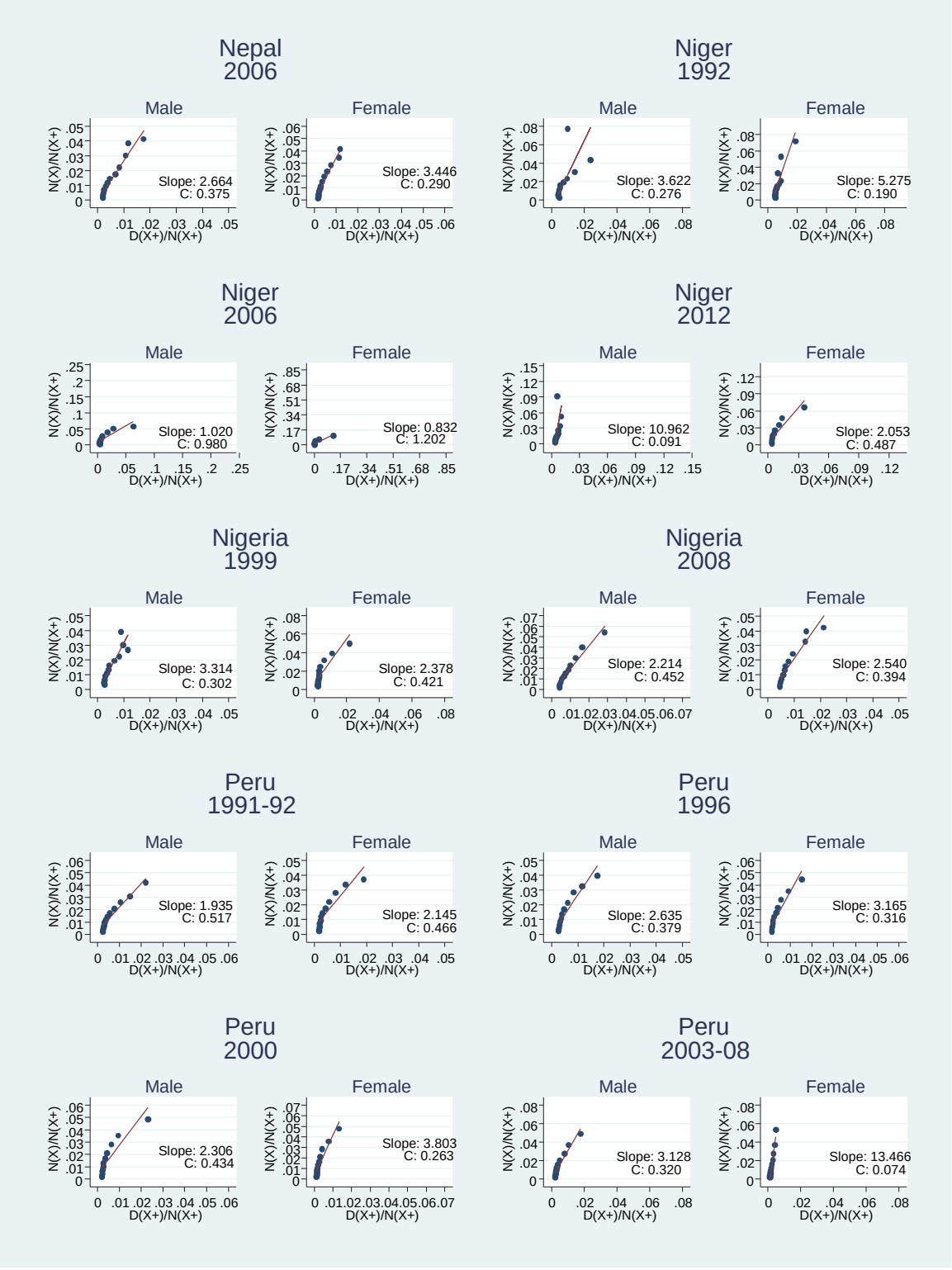

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Figure 4.10 – *Continued*

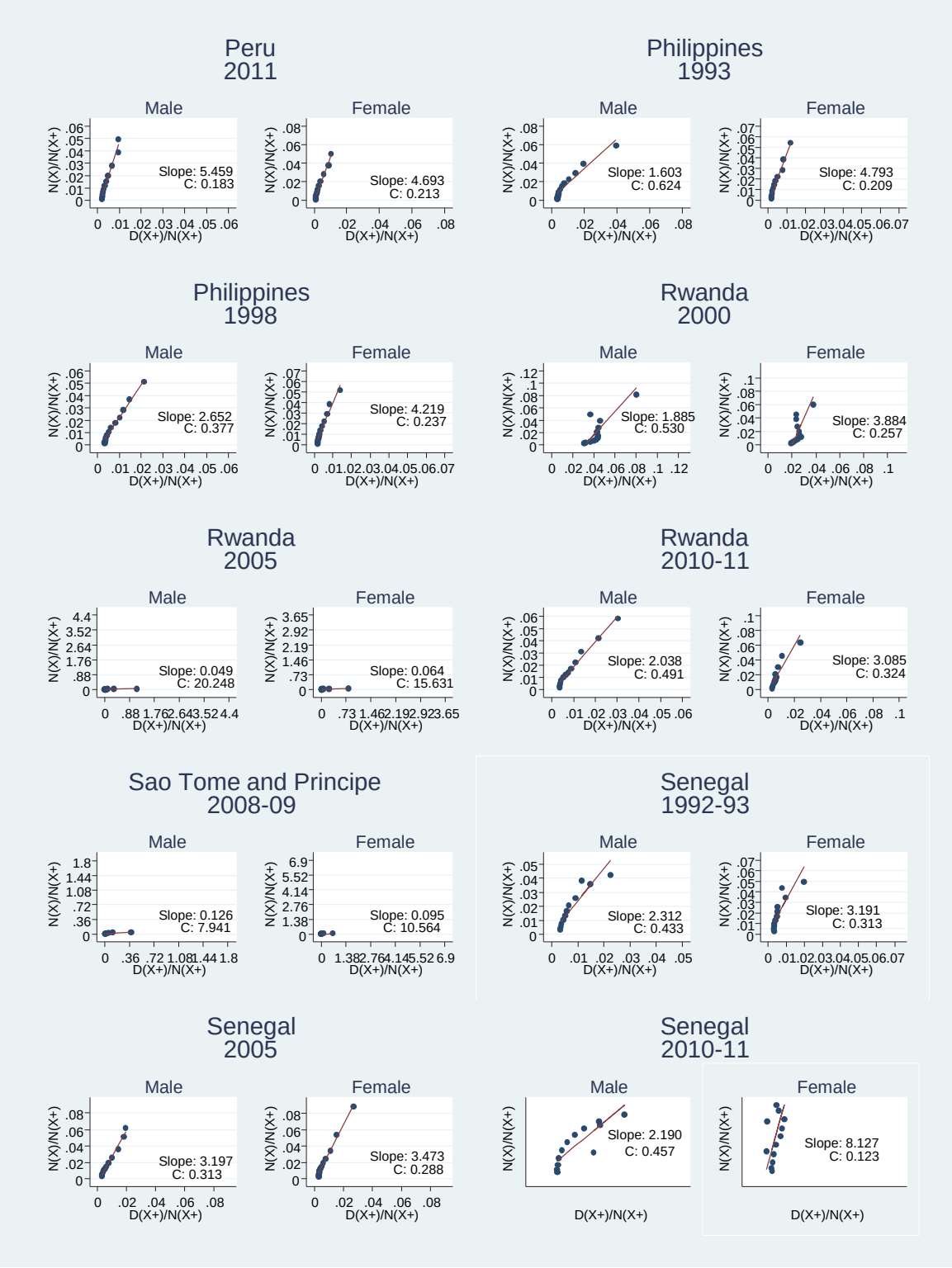

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Figure 4.10 – *Continued*

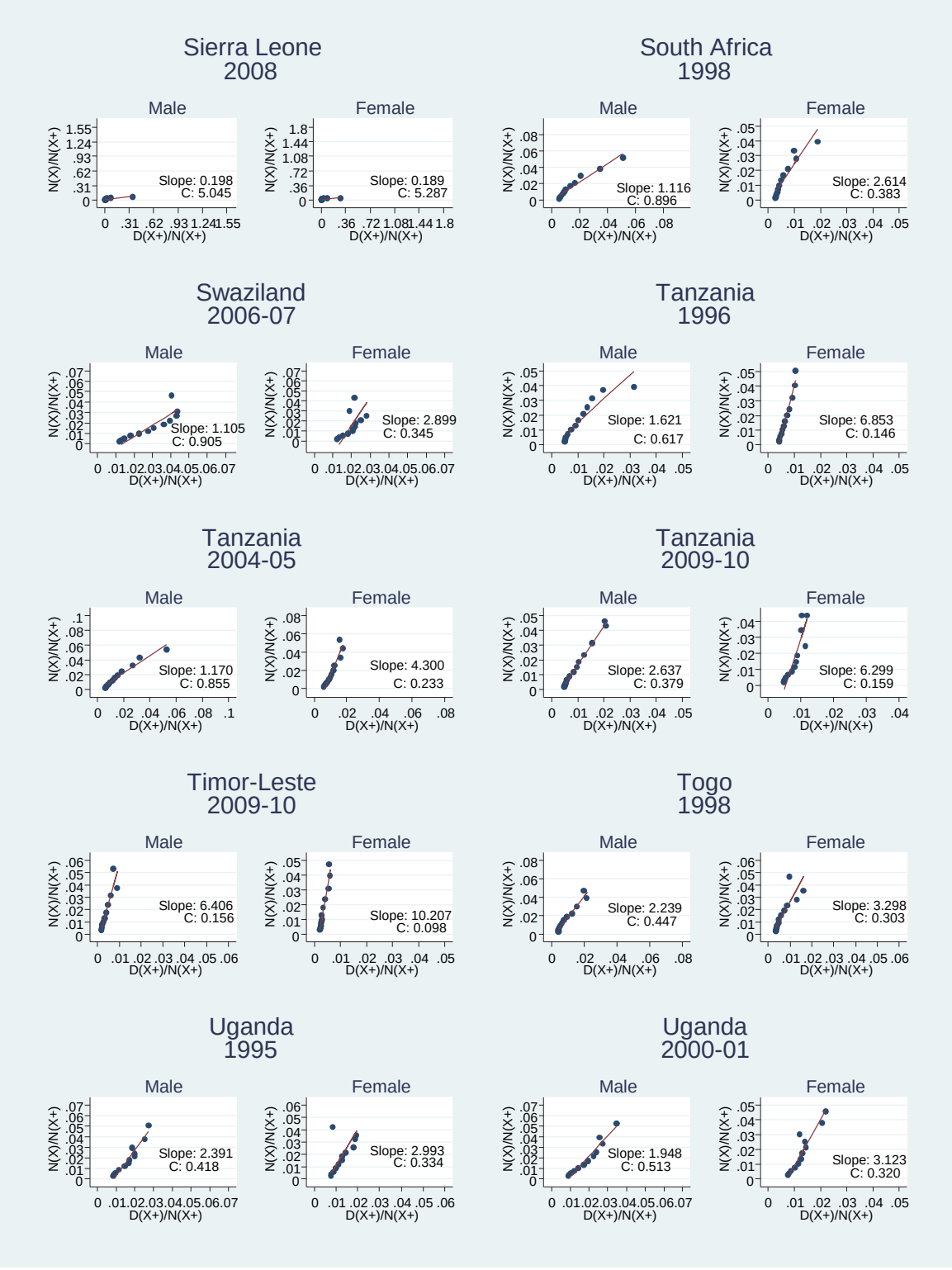

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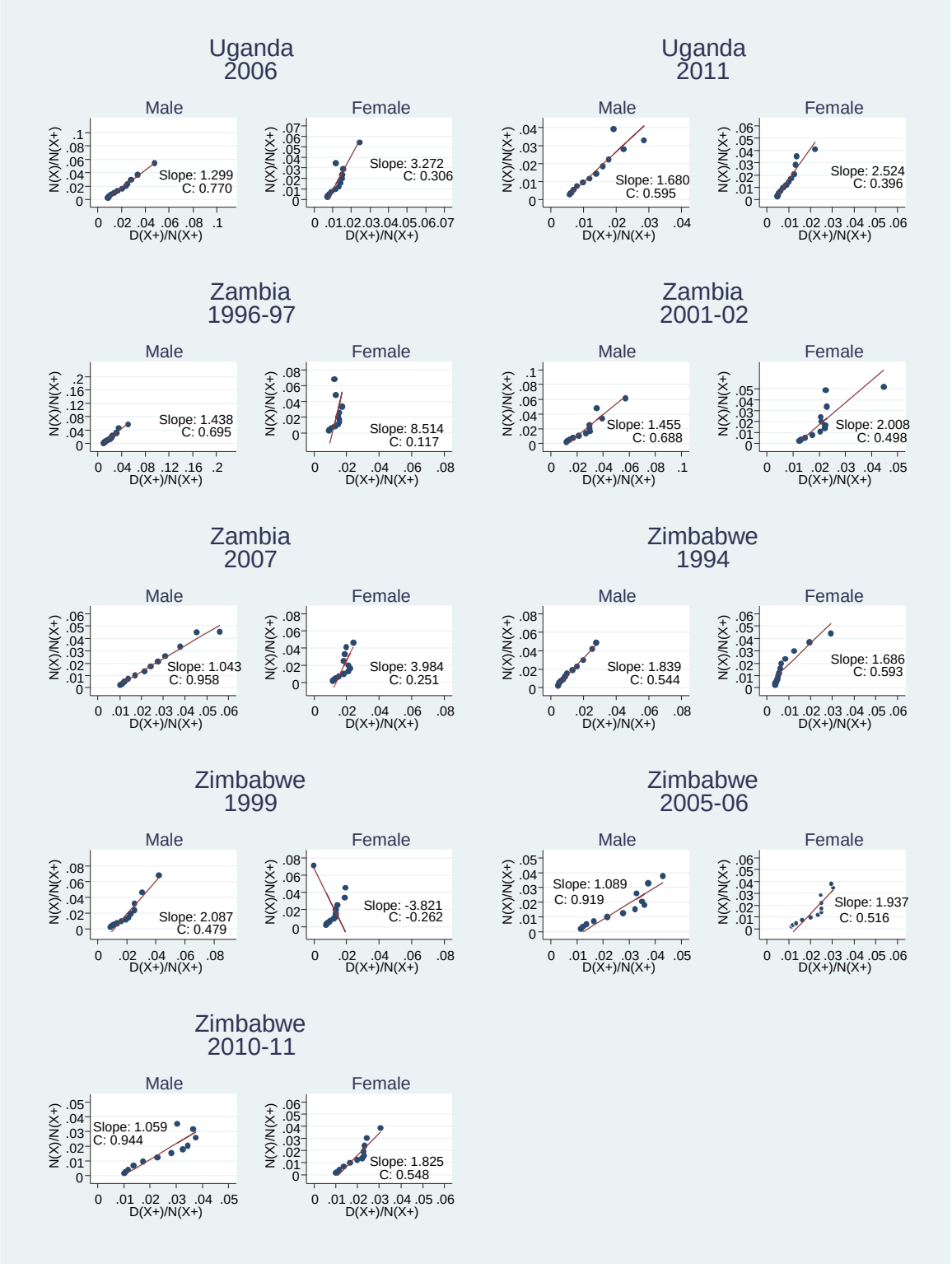
Figure 4.10 – *Continued*



5. Conclusions

The Demographic and Health Surveys (DHS) Program uses the sisterhood method for maternal mortality estimations. The limitations of the sisterhood method are discussed extensively in the demographic literature. The most notable limitation is that the method is not suitable for tracking progress in safe motherhood over a short period of time. Because the place of death of sibling sisters is not known (i.e., not asked) the method is also not suitable for assessing geographical variations or for helping to target high-risk regions. Nevertheless, the DHS surveys remain the major source of empirical data on maternal mortality in developing countries. Utilizing modeling techniques, the United Nations Maternal Mortality Estimation Inter-agency Group (MMEIG) (consisting of WHO/UNICEF/UNFPA, and the World Bank) and IHME have utilized the DHS sisterhood data for tracking global maternal mortality trends.

Recent studies have consistently indicated that maternal mortality has declined substantially worldwide since 1990. The reduction is largely due to declines in maternal mortality in developing countries. This achievement became known after maternal mortality estimates became widely available as the result of many rounds of DHS surveys, which have been used in tracking mortality.

In addition to sampling errors, survey data are affected also by non-sampling errors, such as reporting errors, missing responses, and biased responses. Data from DHS sibling survival history are not exceptions. Our in-depth analyses suggest that the overall quality of sibling history data is similar to the quality of data from individual respondents (women age 15-45) in DHS surveys in terms of age-reporting (e.g., age-heaping, missing in reported age and date of birth, and age-displacement). Reporting events and placing the events in calendar time remain major challenges by the respondents based on memory recall.

While the overall value of DHS maternal mortality estimates is undeniable, our examination of the quality of the DHS maternal mortality estimation suggests that there is a major problem with the current sibship survival method that has resulted in underestimation bias in DHS maternal mortality estimation. The problem is the high non-response rates associated with both the calendar timing reference for deaths and the reporting of pregnancy status at the time of death.

In current practice, deaths that are reported to have occurred during pregnancy, delivery, or the postpartum period (2 months in recent DHS surveys; 6 weeks in some earlier DHS surveys) are considered maternal deaths by DHS. Deaths with unknown pregnancy status are classified as non-maternal. This assumption introduces significant bias and underestimates maternal mortality in countries with a high non-response rate for the pregnancy status variable. The DHS analytical manual, titled "Guide to DHS Statistics" (Rutstein and Rojas 2006), suggests to address the missing responses on maternal status at the time of death by allocating those proportionally to the maternal death distribution in the complete case reporting. The specific recommendation is as follows:

> "Siblings whose maternal status at the time of death is unknown to the respondent or is missing in the data set are allocated to maternal deaths in the proportion they are to deaths of any maternal status. For each age group of siblings, the number of deaths of known maternal status is divided by the number of deaths of any status to get the proportion of maternal deaths. This proportion is then multiplied by the number of deaths of unknown status to calculate the number of deaths to add to the known maternal deaths to get the total number of maternal deaths in each age group."

The maternal mortality estimates by Stanton et al. (1997) are adjusted based on this recommended procedure. However, the procedure was not fully implemented by DHS. The DHS country reports, which are the main source of maternal mortality data for MMEIG, IHME, and country officials, are based on no adjustment for missing values in maternal status during death. DHS surveys do not routinely collect data

on marital status of the siblings. In many countries, out-of-wedlock pregnancies are not socially and culturally acceptable. Although these countries experience abortion-related deaths, it was of significant uncertainty that all sisters with missing responses in such settings were likely to experience a maternal death rate similar to the sisters with complete responses on maternal status at the time of death. While debating the concerns, the DHS surveys moved away from the recommendation of correcting maternal death counts for missing values.

In this report, we have shown the implications of missing responses on maternal status during death for maternal mortality indicators, such as MMR. We suggest that some simple statistical adjustments can be made that will substantially reduce the underestimation bias.

The sibling survival module collects information on all siblings, including those who died several years ago. Many respondents have difficulty remembering the age at death and the calendar timing of death for siblings who died in the distant past. In addition, focusing on these questions can put undue pressure on respondents to recall sensitive events in the distant past and can be time consuming for the interviewer. It is well recognized that the reporting of recent deaths is substantially more reliable than reporting of deaths that occurred in the distant past, which is the reason DHS limits analysis of mortality data to the last five to seven years. This is also done recognizing that the age-structure of respondents and hence the age-structure and parity of sisters may vary between recent and distant periods. Considering the high level of non-response for death information—especially regarding deaths that occurred many years ago—and considering that the information is never used by DHS for any analysis, we think it would be beneficial to examine the impact of limiting the history recall period with a *truncated sibling history module*. As an example, instead of listing all siblings in order of birth, list the surviving siblings first and then list the siblings that died in the last seven years. A similar approach was used in the *direct household maternal mortality estimation module* in the Household Questionnaire for the Bangladesh Maternal Health Services and Maternal Mortality Survey (NIPORT et al. 2003); a separate table was included for listing the individual household members who died during the last three years. An illustration is shown in Appendix 1. Despite the concerns of displacement of timing of deaths in such a truncated survival table, the maternal mortality ratio (MMR) estimates in Bangladesh, Afghanistan, and Ghana showed overestimation, rather than underestimation, compared with sibling history-based estimates for the same period (Bangladesh Maternal Mortality and Health Care Survey in 2001 and 2010, Afghanistan Mortality Survey 2010, and Ghana Maternal Health Survey 2007).

However, if age or calendar displacement is a real or anticipated concern, the data collection observation period in the *truncated sibling history module* may be extended by one year to siblings who died within 8 years, instead of seven years, and the information from the last year may discarded during data analysis.

Recommendations

We provide the following sets of recommendations to improve the quality of the DHS sibling survival data.

1. Develop a standard protocol for addressing missing responses in the sibling survival history module. Considering the high non-response rate in age and date of birth, DHS routinely performs imputation in age- and date-related variables. All the publicly available DHS data are imputed. A similar standardizing approach may be undertaken for missing values in pregnancy status at the time of death.

2. The current method of maternal mortality estimation considers all deaths with unknown pregnancy status at the time of death as non-maternal. The MMR estimates are biased under this assumption. We suggest correcting the underestimation with a suitable statistical method. Multiple imputations may be the best way to take into account uncertainty in the missingness. However, replication of the results will be a challenge for external data users. Moreover, this may not be practical for

distributing data for public use with multiple imputation. Weighting is a simple method but may not be efficient (proportion of maternal deaths is considered constant in both missing and non-missing groups, which may not be true). In addressing the problem, DHS may need to strike a balance between efficiency and convenience.

3. Although information is collected on all siblings, DHS does not utilize information from the siblings who died in the distant past. Considering the high level of non-response associated with the collection of death information, especially regarding deaths that occurred a long time ago, it may be useful for DHS to test a modified sibling survival history tool that collects information on deaths only for the recent period. Truncated histories, however, have been shown to be more subject to biases due to omissions than full histories. Nevertheless, the experience of household reporting of recent deaths in the "direct household maternal mortality module" in Bangladesh, Afghanistan, Ghana, and other countries suggests that it is possible to collect truncated survival history. Respondents experience considerable challenge in placing deaths in reference to calendar timing. It would be useful to incorporate country-specific milestone events into the calendar to provide time references for the respondents. These milestone events can also be incorporated into the training manual and emphasized during interviewer training. It is important that the interviewer training specifically addresses the challenges associated with collecting death information. Innovative attempts should be made to reduce missing responses.

4. Safe motherhood programs need to identify high-risk population groups and target geographical regions with high maternal mortality levels. Unfortunately, the current method used by DHS to estimate maternal mortality (sisterhood method) is suitable for assessing maternal mortality at the national level only. As a result, DHS estimates have little utility for local health administrators who need data at the regional level. We suggest improving the sibling history module to capture subnational variability in maternal deaths. With the advancements in small area estimation methods, it may not be difficult to capture subnational maternal deaths at the regional level (Ahmed and Hill 2011).

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Appendix

Table A.1 DHS country code list for the selected countries included in the report

Country	DHS code
Benin	BJ
Bolivia	BO
Brazil	BR
Burkina Faso	BF
Burundi	BU
Cambodia	KH
Cameroon	CM
Central African Republic	CF
Chad	TD
Congo (Brazzaville)	CG
Congo Democratic Republic	CD
Cote d'Ivoire	CI
Dominican Republic	DR
Ethiopia	ET
Gabon	GA
Guatemala	GU
Guinea	GN
Haiti	HT
Indonesia	ID
Jordan	JO
Kenya	KE
Lesotho	LS
Liberia	LB
Madagascar	MD
Malawi	MW
Mali	ML
Morocco	MA
Mozambique	MZ
Namibia	NM
Nepal	NP
Niger	NI
Nigeria	NG
Peru	PE
Philippines	PH
Rwanda	RW
Sao Tome and Principe	ST
Senegal	SN
Sierra Leone	SL
South Africa	ZA
Swaziland	SZ
Tanzania	TZ
Timor-Leste	TL
Togo	TG
Uganda	UG
Zambia	ZM
Zimbabwe	ZW

Table A.2 The distribution of reported timing of death before survey among sisters listed as dead in the sibling survival history (unweighted analysis), Demographic and Health Survey 1990-2013

Country	DHS survey round	Year of survey	No. of sisters ever died	Sisters died in 0-6 years		Sisters died in 7-13 years	
				Number	Percent	Number	Percent
Sub-Saharan							
Benin	DHS-III	1996	3,681	380	10.3	520	14.1
Benin	DHS-V	2006	8,244	1,105	13.4	1,142	13.9
Burkina Faso	DHS-III	1998-99	3,340	638	19.1	569	17.0
Burkina Faso	DHS-IV	2003	5,672	1,043	18.4	1,020	18.0
Burkina Faso	DHS-VI	2010	8,714	1,235	14.2	1,538	17.6
Burundi	DHS-VI	2010-11	6,984	748	10.7	1,346	19.3
Cameroon	DHS-III	1998	2,884	447	15.5	415	14.4
Cameroon	DHS-IV	2004	6,529	1,326	20.3	1,021	15.6
Cameroon	DHS-VI	2011	9,065	1,821	20.1	1,744	19.2
Central African Republic	DHS-III	1994-95	2,788	678	24.3	511	18.3
Chad	DHS-III	1996-97	4,411	691	15.7	788	17.9
Chad	DHS-IV	2004	4,017	734	18.3	858	21.4
Congo (Brazzaville)	DHS-V	2005	3,565	841	23.6	811	22.7
Congo (Brazzaville)	DHS-VI	2011-12	5,009	967	19.3	1,068	21.3
Congo Democratic Republic	DHS-V	2007	6,100	1,335	21.9	1,269	20.8
Cote d'Ivoire	DHS-III	1994	3,531	653	18.5	558	15.8
Cote d'Ivoire	DHS-V	2005	2,144	453	21.1	353	16.5
Cote d'Ivoire	DHS-VI	2011-12	5,825	1,042	17.9	1,076	18.5
Ethiopia	DHS-IV	2000	11,203	1,798	16.0	1,944	17.4
Ethiopia	DHS-IV	2005	7,522	1,441	19.2	1,494	19.9
Ethiopia	DHS-VI	2011	10,054	1,340	13.3	1,827	18.2
Gabon	DHS-III	2000-01	2,507	478	19.1	368	14.7
Gabon	DHS-VI	2012	3,314	740	22.3	612	18.5
Guinea	DHS-III	1999	3,634	468	12.9	600	16.5
Guinea	DHS-IV	2005	5,006	786	15.7	844	16.9
Guinea	DHS-VI	2012	4,848	805	16.6	808	16.7
Kenya	DHS-III	1998	2,903	736	25.4	459	15.8
Kenya	DHS-IV	2003	3,530	1,001	28.4	549	15.6
Kenya	DHS-V	2008-09	2,795	819	29.3	617	22.1
Lesotho	DHS-IV	2004-05	3,052	1,092	35.8	369	12.1
Lesotho	DHS-V	2009-10	3,075	1,190	38.7	550	17.9
Liberia	DHS-V	2006-07	1,762	508	28.8	347	19.7
Madagascar	DHS-III	1997	2,753	663	24.1	635	23.1
Madagascar	DHS-IV	2003-04	1,731	467	27.0	360	20.8
Madagascar	DHS-V	2008-09	6,594	1,397	21.2	1,363	20.7
Malawi	DHS-II	1992	4,158	628	15.1	621	14.9
Malawi	DHS-IV	2000	10,602	2,291	21.6	1661	15.7
Malawi	DHS-IV	2004-05	7,133	1,998	28.0	1,244	17.4
Malawi	DHS-V	2010	18,363	3,042	16.6	3,200	17.4
Mali	DHS-III	1995-96	6,667	807	12.1	1,059	15.9
Mali	DHS-IV	2001	7,801	1,200	15.4	1,284	16.5
Mali	DHS-V	2006	9,679	1,293	13.4	1,635	16.9

(Continued...)

Table A.2 – *Continued*

Country	DHS survey round	Year of survey	No. of sisters ever died	Sisters died in 0-6 years		Sisters died in 7-13 years	
				Number	Percent	Number	Percent
Sub-Saharan							
Mali	DHS-VI	2012-13	1,895	378	19.9	387	20.4
Mozambique	DHS-III	1997	3,385	670	19.8	646	19.1
Mozambique	DHS-IV	2003-04	6,051	1,205	19.9	932	15.4
Mozambique	DHS-VI	2011	4,359	1,036	23.8	890	20.4
Namibia	DHS-II	1992	1,878	384	20.4	338	18.0
Namibia	DHS-IV	2000	2,003	604	30.2	289	14.4
Namibia	DHS-V	2006-07	3,421	1,428	41.7	584	17.1
Niger	DHS-II	1992	4,685	658	14.0	903	19.3
Niger	DHS-V	2006	5,960	941	15.8	1,135	19.0
Niger	DHS-VI	2012	7,885	997	12.6	1,304	16.5
Nigeria	DHS-III	1999	2,260	580	25.7	433	19.2
Nigeria	DHS-V	2008	13,993	3,030	21.7	2,736	19.6
Rwanda	DHS-IV	2000	8,564	3,537	41.3	1,387	16.2
Rwanda	DHS-IV	2005	9,980	1,694	17.0	4,237	42.5
Rwanda	DHS-VI	2010-11	9,785	827	8.5	1,844	18.8
Sao Tome and Principe	DHS-V	2008-09	1,194	288	24.1	362	30.3
Senegal	DHS-II	1992-93	3,752	417	11.1	609	16.2
Senegal	DHS-IV	2005	7,212	983	13.6	1,130	15.7
Senegal	DHS-VI	2010-11	7,874	994	12.6	1,134	14.4
Sierra Leone	DHS-V	2008	2,725	703	25.8	472	17.3
South Africa	DHS-III	1998	2,445	495	20.2	341	13.9
Swaziland	DHS-V	2006-07	1,894	1,001	52.9	298	15.7
Tanzania	DHS-III	1996	3,908	702	18.0	580	14.8
Tanzania	DHS-IV	2004-05	6,205	1,150	18.5	1,011	16.3
Tanzania	DHS-V	2009-10	4,358	763	17.5	794	18.2
Togo	DHS-III	1998	5,091	610	12.0	644	12.6
Uganda	DHS-III	1995	4,327	1,183	27.3	712	16.5
Uganda	DHS-IV	2000-01	4,908	1,170	23.8	987	20.1
Uganda	DHS-V	2006	6,854	1,226	17.9	1,392	20.3
Uganda	DHS-VI	2011	6,188	900	14.5	1,156	18.7
Zambia	DHS-III	1996-97	4,681	1,466	31.3	862	18.4
Zambia	DHS-IV	2001-02	4,751	1,756	37.0	985	20.7
Zambia	DHS-V	2007	3,793	1,371	36.1	942	24.8
Zimbabwe	DHS-III	1994	2,583	475	18.4	370	14.3
Zimbabwe	DHS-IV	1999	2,028	813	40.1	238	11.7
Zimbabwe	DHS-V	2005-06	3,324	1,665	50.1	639	19.2
Zimbabwe	DHS-VI	2010-11	3,082	1,341	43.5	768	24.9
North Africa							
Jordan	DHS-III	1997	2,718	113	4.2	139	5.1
Morocco	DHS-II	1992	5,049	337	6.7	548	10.9
Morocco	DHS-IV	2003-04	8,148	394	4.8	559	6.9

(Continued...)

Table A.2 – *Continued*

Country	DHS survey round	Year of survey	No. of sisters ever died	Sisters died in 0-6 years		Sisters died in 7-13 years	
				Number	Percent	Number	Percent
Asia							
Cambodia	DHS-IV	2000	6,731	918	13.6	1,080	16.0
Cambodia	DHS-V	2005-06	7,958	881	11.1	1,191	15.0
Cambodia	DHS-V	2010-11	6,017	654	10.9	809	13.4
Indonesia	DHS-III	1994	9,607	1,041	10.8	1,024	10.7
Indonesia	DHS-III	1997	7,314	835	11.4	788	10.8
Indonesia	DHS-IV	2002-03	6,523	863	13.2	688	10.5
Indonesia	DHS-V	2007	7,952	1,078	13.6	869	10.9
Indonesia	DHS-VI	2012	11,975	1,521	12.7	1,179	9.8
Nepal	DHS-III	1996	5,643	441	7.8	647	11.5
Nepal	DHS-V	2006	5,427	336	6.2	542	10.0
Philippines	DHS-II	1993	3,472	604	17.4	556	16.0
Philippines	DHS-III	1998	3,701	566	15.3	583	15.8
Timor-Leste	DHS-VI	2009-10	4,896	516	10.5	776	15.8
Latin America and Caribbean							
Bolivia	DHS-III	1993-94	3,646	408	11.2	557	15.3
Bolivia	DHS-IV	2003-04	8,111	721	8.9	1,045	12.9
Bolivia	DHS-V	2008	6,547	540	8.2	706	10.8
Brazil	DHS-III	1996	4,929	406	8.2	451	9.1
Dominican Republic	DHS-IV	2002	3,079	438	14.2	358	11.6
Dominican Republic	DHS-V	2007	6,034	865	14.3	667	11.1
Guatemala	DHS-III	1995	5,515	509	9.2	729	13.2
Haiti	DHS-IV	2000	7,170	955	13.3	1,030	14.4
Haiti	DHS-V	2005-06	7,027	897	12.8	1,056	15.0
Peru	DHS-II	1991-92	4,928	687	13.9	806	16.4
Peru	DHS-III	1996	13,209	1,245	9.4	1,603	12.1
Peru	DHS-IV	2000	11,971	902	7.5	1,291	10.8
Peru	DHS-V	2003-08	16,874	975	5.8	1,383	8.2
Peru	DHS-VI	2011	7,925	474	6.0	514	6.5

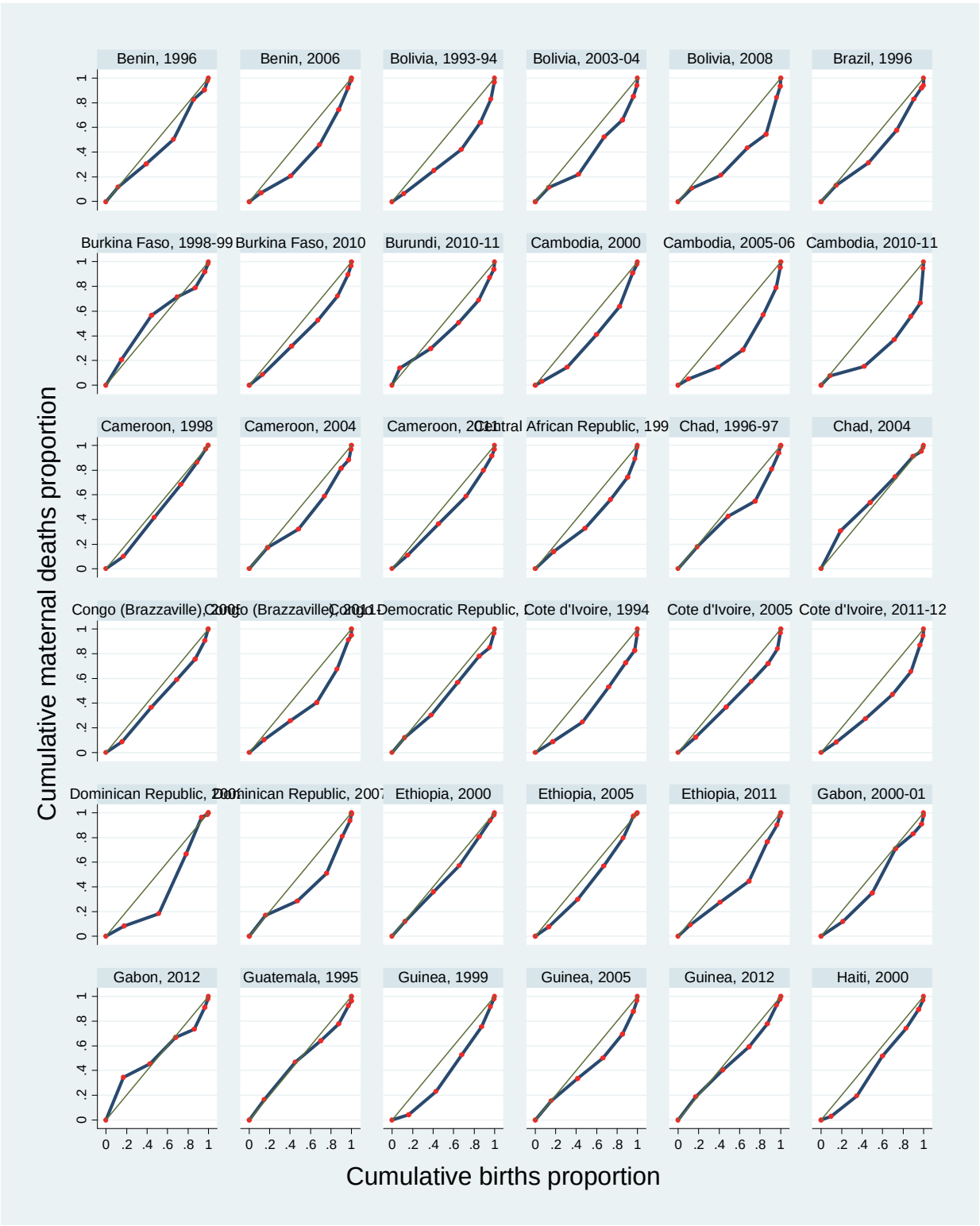
Figure A.1 Listing table of household members who had died in recent period, BMMS 2001

I would like to know about the person died in your household since April 1997 (Baishak 1404). Please provide me the information first on recent death.

24	25	26	27	28	29	FOR 13-49 YEARS OLD WOMEN					
						30	31	32	33	34	35
What (was/were) the name(s) of the person(s) who died?	Was (NAME) a male or female?	How old was he/she when he/she died? RECORD DAYS IF LESS THAN ONE MONTH, MONTHS IF LESS THAN TWO YEARS, OR YEARS IF TWO OR MORE YEARS.	In what month and year did (NAME) die?	What did (NAME) die of?	CHECK 25 AND 26: DECEASED WAS FEMALE AGED 13-49 AT THE TIME OF DEATH.	Was (NAME) married?	Was (NAME) pregnant when she died?	Did (NAME) die during childbirth?	Did (NAME) die within six weeks after the end of a pregnancy or childbirth?	ELIGIBILITY FOR VERBAL AUTOPSY: IF CIRCLE '1' IN Q.29 THEN CIRCLE LINE NUMBER	Did (NAME) die at home or outside home?
01 _____ (NAME)	MALE ..... 1 FEMALE 2	DAYS ..... 1 MONTHS ... 2 YEARS 3	MONTH YEAR	_____ _____	YES ..... 1 NO ..... 2 (GO TO NEXT DEATH)	YES ..... 1 NO ..... 2 (GO T0 34)	YES ..... 1 (GO TO 34) NO 2	YES ..... 1 (GO TO 34) NO 2	YES ..... 1 NO 2	01	AT HOME ..... 1 OUT SIDE HOME 2
02 _____ (NAME)	MALE ..... 1 FEMALE 2	DAYS ..... 1 MONTHS ... 2 YEARS 3	MONTH YEAR	_____ _____	YES ..... 1 NO ..... 2 (GO TO NEXT DEATH)	YES ..... 1 NO ..... 2 (GO T0 34)	YES ..... 1 (GO TO 34) NO 2	YES ..... 1 (GO TO 34) NO 2	YES ..... 1 NO 2	02	AT HOME ..... 1 OUT SIDE HOME 2
03 _____ (NAME)	MALE ..... 1 FEMALE 2	DAYS ..... 1 MONTHS ... 2 YEARS 3	MONTH YEAR	_____ _____	YES ..... 1 NO ..... 2 (GO TO NEXT DEATH)	YES ..... 1 NO ..... 2 (GO T0 34)	YES ..... 1 (GO TO 34) NO 2	YES ..... 1 (GO TO 34) NO 2	YES ..... 1 NO 2	03	AT HOME ..... 1 OUT SIDE HOME 2

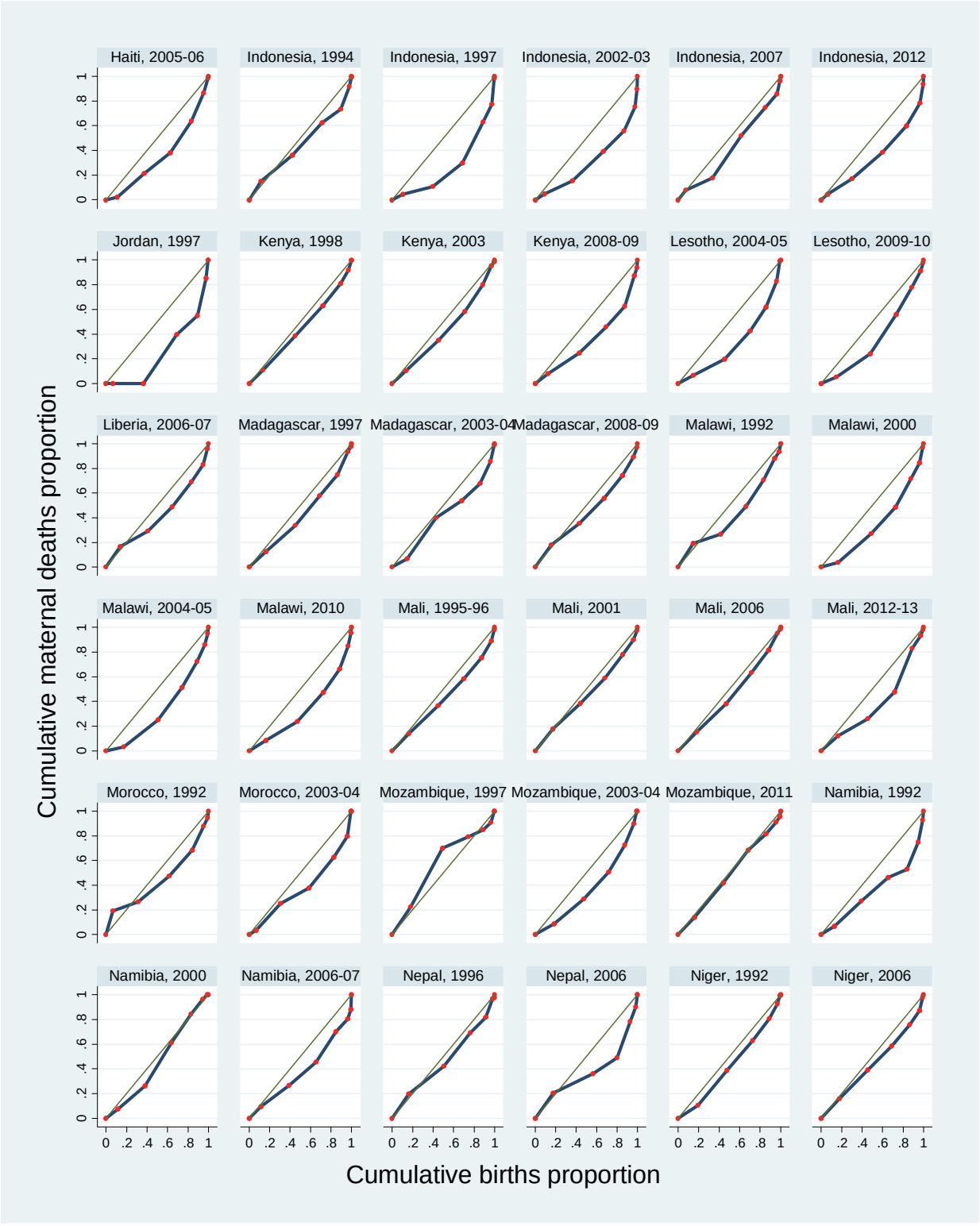
36 TOTAL NUMBER OF PERSONS CIRCLED IN Q.34 ..... (INTERVIEWERS: PLEASE INFORM YOUR SUPERVISOR ABOUT THE NUMBER OF ELIGIBLE VERBAL AUTOPSY CASES IN THIS HOUSEHOLD)

Figure A.2 Maternal death concentration curve, Demographic and Heath Surveys 1990-2013



(Continued...)

Figure A.2 – *Continued*



(Continued...)

Figure 4.10 – *Continued*