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UNDERSTANDING THE CAUSES OF MATERNAL MORTALITY IN INDONESIA

Is the increase in Indonesia's 2012 maternal mortality ratio due to methodological differences?

This research was carried out in collaboration with the Governments of Australia and Indonesia, but the analysis and findings in this paper represent the views of the author/s and do not necessarily represent the views of those Governments.

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Understanding the Causes of Maternal Mortality in Indonesia

Technical Note: Is the increase in Indonesia's 2012 maternal mortality ratio due to methodological differences?

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LIST OF ABBREVIATIONS

DHS	Demographic Health Survey
GFR	General Fertility Rate
ICD-10	International Statistical Classification of Diseases and Related Health Problems 10th Revision
IDHS	Indonesian Demographic and Health Survey
MDG	Millennium Development Goal
MMR	Maternal Mortality Ratio; a standardized calculation of deaths of women which are related to the pregnancy or its management aside from accidental causes denominated by 100,000 live births in a certain area/country. (WHO)
MMRate	Maternal Mortality Rate
MoH	Indonesia Ministry of Health
NAoS	National Academy of Sciences
SUSENAS	*Survei Sosial Ekonomi Nasional* (National Socio-Economic Survey)
WHO	World Health Organization

ABSTRACT

Indonesia uses a multipurpose household survey—that is Demographic Health Survey (DHS), to record maternal deaths once in 5-year period, but there remains a paucity in the subject: the uncertainty in measurement of MMR. Two of which highlighted are the 2007 and 2012 DHS where there is a significant increase ratio found (359 deaths per 100,000 live births in 2012, compared to the 228 deaths per 100,000 live births in 2007). The focus of this study is to identify methodological differences across the two surveys, and whether they contribute a significant impact. In this note, we outline the method used in calculating a MMR in the 2007 and 2012 DHS data and define its components. Using the technical adjustments in statistical approach such as weighting functions and factor, we replicate the calculation of the MMR to identify potential sources of discrepancy at each step in the process, followed with the sensitivity analysis to gauge the impact. There are two main differences found in both surveys, namely the use of terms and structures in the questionnaire, and the sampling design which are considered as non-significant factors to the increase of ratio between the respective time periods. This conclude that the increase is likely due to the high degree of imprecision in the DHS estimates. Thus, we suggest that Indonesia needs an accurate vital registration system to perform an effective efforts evaluation in reducing maternal death as well as planning the strategy to fulfil both national and international target, such as MDGs.

Keywords: Maternal Mortality Ratio (MMR), Demographic Health Survey (DHS), estimation

1 INTRODUCTION

This technical note replicates the official 2007 and 2012 Indonesian Demographic and Health Survey (DHS) estimates of the maternal mortality ratio (MMR)[2]. It provides a detailed comparison of the respective samples used and the components making up the overall ratio. This allows identification of the extent to which the high point estimate obtained using the 2012 DHS (359 deaths per 100,000 live births, compared to 228 using the 2007 DHS) is likely to be reflective of methodological differences across the two surveys, rather than a worsening of maternal death rates per se. Particularly, as the MMR confidence intervals overlap.[3] Inconsistencies could result from differences in questionnaire design (e.g. wording, question sets used, skip patterns), in particular those that relate to identification of a maternal death; sampling and sample design including weighting functions; and the calculation methods themselves.

In this note we first outline the method used in calculating a MMR using the DHS (the direct sisterhood method) and define its components. We replicate calculation of the MMR using the 2007 and 2012 DHS data, identifying potential sources of discrepancy at each step in the process. Next we perform some sensitivity analysis to gauge the impact of technical adjustments made in the 2007 results. Lastly we summarise our key findings to conclude that although there are differences in question wording/structure and differences in the sample design between 2007 and 2012, these differences are unlikely to have caused the apparent large increase in Indonesia's MMR in 2012. Rather, the increase is likely the result of the high degree of imprecision in the DHS estimates.

[2] *See Statistics Indonesia (2013, 2008). The MMR relates to the 5-year period preceding the survey.*

[3] *2007 DHS estimated 228 MMR with a confidence interval of 132 to 323 and 2012 DHS estimated a MMR of 359 with a confidence interval of 239 to 478.*

2 ESTIMATING THE MATERNAL MORTALITY RATIO (MMR)

2.1 THE DIRECT SISTERHOOD METHOD

In the absence of comprehensive vital registration systems to identify and record maternal deaths, the sisterhood method provides a low-cost approach to estimating the MMR by incorporating particular questions into a multipurpose household survey, such as the DHS.4

The DHS women's questionnaire asks women (aged 15-49) in the household about the survivorship of all the live-born children of her mother, that is, her maternal siblings. For any female siblings who died at age 10 or above, further questions determine the age and year of death, and whether the death was pregnancy-related (pregnant when died, died during childbirth or died within 42 days after the end of a pregnancy).[5] Thus the sisterhood method allows data to be collected on pregnancy-related deaths for a larger sample of women – not just those in the immediate household being surveyed, but also the sisters of those women in the surveyed household.6

2.2 THE RATIO AND ITS COMPONENTS

The MMR is calculated among women of childbearing age (15-49) in the five years prior to the survey as follows:

$$\text{MMR} = \frac{\text{Number of maternal deaths}}{\text{Number of live births}} \times 100\,000$$

Denominated with respect to the number of live births, the MMR provides a measure of obstetric risk.

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[4] As maternal death is a rare event, power considerations are necessary in obtaining estimates using the sisterhood method. For example, to calculate a MMR of 300 per 100,000 live births correct to within 20% there is a minimum requirement of 5,000 DHS adult respondents.

[5] The DHS generally does not ascertain whether deaths are "caused or aggravated by the pregnancy", hence are referred to as "pregnancy-related" deaths rather than a true maternal death according to the ICD-10 definition.

[6] The method described here relates to a variant of the sisterhood method known as the "direct" approach, used in the official DHS reports. A simpler "indirect" approach also exists: see Graham, Brass, and Snow (1988) and WHO (1997) for detail and comparison of these variants. The direct sisterhood method asks women in the surveyed households about survival status of all the sisters from the same mother during the past 5 years. However, as information on sisters' place of residence is not asked, it is not possible to produce maternal mortality indicators by regions.

The MMR can also be expressed in terms of the risk of maternal death among women of reproductive age (the maternal mortality rate: MMRate), and the fertility rate among women of this age (the number of live births per 1000 women aged 15-49: the general fertility rate):

$$\text{MMR} = \frac{\text{Number of maternal deaths/Number of women aged 15-49 years}}{\text{Number of live births/Number of women aged 15-49 years}} \times 100\,000$$
$$= \frac{\text{MMRate}}{\text{General fertility rate}}$$

Hence declining fertility rates over time can affect the path of the MMR, as can shifts in the age structure of a population – for example, an aging population may result in a decline in the number of women aged 15-49 years. General trends around the timing of (first) pregnancy can also affect the mortality rate, for example, women who have their first child late in their reproductive years have a higher maternal risk (Luke & Brown, 2006).

The DHS methodology for calculating the MMR uses this ratio between the MMRate and the general fertility rate (from the DHS Women's Questionnaire) to calculate the MMR.

2.3 MATERNAL MORTALITY RATE (MMRate)

Reflecting the risk of maternal death among women of reproductive age, the MMRate essentially aggregates the risk of maternal death for each female respondent of the DHS. This risk is attributed to the respondent women based on information gathered from the sample of sisters, for whom we observe maternal mortality status: we have data on the number of maternal deaths observed among the sample of sisters in the respondent's age group, and the number of years of exposure to mortality risk in each age group.[7,8]

That is, for each age group a, a maternal mortality rate among the sisters in this age group mms_a is calculated as follows:

$$\text{mms}_a = \frac{\text{Number of maternal deaths among sisters in age group a}}{\text{Years of exposure to risk in age group a}} \times 1000$$

This provides an estimate of maternal mortality risk for women in each age group, based on data from the sisters. Sisters are then attributed a value according to their own age group, and the overall MMRate is calculated as the average of these individual values weighted by the female respondents age group distribution. Essentially an average risk weighted according to the age distribution of the DHS respondent sample, this method produces an

[7] *Age groups are in five-yearly groupings: 15-19, 20-24, etc.*

[8] *Years of exposure to mortality risk essentially identifies which age group each sister was in during each of the five (living and reproductive) years preceding the survey, to obtain a distribution of exposure-years for the sample of sisters. For example, a surviving sister aged exactly 23 at the time of interview was in age group 15-19 for two of the preceding five, and age group 20-24 for three of the five. She would therefore contribute two exposure years to age group 15-19 and three exposure years to age group 20-24.*

estimate of the MMRate that is representative of women of reproductive age in the DHS sample.

2.4 GENERAL FERTILITY RATE

Calculated as the number of live births per 1000 women aged 15-49, the general fertility rate is calculated over the five years preceding the survey directly from the recent birth history reported by respondents of the DHS Women's Questionnaire.

3 DIFFERENCES BETWEEN THE 2007 AND 2012 INDONESIAN DHS

3.1 RESPONDENTS

The respondent groups for the DHS Women's Questionnaire were different in 2007 and 2012: the 2007 sample was comprised of only women aged 15-49 who had ever been married, while the 2012 sample was comprised of all (never and ever-married) women aged 15-49. Unmarried women who become pregnant are likely to be at higher risk of maternal mortality since they are more likely to meet some criteria for high-risk pregnancies: being young, having their first child and undertaking unsafe abortion.[9]

Although not explicit in the DHS reports for Indonesia, the 2007 (and prior) estimates of maternal mortality were based on an "all-women factor" adjustment designed to re-weight the sample to be representative of all women, not just the ever-married women that were interviewed. With maternal deaths being such a rare occurrence, even small adjustments can have large implications for the MMR. In section 4 we exploit the fact that the 2012 DHS sample uses all women to examine what the 2012 MMR would be if only the ever-married women were sampled, and an "all-women factor" applied (i.e. analogous to the procedure used in 2007).

The 2007 DHS includes a sibling mortality module in the Men's Questionnaire[10], however based on our calculations it appears these data were not used for calculating the estimate of the MMR.

3.2 LOCATIONS AND SAMPLING WEIGHTS

The 2007 and 2012 DHS are designed to be representative of the Indonesian population at their respective points in time. Since population growth is not constant across all areas of the archipelago, the geographical distribution of the sample will differ across surveys. This is exemplified in Table 1 by a much larger proportion of urban dwellers being sampled in the 2012 DHS, reflecting generally higher population growth rates in urban areas (and expanding areas classified as "urban"). By comparison, there has been relatively little expansion in the sample in rural areas.

While we would expect urban areas to have lower rates of maternal mortality, potentially lowering the national estimate overall, note that the urban provinces whose sample size has grown the most tend to be in areas of eastern Indonesia and Sulawesi. Soemantri (2012, cited in: NAoS, 2013) finds these regions to have much higher rates of maternal mortality than the

[9] *Both surveys use the sisterhood method, so observation of a maternal death relates to the sisters of these respondents, so the link is less clear.*

[10] *That is, a sibling survival history could also be constructed from the male respondents.*

rest of Indonesia, and so a sample that includes more observations from these provinces could indeed find an overall higher rate of maternal mortality.

Table 1. Sample Sizes (unweighted) for the Women's Questionnaire

Region	Number of Respondents						Expansion in Sample Size (%)		
	2007			2012					
	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Overall
Aceh	162	767	929	513	920	1,433	217	20	54
North Sumatera	484	642	1,126	893	937	1,830	85	46	63
West Sumatera	258	647	905	639	700	1,339	148	8	48
Riau	451	540	991	620	766	1,386	37	42	40
Jambi	231	643	874	427	685	1,112	85	7	27
South Sumatera	350	705	1,055	537	798	1,335	53	13	27
Bengkulu	236	517	753	368	629	997	56	22	32
Lampung	222	698	920	524	830	1,354	136	19	47
Bangka Belitung	335	480	815	528	567	1,095	58	18	34
Kep Bangka Belitung	577	154	731						
Riau Islands				681	360	1,041			
Jakarta	1,722		1,722	2,391		2,391	39		39
West Java	894	799	1,693	1,448	776	2,224	62	-3	31
Central Java	598	852	1,450	1,022	976	1,998	71	15	38
Yogyakarta	645	465	1,110	947	572	1,519	47	23	37
East Java	620	865	1,485	1,025	954	1,979	65	10	33
Banten	787	626	1,413	1,384	684	2,068	76	9	46
Bali	678	624	1,302	935	666	1,601	38	7	23
West Nusa Tenggara	353	611	964	632	736	1,368	79	20	42
East Nusa Tenggara	125	696	821	402	816	1,218	222	17	48
West Kalimantan	233	700	933	477	790	1,267	105	13	36
Central Kalimantan	252	540	792	417	579	996	65	7	26
South Kalimantan	361	592	953	587	686	1,273	63	16	34
East Kalimantan	471	366	837	650	429	1,079	38	17	29
North Sulawesi	326	568	894	558	723	1,281	71	27	43
Central Sulawesi	147	671	818	441	701	1,142	200	4	40
South Sulawesi	367	850	1,217	809	969	1,778	120	14	46
Southeast Sulawesi	182	585	767	422	672	1,094	132	15	43
Gorontalo	235	649	884	463	690	1,153	97	6	30
West Sulawesi	123	634	757	414	636	1,050	237	0	39
Maluku	202	603	805	509	620	1,129	152	3	40
North Maluku	162	592	754	450	699	1,149	178	18	52
West Papua	195	507	702	497	511	1,008	155	1	44
Papua	103	620	723	288	632	920	180	2	27
Total	**13,087**	**19,808**	**32,895**	**22,898**	**22,709**	**45,607**	**75**	**15**	**39**

Table 1 above provides the raw, unweighted number of observations included in the 2007 and 2012 DHS. The DHS sampling design over-samples some households in the population to reduce sample variability. An adjustment factor is then used to weight the observations

back to be representative of the population. Table 2 provides the weighted number of observations.

Table 2. Sample Sizes (weighted) for the Women's Questionnaire

Region	Weighted Number of Respondents						Expansion in Sample Size (%)		
	2007			2012					
	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Overall
Aceh	106	407	514	230	647	877	116	59	71
North Sumatera	652	835	1,487	1,257	1,138	2,394	93	36	61
West Sumatera	158	413	570	345	507	852	119	23	49
Riau	171	322	494	444	596	1,040	159	85	110
Jambi	86	281	367	180	400	580	110	42	58
South Sumatera	304	624	928	488	870	1,358	60	40	46
Bengkulu	60	151	211	94	213	306	57	41	45
Lampung	221	742	963	411	1,032	1,443	86	39	50
Bangka Belitung	75	119	194	115	131	245	53	10	27
Kep Bangka Belitung	111	29	140						
Riau Islands				269	54	323			
Jakarta	1,471		1,471	1,939		1,939	32		32
West Java	2,717	2,828	5,545	5,636	2,629	8,265	107	-7	49
Central Java	2,161	3,222	5,383	2,925	3,316	6,240	35	3	16
Yogyakarta	321	230	551	454	200	654	41	-13	19
East Java	2,262	3,663	5,924	3,681	3,693	7,374	63	1	24
Banten	766	544	1,310	1,516	632	2,148	98	16	64
Bali	297	290	587	518	272	790	74	-6	35
West Nusa Tenggara	237	468	705	417	580	997	76	24	41
East Nusa Tenggara	93	534	627	190	701	892	105	31	42
West Kalimantan	169	458	628	217	539	756	28	18	20
Central Kalimantan	70	224	294	147	262	409	111	17	39
South Kalimantan	187	363	550	314	416	730	67	15	33
East Kalimantan	258	217	475	438	232	671	70	7	41
North Sulawesi	135	238	373	196	231	427	45	-3	14
Central Sulawesi	57	282	339	128	357	486	125	27	43
South Sulawesi	322	746	1,067	654	876	1,530	103	17	43
Southeast Sulawesi	64	195	259	115	267	382	80	37	48
Gorontalo	46	118	163	72	131	203	57	11	24
West Sulawesi	23	116	139	53	138	191	126	19	37
Maluku	46	122	168	117	143	260	155	17	54
North Maluku	29	100	129	57	131	188	96	31	46
West Papua	29	60	89	51	80	130	75	32	46
Papua	41	210	251	137	389	527	239	85	110
Total	**13,745**	**19,150**	**32,895**	**23,805**	**21,802**	**45,607**	**73**	**14**	**39**

The use of sample weights dampens the story somewhat: eastern Indonesia and Sulawesi still receive a large expansion in proportional sample size, yet so too do parts of northern Sumatera, West Java and Banten.[11]

3.3 INTERVIEW QUESTIONS

Figure 1 below compares the set of DHS questions for 2007 and 2012 to be used in calculating an estimate of the MMR.

Figure 1. Interview Questions used in the Maternal Mortality Module of the Indonesian DHS

2007

For each maternal sister of respondent aged 15-49:

07. Is [sister] still alive?
- IF NO: In what year did [sister] die? / How old was [sister] when she died?
  - IF AGED 10+ AT DEATH: Was [sister] pregnant when she died or did [name] die during childbirth?
    - IF NO: 07.1.1.1. Did [sister] die within 42 hours[12] after the end of a pregnancy?

Did [sister] die due to complications of pregnancy or childbirth?

2012

For each maternal sister of respondent aged 15-49:

12. Is [sister] still alive?
- IF NO: 12.1. In what year did [sister] die? / How old was [sister] when she died?
  - IF AGED 10+ AT DEATH: 12.1.1. Was [sister] pregnant when she died?
    - IF NO: 12.1.1.1. Did [sister] die during childbirth?

[11] *Changes in the sample size may reflect underlying changes in the population structure, in the sampling method or in both. To examine what was happening to the population structure, we use the nationally representative Socio-Economic Survey* (SUSENAS) to calculate changes in province populations of women aged 15 to 49 *between 2007 and 2012. The SUSENAS is a household survey which is representative down to the district level. The changes in provincial populations are a lot smaller than the changes in the DHS presented in Table 2. The average change in province population is only 8% and provinces like Aceh, North Sumatra and Riau have an overall expansion of 6, 2 and 15% respectively.*

[12] *We assume the use of "hours" here is a mistranslation and should be days: days is used in the 2002/3 survey where the remainder of this module is identical.*

Note that the question sets are not identical (the questions for 2007 are identical to the 2002/3 DHS, however). Some of these inconsistencies appear fairly minor (such as 07.1.1 being split into two questions 12.1.1 and 12.1.1.1), the use of 42 days rather than 2 months (07.1.1.1 versus 12.1.1.1.1).

More concerning is that the questions for 2007 appear to attempt to identify pregnancy as the cause of death, more so than the 2012 versions. With under- and misreporting of maternal death a major issue in calculation of the MMR (NAoS, 2013), this difference could see a much higher number of maternal deaths reported in the 2012 data. This could mostly be offset if question 07.1.2 were disregarded in identification of a maternal death (i.e. the sister is reported as having died while pregnant or in childbirth, or within 42 days postpartum). Unfortunately the set of variables available in the DHS data files for both years do not exactly match these questions, rather a single variable is available:

Variable stub name	Variable label
mm9_	sibling's death and pregnancy

It is thus unclear if this variable contains the raw data pertaining to 07.1.1 and 07.1.1.1, and not also recoded to take into account 07.1.2. The 2012 data file also has a single variable with the same name and label.

Table 3 below tabulates the information reported in response to the maternal mortality modules of the 2007 and 2012 DHS. The upper panel compares sample sizes (unweighted) by sex and survival status, while the lower panel compares values of the maternal mortality variable mm9 for the female siblings who died aged 10 or above during the time period under consideration.

Table 3. Sibling Sample Characteristics as Reported by Respondents of the Women's Questionnaire, DHS 2007 and 2012

	2007		2012	
Number of respondents of the Women's Questionnaire	32,895		45,607	
Total number of siblings reported	149,843		196,420	
By sex:				
Male	76,915	51.33%	101,188	51.52%
Female	72,652	48.49%	94,757	48.24%

	2007		2012	
Sex not reported	276	0.18%	475	0.24%
By survival status:				
Dead	17,935	11.97%	27,504	14.00%
Alive	131,747	87.92%	168,730	85.90%
Status not reported	161	0.11%	186	0.09%
Number of female siblings that died within the last 5 years and were aged 10 or above when they died	760		1,150	
Values of variable mm9 for these siblings:				
Death not related to pregnancy	544	71.58%	886	77.04%
Died while pregnant			33	2.87%
Died during delivery	61	8.03%	47	4.09%
Died within 42 hours after delivery	9	1.18%		
Died within 2 months after delivery			16	1.39%
Missing	146	19.21%	168	14.61%

The larger sample of women respondents in 2012 produced a larger sample of siblings, with similar ratios of males, females and missing values. A slightly higher percentage of siblings had died in the 2012 sample (14% compared to 12% in 2007). The larger sample size and the slightly higher death rate (for both men and women) carries over into the lower panel, where we observe a larger sample of female siblings for examination of variable mm9.

Codes for variable mm9 are different between 2007 and 2012 datasets, however upon closer examination this does not appear to be problematic:

- The variable mm9 for 2007 does not appear to include "died while pregnant", however question *07.1.1: Was [sister] pregnant when she died or did [name] die during childbirth?* Groups this with "died during delivery". The 8.03% value for this can largely be reconciled by combining categories "died while pregnant" and "died during delivery" in 2012 (6.96%).

- The post-partum death rates are similar rates across the two surveys, despite the slightly different time period under consideration (42 days versus 2 months).

- Despite the 2007 questions attempting to identify the death as caused or aggravated by the pregnancy, the 2007 data actually shows a smaller proportion of deaths being unrelated to the pregnancy than that from 2012.

- One point of difference is the higher proportion of missing values in 2007 compared to 2012: if these missing values are indeed pregnancy-related deaths, then this could affect the differential MMRs between the two years.

Figure 2. Different causes of death by age grouping in 2007.

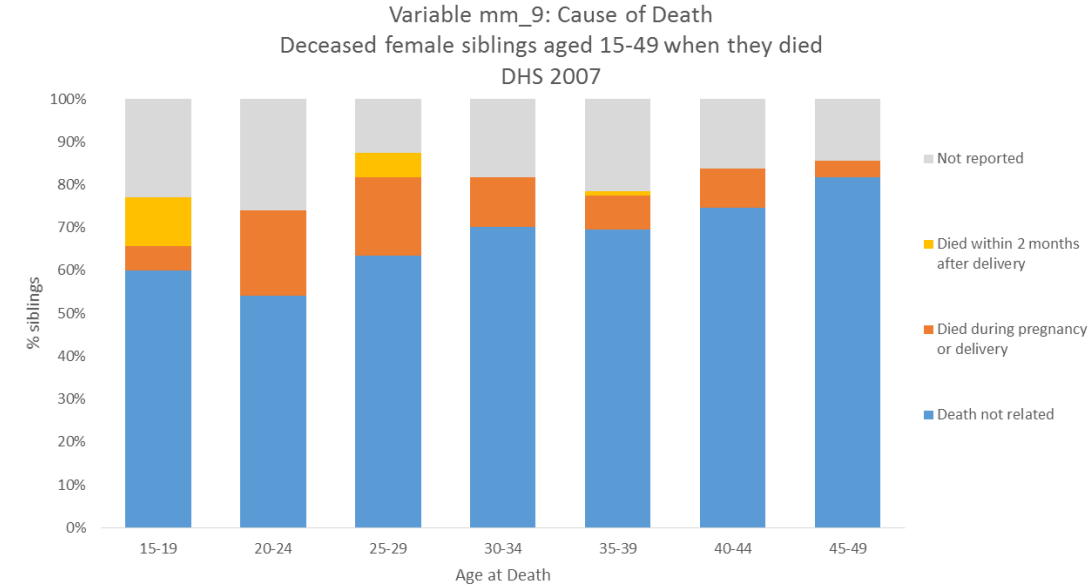
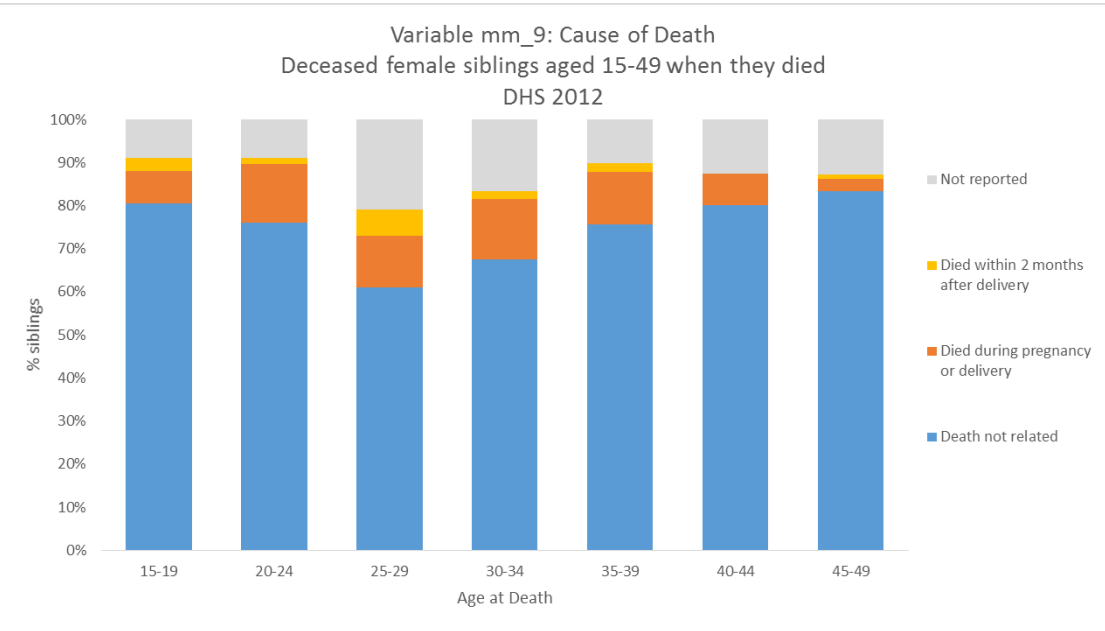


Figure 3. Different causes of death by age grouping in 2012



Summing up, what variable mm9 reveals is that in the raw data there is no obvious higher rate of deaths being pregnancy-related in 2012 (and in fact, potentially the opposite). It does highlight however, that the calculations involve a very small number of deaths, and there is potential that a slight difference in wording, coding or missing values could affect the differential rates quite substantially – this is reflected in the large, overlapping confidence intervals for the MMR.

3.4 CHARACTERISTICS OF THE RESPONDENTS OF THE WOMEN'S QUESTIONNAIRE: ARE THEY DIFFERENT IN 2012?

3.4.1 VALUES OF MORTALITY INDICATORS

Table 4 summarises a range of mortality indicators in 2007 and 2012, taken from the official DHS reports.

Table 4. Summary of Maternal Mortality Indicators from DHS reports 2007 and 2012

Mortality Indicators	2007	2012
Female mortality rate per 1000	1.95	2.49
Male mortality rate per 1000	2.68	3.11
Probability of dying between age 15 and 50 per 1000 person-years of exposure Females Males	 69 94	 87 108
Proportion of deaths of females of reproductive age that are maternal (PMDF)	10	11.7
MMRate (age adjusted)	0.18	0.27
MMRatio	228	359
General fertility rate per 1000	78	75

Mortality rates in general appear to have increased. Since identifying maternal deaths is often miss- or under-reported, increasing adult mortality rates could spill over into increasing maternal mortality even if true maternal mortality has not risen.[13]

The general fertility rate (number of live births per 1000 women of reproductive age) has not changed dramatically over the sample periods, suggesting movement in the MMR has largely been driven by death rates.

[13] *The increased female and male mortality rates in 2012 opens up the question of whether the increased estimated mortality rates are related to changes in sample design. Remember that 2007 DHS interviewed 15-49 ever-married women and used the "all women" factor to calculate the MMR, while in 2012 the sample included all 15-49 women and no factor was required.*

3.4.2 MATERNAL MORTALITY RATIO BY AGE GROUP

Since age grouping is the means of linking the sibling sample with respondents of the Women's Questionnaire, Table 5 breaks down the number of maternal deaths, years of exposure and rates of maternal mortality by age group for women in the 2007 and 2012 DHS samples.

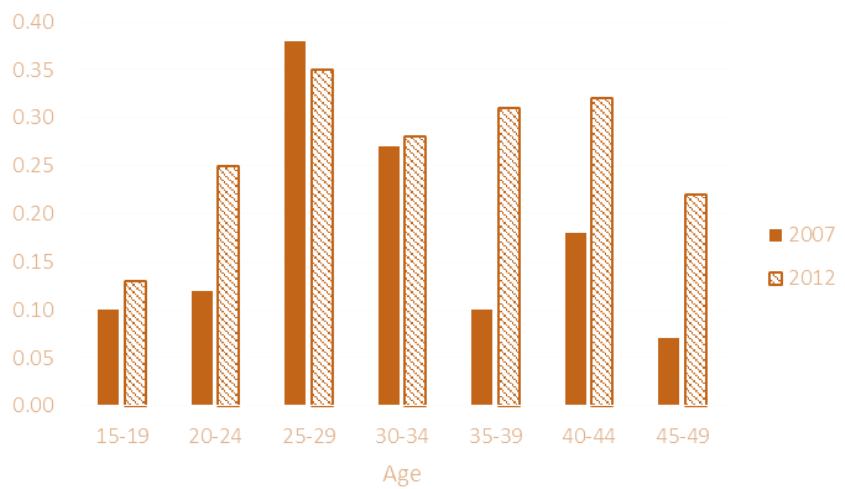
Table 5. Maternal Mortality Indicators for the period 0-5 years preceding the survey

2007					2012				
Age	Maternal deaths	Exposure (Years)	Mortality rates	Respondents proportion	Age	Maternal deaths	Exposure (Years)	Mortality rates	Respondents proportion
15-19	4	36631	0.10	14.76	15-19	4	34164	0.13	15.19
20-24	6	52378	0.12	15.55	20-24	12	45438	0.25	13.82
25-29	22	58635	0.38	15.93	25-29	20	57051	0.35	15.26
30-34	16	59058	0.27	15.07	30-34	17	60601	0.28	15.08
35-39	5	54252	0.10	14.46	35-39	18	56825	0.31	15.09
40-44	7	40489	0.18	12.85	40-44	14	44343	0.32	13.71
45-49	2	25726	0.07	11.37	45-49	7	30496	0.22	11.86
Total 15-49	62	327170	0.18[a]		Total 15-49	92	328918	0.27[a]	
General fertility rate[1]			0.078[b]		General fertility rate[1]			0.075[b]	
Maternal mortality Ratio[2]			228		Maternal mortality Ratio[2]			359	

[1] Expressed per 1,000 women-years of
[2] Expressed per 100,000 live births; calculated as maternal mortality rate divided by the general fertility rate
[a] Age adjusted
[b] Using the GFR reported in DHS

Source: Authors replication of DHS calculations

Figure 4. Maternal Mortality Rate (x 1,000) by age-groups



Source: DHS Reports

Comparing the maternal mortality rates in 2007 with 2012 at each age group, we see that mortality rates are higher for almost all age groups in 2012, and much higher for women aged 35 and above.

Increases in these age group-specific mortality rates between 2007 and 2012 reflect differences in the number of maternal deaths observed in the sample of sisters and/or differences in the years of exposure to maternal mortality.

The latter of these would be expected to have remained relatively constant over the 10 year period under consideration, affected only by significant changes in surviving rates among women (e.g. virus outbreaks). We are not aware of such a phenomenon affecting Indonesia between 2007 and 2012.

This leaves us with the actual number of maternal deaths reported. Why would older women experience higher mortality in 2012 compared to 2007? Perhaps women are having babies later in their reproductive lives, and since mortality risk is higher amongst older women, this results in higher overall maternal mortality. To check whether this is the case, Table 6 presents fertility rates by age category, taken from the official 2012 DHS report. While there has been shifting fertility rates over this 20 year period, there has not been a dramatic change between 2007 and 2012.

Table 6. Trend in Total Fertility Rate (Indonesian DHS, 1991-2012)

Age-specific and total fertility rates (TFRs) among women age 15-49 for the three-year period preceding the survey, IDHS surveys, Indonesia 1991-2012

Mother's age at birth	1991 IDHS	1994 IDHS	1997 IDHS	2002-2003 IDHS[1]	2007 IDHS	2012 IDHS
15-19	67	61	62	51	51	48
20-24	162	147	143	131	135	138
25-29	157	150	149	143	134	143
30-34	117	109	108	99	108	103
35-39	73	68	66	66	65	62
40-44	23	31	24	19	19	21
45-49	7	4	6	4	6	4
TFR 15-49	3.0	2.9	2.8	2.6	2.6	2.6

Note: Total fertility rates are for the period 1-36 months preceding the interview. Age-specific rates are per 1,000 women.
[1] The 2002-2003 IDHS did not include Nanggroe Aceh Darussalam, Maluku, North Maluku, and Papua provinces. The 1991 IDHS, 1994 IDHS, and 1997 IDHS included East Timor.
Source: CBS et al., 1992; CBS et al., 1994; CBS et al., 1998; CBS et al., 2003; CBS et al., 2008

Source: 2012 DHS report

4 SENSITIVITY OF THE MMR TO TECHNICAL ADJUSTMENTS

Indicators of maternal mortality such as the MMR are defined with respect to all women of reproductive age. However, the 2007 DHS sample of women respondents includes only women aged 15-49 who have ever been married. A technical adjustment is then made to the 2007 data to make it representative of all women in this age group. The technical adjustment, denoted the "all women factor" in the DHS, expands the ever-married sample by a factor equal to the ratio of never married women to all women by age. This adjustment is not necessary using the 2012 DHS, as the sample is already representative of all women aged 15-49. The maternal mortality and fertility figures in the 2007 DHS report have had this factor applied.

As a simple ratio the adjustment factor based on age assumes that the information on siblings reported by ever-married women is the same as never-married women of the same age. This may not be a valid assumption, since, for example, women who marry younger may tend to come from a socio-economic group that tend to have more children, meaning they tend to have more siblings and these siblings also tend to have more children which increases their exposure to the risk of maternal mortality.

In this section we exploit the fact that the 2012 data has information, including marital status, on all women of childbearing age to examine how accurate it is to estimate a MMR for all women using a sample of ever-married women and applying an all women factor. To do this, we restrict our 2012 DHS sample to only those respondents of the Women's Questionnaire who have ever been married. All calculations and analysis is then performed on this reduced sample of women, first without any adjustment, and then including an "all women" adjustment factor. The results are then compared to the "true" calculations using the full sample of women in the 2012 DHS.

A second technical adjustment is made to both the 2007 and 2012 data: the use of sampling weights. As mentioned earlier, in the case of over-sampling, sampling weights are used to weight observations back to be representative of the population. For calculation of population-based proportions such as the MMR, use of sampling weights is imperative. This section will also illustrate the effect of applying sampling weights on estimating the MMR, with and without the all women factor.

4.1 EVER-MARRIED AND NEVER-MARRIED WOMEN IN THE 2012 DHS

Table 7 shows the proportion of ever-married versus never-married respondents of the Women's Questionnaire in each age group, alongside the number of maternal deaths of siblings reported by these women in the 2012 DHS.

While the majority (78%) of women aged 15-49 were ever-married, the proportions differ by age: in the youngest age group, only 13% had ever been married, while in the oldest age group the proportion is 98%. Thus a sample of ever-married women of reproductive age will be older on average than a sample of all women. Furthermore, in this youngest age group information from a sample of only ever-married women would be restricted to a sample representing only 13% of women of this age.

Looking to the number of maternal deaths (of sisters) reported by these women, out of the total 92 maternal deaths reported in 2012, 14 were reported by never-married women.

Table 7.Maternal deaths and respondent proportions by marital status and age group, women aged 15-49, DHS 2012, weighted

	Respondents proportion by age groups		Maternal deaths 2012	
Age	Ever-married	Never-married	Ever-married	Never-married
15-19	13%	87%	4.3	0.2
20-24	62%	38%	7.6	4.0
25-29	89%	11%	9.7	10.2
30-34	95%	5%	17.2	0
35-39	97%	3%	17.8	0
40-44	98%	2%	14.0	0
45-49	98%	2%	6.9	0
Total 15-49	**78%**	**22%**	**77.4**	**14.3**

4.2 ESTIMATES OF THE MMR

Table 8 presents the MMR calculations using the 2012 DHS sample, first on the full sample of all women (the original results), and then on the restricted sample of only ever-married women.

Table 8. MMR calculations using the 2012 DHS sample

Age	2012 Full Sample (All Women)		2012 Ever-Married Sample			
	(1) No weights	(2) Weights applied	(3) No weights	(4) Only weights applied	(5) Only all women factor	(6) Weights and factor
Maternal Deaths						
15-19	7	4	6	4	14	10
20-24	10	12	7	8	8	8
25-29	18	20	12	10	19	15
30-34	17	17	17	17	19	18
35-39	21	18	21	18	22	18
40-44	13	14	13	14	14	15
45-49	7	7	7	7	7	7
Total 15-49	93	92	83	77	103	91
Exposure (Years)						
15-19	34165		23971	22219	37296	33140

Age	2012 Full Sample (All Women)		2012 Ever-Married Sample			
	(1) No weights	(2) Weights applied	(3) No weights	(4) Only weights applied	(5) Only all women factor	(6) Weights and factor
20-24	45448		35446	32586	48369	43634
25-29	57042		49006	46605	59804	56584
30-34	60604		55912	54100	62416	60240
35-39	56824		54149	53230	57786	56732
40-44	44339		41509	42791	43288	44644
45-49	30496		27925	29666	28850	30627
Total 15-49	328918		287917	281197	337809	325601
Maternal Mortality Rate						
15-19	0.13		0.25	0.30	0.38	0.30
20-24	0.25		0.20	0.19	0.16	0.19
25-29	0.35		0.24	0.26	0.31	0.26
30-34	0.28		0.30	0.30	0.30	0.30
35-39	0.31		0.39	0.33	0.38	0.33
40-44	0.32		0.31	0.33	0.32	0.33
45-49	0.22		0.25	0.23	0.25	0.23
Total 15-49[a]	0.27		0.29	0.28	0.30	0.28
MMRatio*	359		386	371	406	370

Note: *(Using GFR=0.075 calculated using data from all women); [a]Age adjusted

Restriction to only ever-married women produces 83 deaths in the raw data (before weighting, column 3). Application of sampling weights reduces this overall number of deaths to 77 (as we saw in Table 7), indicating that the households that were over-sampled were also those reporting higher numbers of deaths. Columns 5 and 6 scale up columns 3 and 4 to be representative of all women, increasing the number of deaths to 103 and 91 respectively.

The key comparison here is column 2 with column 6: column 2 is the "true" number of maternal deaths for the full sample of respondents (all women aged 15-49), while column 6 is the prediction for all women had we only a sample of ever-married women. The end result of 91 compared to 92 deaths suggests that the all women factor is quite accurate. However, comparing the actual and predicted number of deaths in each age grouping, the all women factor is least accurate at the younger age groups where the never-married women are more likely to be. The discrepancy is most striking in the Maternal Mortality Rate panel, where the MMRate for 15-19 year olds is predicted at 0.30, but for the full sample it is only 0.13. Thus the all women factor is not necessarily accurate, it just happens to have predicted values that cancel each other out.

What does this mean for comparisons between 2007 and 2012 DHS data? While the all women factor may not be particularly accurate at predicting mortality rates at the age group level, this appears not to have had a great impact on the overall MMR value (the 2012 MMR

based on the full sample of women is 370 compared to 359 based on just the ever-married women).

5 CONCLUSIONS AND RECOMMENDATIONS

To sum up:

We have identified key differences between the 2007 and 2012 DHS data that may play a role in the increase in the estimate of the Indonesian maternal mortality between 2007 and 2012 which has been the subject of much policy debate. The differences are:

(i) the sample design—the 2007 survey covers ever married women aged 15-49 years (with reweighting being used to convert the maternal mortality estimate to one applicable to all women in this age group) while the 2012 survey samples both ever married *and* never married women in this age range.

(ii) the questions asked to identify maternal mortality:

a) the 2007 DHS specifically asks whether the death was attributable to complications of pregnancy or child birth while the 2012 DHS does not;

b) the 2007 DHS asks about deaths up to 42 days after the end of the pregnancy while the 2012 survey asks about the period up to two months after the end of the pregnancy.

However, our analysis of the data establishes that these differences are unlikely to have caused the increase in the estimate of maternal mortality. The reweighting of the 2007 sample to represent all women was largely successful and only very small numbers of women died either within 42 hours, or 2 months of delivery.

That both adult mortality and maternal mortality were found to increase from 2007 to 2012 raises the possibility that both may be a function of the altered sampling design between the two years, but this is difficult to confirm. The greater sampling coverage of urban Eastern Indonesia and Sulawesi is another potential contributor to the increase, but here too the reweighting of the sample to be nationally representative minimises this impact.

Thus while we have identified a number of differences between the two data sets that could potentially lead to an artificially high estimate of maternal mortality in 2012 compared to 2007, we have not been able to conclusively demonstrate such a bias. What is clear, however, is that relying on a sample of moderate size like the DHS to estimate maternal mortality is fraught. The resulting estimates are constructed off the observation of only a very small number of maternity-related deaths and so are estimated imprecisely. Although the estimate of maternal mortality constructed from the DHS increased from 228 deaths per 100,000 live births in 2007 to 359 live births in 2012, these two estimates are not statistically significantly different from one another.[14] Hence it is not possible to conclude with any confidence that maternal mortality either increased or decreased over this period. This highlights Indonesia's need for an accurate vital registration system which would reliably identify all maternal

[14] *The 95% confidence interval on the DHS 2007 estimate is 132-323. In 2012 the 95% confidence interval is 239-478. Hence the confidence intervals overlap indicating a lack of statistically significant difference between the estimates for the two years.*

deaths in the country. Without such a system it is close to impossible to evaluate efforts aimed at reducing maternal death and also to plot progress against national and international targets, such as the Millennium Development Goals.

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