Applications for measuring maternal mortality: three case studies using verbal autopsy methodology

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Introduction and Background

An estimated 287,000 women die each year from complications in pregnancy or childbirth with over half of these occurring in sub-Saharan Africa (UNFPA, UNICEF, WHO, World Bank, 2012). Millennium Development Goal 5 (MDG5), to improve maternal health, includes a target to reduce the maternal mortality ratio by three quarters by 2015 (United Nations, 2005). As this deadline approaches, renewed emphasis on improving maternal health and meeting this target has prompted the formation of new coalitions with the goal of supporting MDG 5 (Godal and Quam, 2012). Accurate measurement of maternal mortality is needed to develop a greater understanding of the problem, to increase effectiveness of program planning and targeting, and to track progress toward this goal (UNFPA, UNICEF, WHO, World Bank, 2012). Without data on deaths and cause of deaths, informed targeting and prioritization of resources based on need is not feasible (Okonjo-Iweala and Osafo-Kwaako, 2007; Shibuya, Scheele and Boerma, 2005).

A primary challenge with regard to tracking changes in maternal mortality is the lack of good quality data in many developing countries. Resource and capacity constraints hinder collection of death statistics, especially in Africa where the majority of deaths occur outside of health facilities, and hence they are not reported and/or certified with information on cause of death. Even where deaths are registered, the cause of death may not be certified by a physician (Mathers, Fat, Inoue, Rao, and Lopez, (2005; Setel, Macfarlane, Szreter, Mikkelsen, Jha, Stout, et al., 2007). Civil registration systems that track births, deaths and cause of death on a continuous and permanent basis are needed to generate vital statistics about maternal deaths (Setel, et al., 2007; AbouZahr, Cleland, Coullare, Macfarlane, Notzon, Setel, et al., 2007).

In the absence of good quality vital statistics, a variety of interim methods to measure maternal mortality may be used (Setel, et al., 2007; AbouZahr, et al., 2007). Population-based interim methods include population census, sample registration systems, demographic surveillance sites, and household surveys (Hill, Lopez, Shibuya, and Jha, 2007; Stanton, Hobcraft, Hill, Kodjogbe, Mapeta, Munene, et al., 2001; Graham, Foster, Davidson, Hauke, and Campbell, 2008). Verbal autopsy (VA) is a commonly used approach to identifying maternal deaths as part of demographic and active surveillance systems, and sample vital registration with verbal autopsy (SAVVY) (Graham, et al., 2008). Deaths identified through these platforms are followed by a verbal autopsy interview, in which an age-specific questionnaire is administered to the caregiver of the deceased. This interview collects information on the deceased's history of illness, signs and symptoms of the illness, utilization of health services, and any additional information from available health records from the period leading up to the death. The World Health Organization first established and disseminated standards for verbal autopsy in 2007 that included verbal autopsy questionnaires, cause-of-death certification and coding guidelines (World Health Organization, 2012). The objective of this study is to review and contrast three community-based platforms for measuring maternal mortality using verbal autopsy: (1) a post-census mortality survey (PCMS) in Mozambique, (2) a large-scale demographic household survey (HHS) in Bangladesh, and (3) a sample vital registration system (SAVVY) in Zambia.

Data and Methods

The first source of data is a post-census mortality survey that identified a sample of 10,080 deaths from the 2007 Mozambique census. This survey, known as the Inquiry on Causes of Mortality (INCAM), was the first post-census mortality survey in Africa. The survey used the World Health Organization (WHO) verbal autopsy tool to classify causes of death consistent with the international classification system (ICD-10). The INCAM sampling frame was the 2007 Mozambique General Census of Population and Housing. The sample was designed to be representative at national, provincial and

urban and rural levels. Enumeration areas (EAs) in 10 provinces from the 2007 census were divided into urban and rural strata and then a sample of EAs was randomly selected from each strata. Outside of the capital city the corresponding and adjoining census supervisory areas (CSAs) for each selected EA were combined to form a segment. A total of 144 segments were selected, which were made up of 64 single CSA segments in Maputo City and 80 double CSA segments in the provinces. Census forms from each INCAM segment were reviewed for deaths in the previous 12 months and each death was given a unique identifier to allow for linkage to the subsequent verbal autopsy forms and death certificates.

Of the 18,105 deaths identified through the census in INCAM segments, 9,895 were found and validated, and an additional 185 deaths were identified during the survey. Reasons that deaths initially identified in the census were invalidated include that the death occurred outside of the designated reference period (4,891 deaths), the household was not located (1,562 households), reported decedents resided outside of INCAM enumeration areas, duplicate reporting of deaths, and stillbirths. For the final sample of 10,080 deaths, an age-specific verbal autopsy interview questionnaire was conducted. Two physicians reviewed and independently determined a cause(s) of death for each case. Where disagreement occurred in the initial review the physicians worked together to reach consensus on the cause of death (Mozambique National Institute of Statistics, U.S. Census Bureau, MEASURE Evaluation, U.S. Centers for Disease Control and Prevention, 2012).

The second source of maternal mortality data is the 2010 Bangladesh Maternal Mortality and Health Care Survey (BMMS-2010). This survey was fielded with 175,621 reproductive-aged women (ages 13-49 years) in 168,629 households and identified maternal deaths that occurred in the selected households since October 2006. The sample was designed to generate nationally representative estimates of maternal mortality with statistical precision to detect a 20 percent decline in MMR (since 2001) with 95 percent significance and 80 percent power. A multi-stage sample selection procedure was used. The primary sampling unit (PSU) for urban areas (formal cities) was ward and for rural and other

urban areas was union. In each PSU, two mohallas (urban PSUs) or mouzas (rural and other urban areas) were selected, segmented and a cluster was drawn from each, resulting in 2,708 clusters. Sixty-five households were randomly selected from each cluster for interview. Ninety-eight percent of sampled, occupied households were interviewed. Household deaths were identified through household report. Field work was conducted from January to August 2010. Results on household and maternal deaths presented here are based on deaths in the 36 months before the interview date, excluding the month of interview and refer approximately to the period from early 2007 to early 2010.

Female deaths among women aged 13-49 since the cutoff date of October 2006 were followed up using a verbal autopsy questionnaire to assess cause of death. BMMS-2010 employed a verbal autopsy protocol similar to the VA tool designed for BMMS-2001 to maximize comparability with estimates obtained from the 2001 survey. This tool used both structured and unstructured questions that were posed to the most knowledgeable household member regarding the woman's death. To assess cause of death, the completed verbal autopsy was reviewed by two physicians. For cases unresolved by review and consultation of two physicians, the verbal autopsy was referred to a third physician for additional review. Deaths that were undetermined after three physician reviews were referred to an expert committee for resolution (National Institute for Population Research and Training, MEASURE Evaluation, International Centre for Diarrhoeal Disease Research, 2011).

The third source of data is a 2009-2010 sample vital registration pilot in Zambia using the SAVVY methodology. The sampling frame used was the 2000 Zambia Census of Population and Housing. Thirty-three CSAs were selected using a one-stage stratified random sample design in four out of Zambia's nine provinces covering both urban and rural areas. A baseline household census was conducted in January 2010 in the selected CSAs. Deaths in the previous 12-month period were identified from household reports during the census and a VA interview was conducted for each death identified. Following the baseline census, key informants were appointed in each community to inform VA interviewers of each

death that occurred in the CSAs in which they worked on an ongoing basis. VA interviews were conducted for all deaths identified by the key informants. Deaths identified in the 12 months preceding and following the baseline census are included in this analysis, allowing estimation of maternal mortality in the 2009-2010 period in sampled districts.

The WHO VA tool was adapted to the Zambian context. Two physicians reviewed each VA questionnaire to determine a probable cause of death. In cases of disagreement between the physicians after the initial review, the two physicians reviewed the VA together to come to consensus on the cause of death. Failure to reach consensus on the cause of death resulted in an "undetermined" cause of death (Mudenda, Kamocha, Mswia, Conkling, Sikanyiti, Potter, et al., 2011).

This study summarizes several key measures of maternal mortality from the three data sources. Maternal death is defined as the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the site or duration of pregnancy, from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes. We also include late maternal deaths in our analysis, which are defined as the death of a woman from direct or indirect maternal causes more than 42 days but less than one year after the termination of pregnancy (World Health Organization, 1992). Maternal deaths are further subdivided into direct and indirect causes. Direct causes are maternal deaths resulting from obstetric complications of the pregnancy state (during pregnancy, labor and the puerperium period), from interventions, omissions, incorrect treatment or from a chain of events resulting in any of the above. Indirect causes are maternal deaths resulting from a previous existing disease or disease that developed during pregnancy and which was not due to direct obstetric causes, but which was aggravated by physiologic effects of pregnancy (World Health Organization, 1992). Using examples from the three case studies, the different platforms and methodologies for conducting verbal autopsies are compared and contrasted, including a discussion of

issues related to (1) death identification and classification, (2) estimating maternal mortality ratios and rates, (3) sample sizes and periodicity of estimates, (4) data quality, and (5) cost.

Results

Table 1 provides a comparative summary of selected sample characteristics for the three surveys. The sample sizes vary considerably between the three surveys. The largest total number of deaths identified was in Bangladesh where a three-year recall period was used (18,608 deaths). However, the number of deaths for women of reproductive age (WRA) was greatest in Mozambique with just a one-year recall period (1,643 deaths). Considerably fewer deaths were identified in the Zambia SAVVY pilot which was based on a much smaller overall sample size. The number of maternal deaths identified through each survey platform was small: 132 maternal deaths in Bangladesh, 259 maternal deaths in Mozambique, and 18 maternal deaths in Zambia.

Table 1. Comparison of Sample Characteristics, (unweighted)

	Bangladesh HHS	**Mozambique** PCMS	**Zambia** SAVVY
Sample size (# households)	168,629	[a]	17,000
Reference period for deaths	Oct 2006 – interview (Jan - Aug 2010)[b]	Aug 2007 – July 2008	Feb 2009 –Dec 2010[c]
Deaths (#)[d]			
All household deaths	18,608	10,080	1,063
WRA (15-49)	878	1,643	171
Maternal deaths[e]	132	259	18

[a] The sampling units for the Mozambique survey were deaths identified from the 2006 census not households. The relevant number of households from which deaths were identified is the total number of households in the selected CSA segments, which is unavailable.
[b] Fieldwork was conducted Jan – Aug 2010. Only deaths 1-36 months before the household interview are included in all subsequent analyses (15,857 household deaths; 768 deaths to WRA; 108 maternal deaths).
[c] Not all deaths occurring in the latter part of 2010 are expected to be included due to the lag time between a death being identified by a key informant and a verbal autopsy being conducted.
[d] This table includes all deaths identified. Subsequent tables exclude deaths with missing information on age (0 in Bangladesh, 4 in Mozambique, and 46 in Zambia) or incomplete verbal autopsy data (2 in Bangladesh).
[e] Maternal death statistics include late maternal deaths (1 in Bangladesh, 46 in Mozambique, 0 in Zambia) and maternal deaths with an underlying cause of HIV/AIDS (0 in Bangladesh, 33 in Mozambique, 3 in Zambia).

Table 2. Verbal autopsy cause of death (COD) review: percent agreement and percent undetermined cause (unweighted)

Survey	Cumulative Reviewer Agreement (%)				Undetermined COD (%, (n))		
	Stage 1	Stage 2	Stage 3	Stage 4	Total	WRA	Maternal
Bangladesh HHS	78.6	84.8	96.0	100	na	10.6 (768)	8.3 (108)
Mozambique PCMS	74.7	100	NA	NA	6.7 (10,076)	6.9 (1,643)	9.4 (255)
Zambia SAVVY	61.2	100	NA	NA	4.6 (1,063)	4.1 (171)	6.7 (15)

Note: Stages of review were as follows: (1) review by 2 physicians; (2) consultation between 2 physicians; (3) review by 3rd physician; (4) review by expert committee.

Table 2 provides an overview of the cause of death review outcomes for each survey. The percentage of physician reviewers who agreed on the COD in the first stage review was slightly lower in Zambia than in the other two surveys. The percentage of deaths among WRA with an undetermined COD ranged from 4.1% in Zambia to 10.6% in Bangladesh.

Table 3 provides a summary of maternal mortality estimates by country using each platform. The proportion of deaths to WRA that are maternal deaths in the three countries ranged from 8.8% in Zambia to 17.3% in Mozambique. The maternal mortality rate (MMRate) requires an estimate of the woman-years of exposure among WRA in the reference period for the denominator. This is only available directly from the HHS and SAVVY platforms; for the PCMS the verbal autopsy survey data has to be linked to the original census data to obtain the denominators. We did not have linked data available to us so were not able to obtain the MMRate for Mozambique. The MMRate for Bangladesh is estimated at 17.0 per 100,000 WRA and in Zambia it is estimated at 69.1 per 100,000 WRA. The maternal mortality ratio (MMR) requires an estimate of the general fertility rate (or number of live births) in the study population in the reference period, which is only available directly from the HHS platform in Bangladesh, providing an estimated MMR of 197 per 100,000 live births [1].

[1] The INCAM report provides an estimate of the MMR among women age 15-49 of 489.3 per 100,000 live births but this estimate is based on the 2007 census data not on the INCAM data (Mozambique National Institute of

Table 3. Maternal mortality statistics by country and survey platform

	Bangladesh HHS	**Mozambique** PCMS	**Zambia** SAVVY
Proportion of deaths that are maternal for WRA (%)	14.2	17.3	8.8
MMRate per 100,000 women of WRA	17.0	na	69.1
MMR for WRA[a] (per 100,000 live births)	197	na	na
Type of maternal death			
Direct (%)	63.9	45.2	80.4
Indirect (%)	35.1	37.8	19.6
Late maternal deaths (%)	0.0	17.0	0.0
HIV-related maternal deaths (%)	0.0	19.1	12.9
Undetermined cause of maternal death (%)	5.0	11.0	7.1
Maternal deaths (weighted n)	103.8	5,662.5	14.8
Deaths for women 15-49 (weighted n)	732.4	32,733.0	168.3
Exposure (weighted life years)	609,785	na	21,418

Note: all numbers are weighted unless otherwise specified.

The percentage of maternal deaths due to direct obstetric causes ranged from 45.2% in Mozambique to 80.4% in Zambia. Seventeen percent of maternal deaths in Mozambique were classified as late maternal deaths. HIV was an underlying cause of death for 19.1% of maternal deaths in Mozambique and 12.9% of maternal deaths in Zambia but was not identified as an underlying cause of death for any maternal deaths in Bangladesh.

Table 4 provides a summary of the proportion of deaths by age group for all deaths identified through the survey platforms (top panel) and also specifically for women of reproductive age (bottom panel). Figure 1 presents the proportion of deaths among WRA by age group. Of all deaths, the greatest proportion occur in the under five and 15-49 year age groups in the two African countries, while in Bangladesh, the majority of deaths occur among individuals aged 50 and above. For women of reproductive age, the proportion of deaths peaks at age 25-29 in Mozambique and Zambia and then declines. In Bangladesh the proportion of deaths to women among WRA increases around age 35.

Statistics, U.S. Census Bureau, MEASURE Evaluation, U.S. Centers for Disease Control and Prevention, 2012, Table 32).

Table 4. Distribution of deaths by age group and country/platform, weighted

Age (years)	**Bangladesh** HHS	**Mozambique** PCMS	**Zambia** SAVVY
All Deaths (men and women, %)			
Under 5	16.1	42.7	36.0
5-14	2.8	7.4	5.5
15-49	11.7	30.9	36.0
50+	69.5	19.0	22.6
Number	15,315.7	225,047.4	1,066.9
Deaths to WRA (%)			
15-19	12.9	11.8	6.5
20-24	14.3	14.6	16.4
25-29	13.7	21.2	23.6
30-34	10.6	18.9	19.0
35-39	17.8	13.9	14.4
40-44	14.5	11.6	11.8
45-49	16.1	8.0	8.3
Number	732.8	32,733.0	168.3

Figure 1. Distribution of deaths among women aged 15-49 by age group and country, weighted

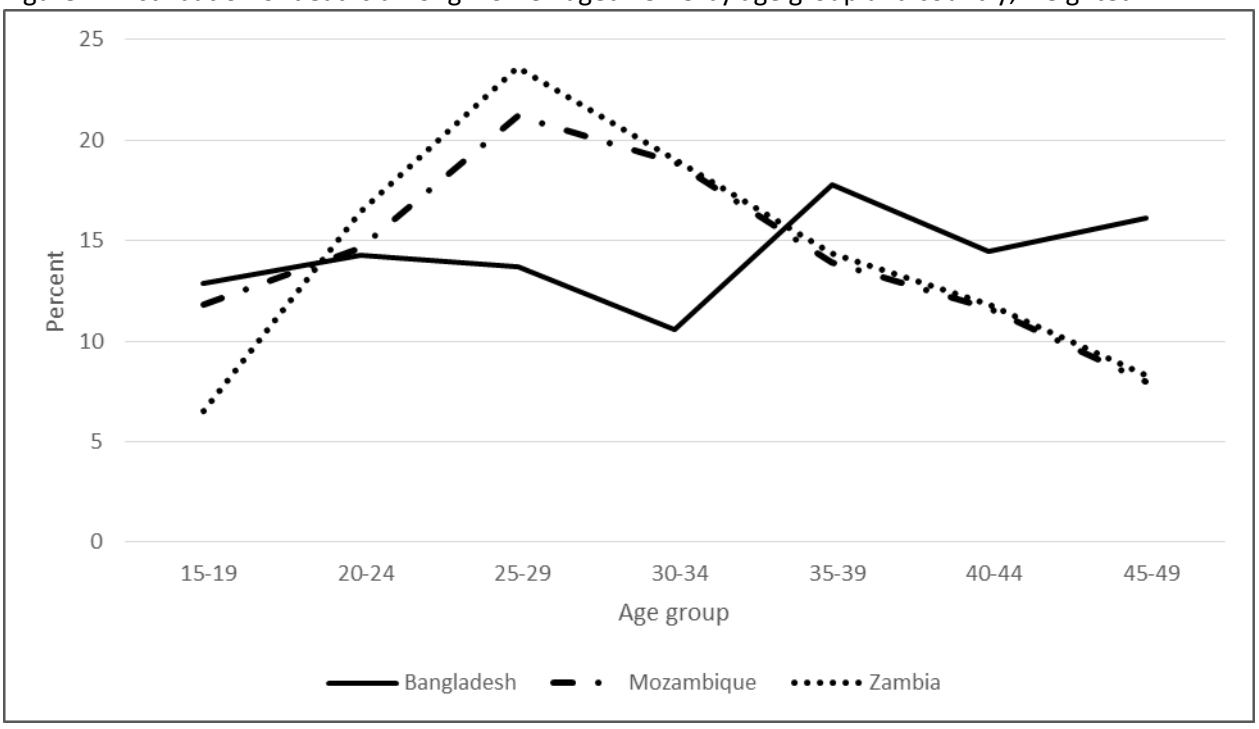


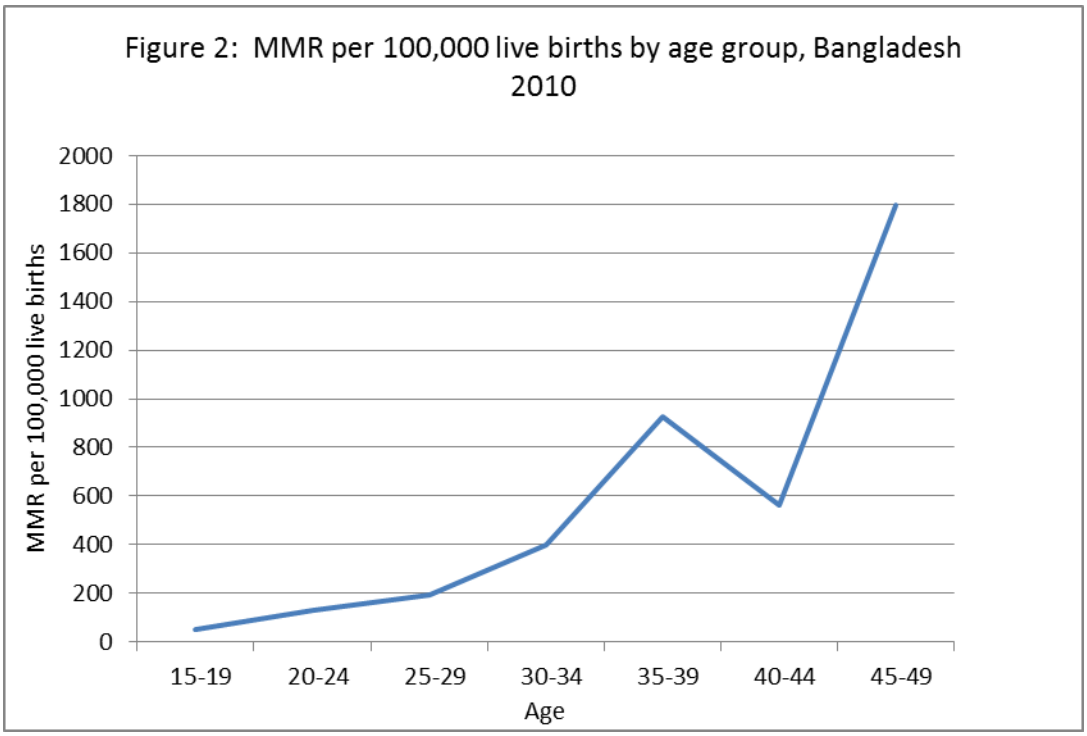
Table 5 provides a snapshot of the share of female deaths that are maternal deaths in each age group for the three survey platforms. The highest percentage of maternal deaths to women of

reproductive age was in Mozambique (17.3%); over one-fifth of adult female deaths were maternal deaths in the 15-19 and 20-24 and 25-29 year age groups (26.2%, 26.0%, and 21.7% respectively). In Bangladesh, over one-fifth of deaths among women aged 20-24, 25-29, and 30-34 were maternal (23.9%. 23.4%, and 28.5% respectively. In Zambia, a much smaller proportion of deaths among women are due to maternal causes in each age group. The highest percentage of maternal deaths to WRA in Zambia was 10.6% in the 20-24 year age group. However, the denominators in each age group in are small so estimates are subject to large sampling error, particularly in Zambia.

Table 5. Maternal deaths as a share of all female deaths by age group (15-49), weighted

	Bangladesh (HHS) % (unweighted n)	**Mozambique (PCMS)** % (unweighted n)	**Zambia (SAVVY)** % (unweighted n)
Age (years)			
15-19	7.4 (97)	26.2 (158)	8.2 (12)
20-24	23.9 (108)	26.0 (241)	10.6 (28)
25-29	23.4 (95)	21.7 (345)	10.4 (40)
30-34	28.5 (87)	16.9 (319)	9.6 (31)
35-39	15.8 (138)	11.2 (226)	7.8 (26)
40-44	3.2 (111)	8.2 (198)	9.7 (20)
45-49	1.7 (132)	1.2 (156)	0.0 (14)
Total	**14.2 (768)**	**17.3 (1643)**	**8.8 (171)**

One check for the internal consistency of data and maternal death classification is to look at the distribution of the maternal mortality ratio (MMR) by age group. The distribution is expected to be J-shaped with a relatively high MMR at early ages that dips and then increases again with age (Blanc, Winfrey, and Ross, 2012). We are only able to calculate the MMR from the household survey platform data in Bangladesh; Figure 2 presents the MMR by age for that survey. The age pattern of MMR does not exhibit the expected J-shaped pattern but increases with age with the lowest age-specific MMR in the 15-19 year age group.



Discussion

This study documents recent experiences applying standard VA methods to estimate maternal mortality. It confirms that VA is a feasible method for collecting maternal mortality data in the absence of reliable vital registration data. The comparison of different platforms for conducting VA (e.g., sample vital registration, post-census mortality survey, and stand-alone household survey) provides insights for those considering applying VA methods to estimate levels and trends in maternal mortality. Following is a discussion of key issues identified through this study with a summary provided in Table 6 by survey platform.

Death identification and classification

There are challenges with identification of deaths through any platform. Accurate recall of deaths is a concern with any of the platforms, as both under-reporting and telescoping of deaths is a known concern with self-reported data (Stanton et al, 2001; Gaskell et al, 2000). Identifying deaths

from the census for the post-census mortality survey resulted in a large number of deaths that were outside of the 12-month reference period. This might have been related to the way the question on deaths in the household was asked in the 2007 census. The question asked about deaths in the last year. Since the census was conducted in July 2007, it appears that some respondents interpreted that question to refer to deaths since January 2006, resulting in inclusion of deaths more than 12 months before the census, and which were identified (and invalidated) during the PCMS data collection. Follow-up validation of deaths identified through the census can help to mitigate forward telescoping, as was done in PCMS, but does not address underreporting. The SAVVY platform in Zambia is the only one to collect data on deaths prospectively (but relies on accurate reporting by community key informants), although in this paper we also used recalled data for the 12 months prior to the baseline census.

Recall of the specific circumstances leading to death may not be accurate, and longer recall periods may exacerbate this problem. The highest percentage of undetermined causes of death for WRA was observed in Bangladesh despite having the most rigorous cause of death assignment process. Bangladesh used a three-year recall period for the VA whereas the other two platforms used a one-year period. VA field practitioners do not recommend using VA methodologies beyond one year of recall (MEASURE Evaluation, Macro DHS, and U.S. Census Bureau, 2008). However, a review of the Bangladesh data did not find any evidence that undetermined cause of death was more common for deaths earlier in the 3-year recall period (data not shown). There was some suggestion that undetermined cause of death may have been more common for interviews conducted earlier in fieldwork suggesting that the quality of the VA interviews improved as interviewers got more experienced, but numbers are too small to draw definitive conclusions. Overall, however, the quality of death identification and basic demographic data for the BMMS using a 3-year recall period appears to be good.

Estimating maternal mortality ratios and rates

The different platforms have different implications for estimation of common maternal mortality indicators. With the data available to us we were able to estimate the proportion of deaths that were maternal deaths from all three platforms. However, only the household survey platform dataset in Bangladesh had all the data needed to calculate both the MMRate and the MMR. The PCMS platform in Mozambique did not permit calculation of the MMRate or the MMR without further linking back to census data to obtain the relevant denominators. The ability to link the VA data to the original census data in a timely way and make linked data available for analysis is an important consideration for the use of a PCMS platform for estimation of maternal mortality indicators. Getting access to national census data to allow for timely linkage with mortality data can be a lengthy and challenging process and hence limit calculation of some analyses that require use of census data. The SAVVY pilot data in Zambia permitted calculation of the MMRate but the lack of data on live births prevented calculation of the MMR. Data on live births is now being collected in the scale up of SAVVY in Zambia to address this limitation so future data should allow calculation of the MMR. With all platforms, the data collection instruments need to anticipate analysis needs and include data on relevant denominators that can be linked to the VA data.

Sample sizes and periodicity of estimates

The Zambia SAVVY data were from a pilot covering 17,000 households and only 18 maternal deaths were identified over almost 2 years. Even with relatively large sample sizes (over 168,000 households in Bangladesh and census data from 224 CSAs in Mozambique), relatively small numbers of maternal deaths were identified. The scale up of the Zambia SAVVY will cover approximately 34,600 households so, assuming the cause specific mortality fractions and MMRates are within the range

observed in the pilot, relatively small numbers of maternal deaths per year could be expected there as well.

These numbers have significant implications for the ability of any of these platforms to provide estimates of change in maternal mortality over short periods of time because small fluctuations in the numbers of death represent large relative changes in the rate[2]. One potential drawback of the PCMS platform is that it can only be used every 10 years or so when a census is conducted, limiting the frequency of estimates. However, the other platforms are also likely to only be able to estimate changes over relatively long periods of time given cost and logistical limitations to sample sizes and associated statistical precision. For example, the BMMS sample of 168,000 households was designed to detect a 20 percent decline in MMR over a 10 year period from 322 deaths per 100,000 live births with 95 percent significance and 80 percent power. The SAVVY platform has the advantage of providing data on a continuous basis but small variations in the number of maternal deaths per year will translate into large relative variation in the rates observed so data will need to be cumulated over several years to obtain stable estimates. The small number of maternal deaths identified through the SAVVY platform in Zambia is due to its design, which is intended to provide the levels and patterns of mortality on all causes and determination of causes of death at the national level. However, SAVVY tools and methodology may be adapted to ensure a large enough sample for meaningful analysis and interpretation of cause specific mortality estimates such as maternal mortality. For example, SAVVY has been adapted as an evaluation tool for the Saving Mothers Giving Life Initiative in Zambia, whereby the baseline survey conducted a complete enumeration of WRA in selected districts. For other diseases with high prevalence in Zambia such as malaria and HIV, the number of deaths from such causes in the

[2] We are planning to add estimates of sampling errors for selected maternal mortality indicators in the next version of this paper.

SAVVY sample is large enough to detect changes over time within a short time interval. Sample size challenges will increase as mortality and fertility rates decline.

Data quality

Several of the maternal deaths in our sample were missing information about age at death, which resulted in their exclusion from age-related analyses. Since maternal death is such a rare event, exclusion of even just a few deaths can have a large impact on the results. In cases where a respondent may not know the exact age of the deceased at time of death, gathering information on estimated age at death, for example in a five- or ten-year ranges, could be useful, or imputation of age at death.

Analysis of BMMS data indicates that data were missing for below 0.1% of cases (National Institute for Population Research and Training, MEASURE Evaluation, International Centre for Diarrhoeal Disease Research, 2011). However, distortions exist with regard to heaping of age reporting for current household members and household deaths for years ending in zero and five, and are more pronounced for females than males. This imprecise reporting, although not uncommon, may be associated with age exaggeration, and in the case of our 5-year age analyses, may shift the distribution of maternal deaths to the right. Future work will involve investigation of age misclassification and age heaping, but was not within the scope of this study.

Overall, age patterns in maternal deaths are broadly consistent with expectations, with some exceptions. In the two African countries, which experience relatively high fertility and higher levels of overall mortality, deaths among women of reproductive age peak among women age 25-29, which coincides with the prime areas for childbearing. This pattern is consistent with the distribution of maternal deaths by age observed in multi-country analysis (Blanc et al. 2012). In Bangladesh the age distribution of deaths among women of reproductive age does not follow this pattern. This is likely associated with the lower fertility and mortality rates in Bangladesh and its different age structure but

warrants further investigation. Maternal deaths represent a greater share of all deaths among women under 30 in Mozambique and among women age 20-34 in Bangladesh, coinciding with higher fertility ages. This pattern is not seen as clearly in the Zambia data; however the numbers in each age group are too small to conclude much from this observation. We were only able to look at the age pattern in the MMR in Bangladesh where it did not conform to the expected J-shaped pattern. The MMR did rise steeply at older ages but was not higher among 15-19 years olds who actually experienced the lowest MMR. While not expected, similar patterns have been documented in other countries and recent evidence suggests the expected excess risk among adolescents may have been over-stated (Blanc et al 2012).

Cost

Because maternal death is a relatively rare event and its measurement requires large sample sizes, the costs of data collection to estimate maternal mortality are high. Costs include not only those for the data collection itself, but also for pilot testing, training, field supplies and equipment, technical assistance, data processing and analysis, and other miscellaneous expenses. Each VA platform has different implications for costing and each platform has different advantages and disadvantages. For example, using a PCMS platform may save cost in terms of death identification but data must also be linked back to the original census to obtain the MMRate and MMR, and the number of out of scope deaths identified may be challenging and require rigorous validation, each with its own costs implications. Implementing a stand-alone survey such as the BMMS is costly, but allows for flexibility and oversight and, if designed correctly, allows for calculation of all maternal mortality indicators and additional background information (e.g. on use of maternal health services). However, unlike the other two platforms, the BMMS did not allow calculation of mortality rates and cause of death distributions for men or for women under 15 or 50 and over. A SAVVY platform provides continuous data allowing data to be built up over time but requires sustained funding for supervision and training of staff on an

ongoing basis. Unfortunately we do not currently have costs available to us for each platform at this time[3].

Table 6. Summary of the pros and cons to conduct verbal autopsy using different survey platforms

Survey Platform	Death identification method	Case study	PROS/CONS
Post-census mortality survey	Deaths identified in selected census enumeration areas and validated through PCMS	Mozambique	**PROS** • Cost of death identification is absorbed by census • May increase targeted sample size easily by adjusting sampling fraction • 12 month recall period is standard on most censuses, accepted as 'reasonable' by many VA practitioners • Ability to calculate cause-specific mortality fractions at subnational level • May be able to leverage multi-donor/sectoral financial support • Data quality can be checked by comparing mortality information with the (overall) mortality statistics produced by the census
			CONS • Census data quality may be relatively worse; many out-of-frame deaths identified in census were not validated in PCMS • Requires link back to census data to calculate rates and ratios • Requires long lead time for planning (estimated 15+ months before census) • Requires 2 visits to household, first to identify the death and then follow-up for the VA; may result in loss of HHs that cannot be re-identified a second time • Since PCMS builds on census, can only be conducted every 10 years

[3] We are currently exploring whether we can get approximate cost data for each platform.

Survey Platform	Death identification method	Case study	PROS/CONS
Household survey	Deaths identified and validated by household questionnaire	Bangladesh	**PROS** • Fieldwork is logistically relatively simple, can be planned for in 4-6 months • Allows for flexibility in terms of timing of VA (during initial HH visit/survey or at follow-up) and duration of recall period • 3-year recall period allowed for more cost-effective identification of deaths
			CONS • Sample size of deaths relatively small (~900 female deaths, 15-49) even with large sample size • Concerns in the literature that the use of a 3- year recall period may yield uncertain VA data quality • Can only detect large relative changes in MMR, which takes time so probably not typically worth doing less than 10 years apart
SAVVY	Deaths identified through sample vital registration in selected Census Supervisory Areas	Zambia	**PROS** • Allows for flexibility in terms of timing of VA (during initial HH visit or at follow-up) • Continuous data collection is advantage once the system is up and running
			CONS • Although it provides ongoing data, sample size per year is likely to be too small to detect short term change; need to build up a sample of deaths over time.

Conclusion

These and other similar community-based methods are interim measures that fill the gap for accurate statistics on mortality and its causes. Hence, they are complements, rather than substitutes, to other facility-based information systems (e.g., maternal health information systems within the health sector)

and a fully functioning vital registration system. This study demonstrates that all of these platforms are viable options for collecting maternal mortality estimates with VA. However, none of these interim methods are likely to be suitable for detecting short term changes in mortality due to prohibitive sample size requirements. Although interim methods can and do provide useful estimates of maternal mortality, comprehensive and continuous civil registration systems to provide high quality vital statistics are essential in the long-term (AbouZahr, et al., 2007). Choice of an appropriate interim method should be tailored to the statistical strengths and weaknesses of each method available, as well as the local context (e.g., existing vital statistics infrastructure, budgetary considerations, timing, political commitment, a legal framework, and public trust (AbouZahr, et al., 2007; Graham, et al., 2008).

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