J Public Health (2017) 25:491–502
DOI 10.1007/s10389-017-0810-7

ORIGINAL ARTICLE

Measurement of reproductive health indicators in Ethiopia: A mixed method study

Mulu Abraha Woldegiorgis[1] · **Janet E. Hiller**[1,2] · **Wubegzier Mekonnen**[3] · **Jahar Bhowmik**[1]

Received: 20 September 2016 / Accepted: 3 May 2017 / Published online: 25 May 2017

Abstract
Aim Various reproductive health (RH) indicators have been formulated and used to measure RH services and status. Despite their widespread use, the measurement of these indicators has never been explored in a systematic manner. This study aimed to examine methods and methodologies in the measurement of common RH indicators in the Ethiopian context.
Subjects and Methods A mixed-method design, comprising in-depth expert interviews, the abstraction of information from relevant public documents and an analysis of peer-reviewed literature, was used. Information from these three sources was then organised and synthesised using a thematic approach.
Results Until now, routine health information system and demographic and health survey have been the primary sources for RH indicators in Ethiopia. A number of improvements have recently been made in data collection and aggregation methods; however, the focus has been more on the coverage of services than the quality of data. We noted that variations were observed in indicator definition between the two data sources and, as a consequence, in their estimates. It was found that many of the inherent limitations in the measurement of RH indicators could be addressed by making small modifications to the data sources and the reporting formats. Data quality concerns mainly occur at the point of data collection although there are also issues with data aggregation, dissemination and use.
Conclusion There is a gap in the measurement of the quality and continuity of RH services. Many of the limitations and data quality concerns in the measurement of RH indicators could be resolved with minimal improvements to the current health information system.

Keywords Reproductive health · Indicators · Measurement · Ethiopia

The original version of this article was revised: The name of Jahar Bhowmiki is incorrect. It should be Jahar Bhowmik.

Headline of contribution: *Do DHS and HMIS measure RH indicators in the same way?*

✉ Mulu Abraha Woldegiorgis
mwoldegiorgis@swin.edu.edu

[1] Swinburne University of Technology, School of Health Sciences, Melbourne, Australia

[2] University of Adelaide, School of Population Health, Adelaide, Australia

[3] Addis Ababa University, School of Public Health, Addis Ababa, Ethiopia

Introduction

Reliable and timely health information is one of the foundations of effective health service management and public health operations. Indicators are markers of health status, service provision or resource availability, designed to enable the monitoring of service performance or programme goals (HMN and World Health Organization 2011; World Health Organization 1997). In both the Millennium Development Goals (MDGs) and their successor the Sustainable Development Goals (SDGs), the need for reducing maternal and child mortality as well as improving the health status of mothers and children has been strongly emphasised. To realise these goals, improving Reproductive Health (RH) services is critical (Brende and Høie 2015; United Nations 2015; Wagstaff and Claeson 2004).

In addition, the World Health Organisation (WHO), together with other international agencies, has formulated a compendium of 17 RH indicators for global monitoring of RH services and status. These indicators encompass the measurement of specific RH services as well as the continuity and

integration of services across health systems and are intended to draw attention to the key measurable areas of reproductive health. Most have been recommended for roll-out in countries for national level data collection, aggregation and dissemination. For these measurements, the Health Management Information System (HMIS) and the Demographic and Health Survey (DHS) programme, along with other special surveys, are the main sources of data (World Health Organization 1997; World Health Organization 2006). The HMIS, also known as the Routine Health Information Systems (RHIS), is a routine data collection system from health facilities specifically designed to support planning, management and decision-making at all levels of the health system (MEASURE Evaluation n.d.-b).

The HMIS typically integrates data collection, processing, reporting and the use of information for improving health service effectiveness and efficiency through better management at all levels of the health services (Lippeveld et al. 2000). Therefore, regular monitoring and evaluation (M&E) of RH services and RH status require repeated measurements using selected indicators aimed at verifying whether the goals and targets have been met (Charles Ngwena 2014; HMN and World Health Organization 2011). In the Sub-Saharan Africa (SSA) region, routine monitoring of RH indicators is particularly important. The region has faced particular challenges in effectively addressing common RH needs, as demonstrated by the fact that its global share of maternal mortality is increasing (World Health Organization, UNICEF, 2014). Despite the global guideline available for reporting these RH indicators, the weakness of health information systems has resulted in the need for statistical modelling exercises such as the Maternal Mortality Ratio (MMR) (Countdown, HMN, Unicef, World Health Organization, 2011) to develop internationally comparable estimates.

Ethiopia, a culturally diverse and multi-ethnic nation, has had good experience with implementing the HMIS at all levels of the health system. The role of the HMIS in improving the health delivery system is acknowledged by key partners such as the World Bank, although an Ethiopian case study (Sambo 2011) revealed that an ongoing improvement strategy is recommended. The Africa Health Monitor has published Ethiopia's HMIS as a demonstration of the country's experiences of African health system strengthening (Sambo 2011). The HMIS (Federal Ministry of Health 2014e) and DHS reports (CSA II, 2012; CSA OM, 2001; CSA OM, 2006) include suggested RH indicators. Commonly reported RH indicators include obstetric care service coverage (antenatal care, delivery care and postnatal care), contraception use, fertility level and maternal mortality. On the other hand, indicators of basic and comprehensive obstetric services are reported less frequently in the HMIS. Another issue is that data quality assessments in the HMIS are less rigorous and often focus only on gross data quality issues.

As mentioned in the standard RH guidelines, evidence about the extent of the measurement of RH indicators is essential for an understanding and interpretation of the level of coverage and quality of service (United Nations n.d.; von Schirnding 2002). This evidence, however, has not been assessed in a systematic manner in the SSA region. The aim of this study was to examine methods and methodologies in the measurement of RH indicators in the Ethiopian context. More specifically, it focused on the tools used and procedures followed, the assumptions made by each source (HMIS and DHS) and any differences in the measurements. The study also identified areas of data quality concerns and put forward improvement strategies.

Methods

Study design

A mixed-method study design, comprising in-depth expert interviews, the critical review of relevant documents and an analysis of peer-reviewed literature relevant to the measurement of common RH indicators, was used.

Study area and period

Ethiopia was selected for a case study involving detailed scrutiny of various aspects of the measurements. Relevant RH-related documents (grey literature) and peer-reviewed literature from 1990 to 2014 were considered for analysis.

Data sources and indicators

Grey literature: Relevant government documents including those in the areas of HMIS, DHS and international agency sources, mainly the WHO (interagency group) and the MEASURE Evaluation, that contain information about the measurement of RH indicators were reviewed.

Scholarly articles: Scholarly articles that assessed and/or reported substantive evidence in the measurement of one or more of the selected indicators were also reviewed to obtain useful insights into the areas measured by those indicators.

Qualitative experts: Purposively selected experts with experience in RH were interviewed about the measurement of RH indicators in Ethiopia.

Six RH indicators that have been regularly reported by health systems were included in this study. These were antenatal care, skilled birth attendance, postnatal care, contraceptive prevalence or acceptance rate, maternal mortality ratio and total fertility rate.

Data collection

Qualitative interview Having received ethical approval from Swinburne University of Technology in Australia for the interview component of the study (SHR Project 2015/121), we selected 12 Ethiopian experts for the in-depth interview. Participants were interviewed using semi-structured qualitative tools. The experts were from the Federal Ministry of Health, Regional Health Bureaus, Central Statistical Agency and development partners in Ethiopia. All interviews were conducted by the primary investigator. The interviews were contextualised within the framework of the respective sectors of the interviewees.

Document review Information including the indicator definition, numerator, denominator, interpretation, limitations and source of indicators was abstracted from selected documents. Data from the review of scholarly articles were then integrated to pinpoint the information collected from the grey literature.

Analysis scheme

Description of measurement of indicators

The measurement of each of the selected indicators was described in terms of its indicator definition including its numerator, denominator, interpretation and assumptions considered (if any). These were described based on the main data sources—HMIS and DHS. The data collection format, data source (health facility registers/surveys), level of disaggregation and aggregation, frequency and approach to data collection and the reporting method (paper-based or electronic) were also reviewed to obtain detailed aspects of data generation and reporting.

Exploration of the differences in measurements

Similarities and differences in the definitions, numerators, denominators, interpretation and assumptions of the indicators between HMIS and DHS were explored. Evidence of attempts to compare the differences in the measurement of RH indicators between sources was examined, along with any trends of data discrepancy across sources. Changes in indicator measurement across time including year of change, reason for change and outcome (if available) were also described and identified.

Identification of data quality concern areas

Limitations associated with the indicator definitions and measurements as well as data quality issues in the actual data generation, compilation and reporting in the HMIS and DHS were identified. Levels of and reasons for data quality issues, as well as the initiatives put in place to address them, were also examined.

Proposal of improvement strategies

Using the evidence from the above three analysis steps, we have proposed alternative improvement strategies, including modification of existing RH indicators, as well as the introduction of new indicators that overcome the identified indicator limitations and data quality issues. Finally, locally relevant data harmonisation and reconciliation for data quality improvement mechanisms are suggested.

Synthesis and presentation of information

Information from the abstraction matrix underwent thematic analysis. Qualitative data from interviews were coded, summarised and analysed using NVivo version 10. The results of the qualitative analysis were synthesised with the analysis output of the document review. Findings are presented using narrative summaries and tables.

Result and discussion

Measurement of reproductive health indicators

The three main areas of focus in this study were maternal health services, fertility and maternal mortality. The selected indicators and their definitions are shown in Table 1.

In Ethiopia, antenatal care (ANC), skilled birth attendance (SBA) and postnatal care (PNC) are measured by both HMIS and DHS, whereas the total fertility rate (TFR) and maternal mortality ratio (MMR) are measured by DHS only. With regard to contraceptive use, the HMIS measures the contraceptive acceptance rate (CAR), whereas DHS measures the contraceptive prevalence rate (CPR). Detailed information on the description of the RH indicators for both sources can be found in Table 2. The most widely used ANC indicator is the proportion of pregnant mothers who attended at least one ANC visit during their pregnancy period. As a proxy indicator for the quality of ANC services, the WHO (World Health Organization 2002) recommends a minimum of four ANC visits for a pregnant woman during the course of her pregnancy. It is also recommended that the number of visits disaggregated by trimester is important to assess besides the coverage, since the effectiveness of certain ANC interventions depends on repeated visits and the trimester in which they occur (Lincetto et al. 2006). However, any coverage during any trimester is considered a measure of ANC service in the Ethiopian health system.

Table 1 Definitions of the indicators in the six selected RH areas

RH Indicator	Definition
Antenatal care coverage (ANC)	The percentage of women attended, at least once during their pregnancy, by skilled health personnel for reasons relating to pregnancy[1,3]
Skilled birth attendance coverage (SBA)	The percentage of births attended by professionals with midwifery and obstetric skills[3]
Postnatal care coverage (PNC)	The percentage of women attended, at least once during postpartum (42 days after delivery), by health professionals for reasons relating to post-partum[1]. Early PNC coverage is defined as when the service is given within 7 days[2]
Contraceptive prevalence rate (CPR)	The percentage of women of reproductive age who are using (or whose partner is using) a contraceptive method at a given point in time[2]
Contraceptive acceptance rate (CAR)	The percentage of women of reproductive age (15–49 years) who are not pregnant and are accepting a modern contraceptive method[2]
Total fertility rate (TFR)	The number of births a woman would have by the end of her reproductive life if she experienced the currently prevailing age-specific fertility rates[3]
Maternal mortality ratio (MMR)	The number of maternal deaths per 100,000 live births
	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[3]

[1] Federal Ministry of Health (2007) *HMIS/M&E Indicator Definitions, HMIS/M&E Redesign: Technical Standards: Area 1 version 1.0*. Addis Ababa, Ethiopia: Federal Ministry of Health

[2] Federal Ministry of Health (2014a, b, c, d, e, f, g) *HMIS Indicator Definitions: Technical Standards: Area 1, Revised Health Management Information System Indicator Definition 2014*. Addis Ababa, Ethiopia: Federal Ministry of Health

[3] World Health Organization (2006) Reproductive health indicators: guidelines for their generation, interpretation and analysis for global monitoring

(RH = reproductive health)

Similarly, SBA focuses on counting delivering mothers attended by skilled health personnel. In PNC coverage, the interest is in the number of mothers who receive the service at least once during the postpartum (42 days after delivery) period. However, there are shifts of focus in the duration of service reception as described in the HMIS guidelines, ranging from 42 days (Federal Ministry of Health 2007) to the first 7 days (Federal Ministry of Health 2014g) following delivery. In the measurement of ANC, SBA and PNC, the consideration of "skilled health personnel" is critical, although the competencies of the skilled personnel are potentially debatable. While the latest ANC (Federal Ministry of Health 2014f), delivery (Federal Ministry of Health 2014d) and PNC (Federal Ministry of Health 2014b) registers do capture basic elements of focused antenatal, delivery and postnatal care services, there is a lack of important standard service packages. For instance, in the ANC register (Federal Ministry of Health 2014f), the recommended ANC components such as foetal well-being, anaemia, multiple pregnancy, blood pressure and Rh group (Lincetto et al. 2006) are not included.

In the measurement of contraception, women who use contraceptives (current user, at least one-time user) among non-pregnant women eligible for contraception are reported. The marital status of women is also a focus area, since sometimes only married women are considered eligible for contraception.

With regard to maternal mortality, only the sisterhood method, a verbal autopsy method based on an interview with a sister of the deceased mother, is still being used by DHS, even though better and more feasible methods are available. The TFR, as measured by DHS, is computed as the sum of age-specific fertility rates in the 3 years preceding the survey.

Differences in measurements

There are several points where the HMIS and DHS differ in the measurement of common RH indicators. The key differences in the measurement of RH indicators, as indicated in Table 2, are: what is actually counted (the numerator), the target population (denominator) and the reference period for which the indicators are computed. The reference period for all HMIS data is the fiscal year (Federal Ministry of Health 2007; Federal Ministry of Health 2014g), while that of the DHS is usually a 5-year period prior to the survey for ANC, SBA and MMR. The reference period of PNC was changed from 5 years in DHS 2000 and 2005 (CSA OM, 2001; CSA OM, 2006) to 3 years in DHS 2011 (CSA II, 2012). Besides these basic differences between HMIS and DHS, the measurement methods and their data sources also vary. The HMIS counts service recipients from facility records while DHS counts reported use by the responding mothers at the time of

Table 2 Differences between the Health Management Information System and the Demography and Health Survey in the measurement of RH

	Health Management Information System	Demographic and Health Survey
Antenatal care	Counts the number of pregnant women who received ANC services at least once in the fiscal year. Denominator is the number of expected pregnancies computed from the population	Counts the number of mothers who report reception of ANC services for their last child in the reference period. Denominator is the number of women with a live birth in the reference period
Skilled birth attendance	Counts the number of deliveries assisted by skilled health personnel during the fiscal year Denominator is the number of expected deliveries in the fiscal year. All skilled delivery services take place at health institutions. Hence, 'institutional delivery' is sometimes used interchangeably with 'skilled birth attendance'	Counts the number of mothers who report their last birth (in the reference period) was attended by skilled health personnel. Denominator is the number of women with a live birth in the reference period
Postnatal care	Counts the number of mothers who received at least one PNC session during the fiscal year. Denominator is the number of expected deliveries in the fiscal year	Counts the number of mothers who report receiving at least one session of PNC within the reference period for their most recent birth. Denominator is the number of women with a live birth in the reference period
Contraception	Counts the number of women who accepted a modern contraceptive method or continued to be protected from unwanted pregnancy during the fiscal year. It reports the contraceptive acceptance rate. Denominator is the number of eligible non-pregnant women	Counts the number of women who report current use of contraception at the time of the survey. It reports the contraceptive prevalence rate. Denominator is the number of married/sexually active women

Sources: Federal Ministry of Health of Ethiopia, health information system indicators definitions 2007 and 2014 and Ethiopia Demographic and Health Survey reports, 2000, 2005 and 2011

ANC = antenatal care, PNC = postnatal care, RH = reproductive health

the survey. The HMIS also uses prospective data collection during service provision (at point of care) while DHS uses retrospective recall interviews (Table 3).

Indicator limitations and data quality issues

Indicator limitations

Despite the broad consensus on what the content and quality should be, it is generally recognised that RH services currently provided in many parts of the world fail to meet standards recommended by the WHO. The available data mostly do not report on specific interventions or the quality of care. The analysis that follows should, therefore, be treated with caution (Abou-Zahr et al. 2003). Likewise, the primary focus of the data sources for all the RH service indicators considered in this study (ANC, SBA, PNC, CPR and CAR) is the count/number of service recipients. DHS (2011) highlighted that the quality of ANC can be measured by the qualifications of the provider, the content of the service received and the kinds of information given during each visit (CSA II, 2012). However, the quality, continuity and adequacy of RH services are not well captured by these indicators. Since there is no "standard package" of ANC, SBA, PNC, CPR and CAR services considered in the measurement of the indicators, the content and consistency of services, and thus the uniform measurement of indicators, cannot be ensured. The definition of skilled health personnel, their competence, their commitment and the health facility setups (health infrastructure) might also vary across different levels of the health care delivery system.

The denominator of ANC, SBA and PNC of the HMIS computed from the estimated general population may also not be reliable. As the expected number of pregnancies and deliveries could be affected by a range of factors such as increments in CPR, computations without frequent updating of the assumptions could affect the reliability of the estimates. On the other hand, the number of live births is used as a denominator in the DHS; therefore, mothers who were pregnant but did not have live births (e.g. abortion, stillbirth) are systematically excluded from the estimation.

The other key limitation in the measurement of ANC, SBA, PNC, CPR and CAR is that the intended outcomes of the services are not addressed by the indicators. These indicators need to be interpreted together with the outcomes of the respective services, which include behavioural intentions, live births (with normal/low birth weight), perinatal mortality rate, maternal mortality rate and fertility rates. For instance, the effectiveness of a skilled delivery may depend on the combined effect of whether the "skilled personnel" really are skilled, whether the health facility is equipped with basic obstetric equipment as well as the commitment of the health workers to provide quality service. Only an outcome indicator can address the combined effect. The actual timing at which mothers sought ANC, SBA and PNC services is also not reported in the HMIS, except in PNC where a wider time span is reported.

It was noted in the analysis that some unwarranted assumptions could also endanger the interpretation and usefulness of the indicators. For instance, the WHO has recommended that postnatal care should be provided in the facility for at least 24 h after birth if the birth takes place in a health facility (World

Table 3 Description of reproductive health indicators based on the routine Health Management Information System (HMIS) and Demographic and Health Survey (DHS)

Indicator	Source	Definition	Numerator	Denominator	Level of disaggregation
Antenatal care coverage	Health Management Information System (HMIS) ✓Health post ✓Health centre ✓Private clinic/hospital ✓Public hospital	Percentage of pregnant women who received antenatal care services during their current pregnancy from a health professional for reasons related to pregnancy	Number of antenatal care visits by trained personnel and health extension workers (sum of reported regional counts)	Total number of expected pregnancies (sum of regional expected pregnancies)	**Health facility** ✓Hospital/health centre ✓Health post **Visit type** ✓First visit ✓Four or more visits
	Demographic and Health Survey (DHS)	Percentage of mothers with live births in the past 5 years who had received services from a health professional for the most recent live birth	Number of mothers with live births who reported that they had at least one visit from a health professional for the most recent birth	Total number of mothers with at least one live birth during the 5 years preceding the survey	**Type of health worker** ✓Doctor ✓Nurse/midwife ✓Other health worker ✓Health extension worker ✓Traditional birth attendant **Background characteristics** ✓Mother's age at birth ✓Birth order ✓Residence (urban, rural) ✓Region ✓Education ✓Wealth quintile **Visit type** ✓First visit ✓Four or more visits
Skilled birth attendance coverage	HMIS ✓Health post ✓Health centre ✓Private clinic/hospital ✓Public hospital	Percentage of births attended by skilled health personnel	Number of births attended by skilled health personnel	Total number of expected deliveries	**Delivery outcome** ✓Live birth ✓Still birth
	DHS	>>	>>	Total number of live births during the specified period	**Health facility type** ✓Private ✓Public **Background characteristics** ✓Mother's age at birth ✓Place of delivery ✓Birth order ✓Residence (urban, rural) ✓Region ✓Education ✓Wealth quintile
	HMIS ✓Health post ✓Health centre ✓Private clinic/hospital ✓Public hospital	Percentage of women who attended postnatal care at least once during the early post-partum period	Number of postnatal visits within 7 days of delivery	Total number of expected deliveries	**Time first PNC received after birth** ✓0–48 h (0–2 days) ✓49–72 h (2–3 days) ✓73 h-6 days (4–6 days)

Table 3 (continued)

Indicator	Source	Definition	Numerator	Denominator	Level of disaggregation
Postnatal care coverage	DHS	Percentage of mothers with live births in the past 2 years who received PNC services from a health professional for the most recent live birth	Number of mothers with live births who reported that they received at least one PNC service from a health professional for the most recent live birth	Total number of mothers with at least one live birth in the last 2 years preceding the survey	**Time after delivery** ✓Less than 4 h ✓4–23 h ✓1–2 days ✓3–6 days ✓7–41 days **Background characteristics** ✓Type of health worker ✓Mother's age at birth ✓Place of delivery ✓Birth order ✓Residence (urban, rural) ✓Region ✓Education ✓Wealth quintile
Contraceptive acceptance rate	HMIS ✓Health post ✓Health centre ✓Private clinic/hospital ✓Public hospital	Percentage of women of reproductive age (15–49 years) who were not pregnant and accepting a modern contraceptive method (new and repeat acceptors)	Number of new and repeat acceptors	Total number of women of reproductive age (15–49) who were not pregnant	**Type of visit** ✓New/repeat **Demographic characteristics** ✓Age **Method** ✓Permanent ✓All others
Contraceptive prevalence rate	DHS	Percentage of women of reproductive age at risk of pregnancy who were using (or whose partner was using) a contraceptive method at the time of the survey	Number of women of reproductive age at risk of pregnancy who were using (or whose partner was using) a contraceptive method at the time of the survey	Number of women of reproductive age at risk of pregnancy at the same point in time	**Methods** ✓Any modern method ✓Female sterilisation ✓Temporary modern female methods ✓Male condom **Background characteristics** ✓Residence (urban, rural) ✓Number of living children ✓Region ✓Education ✓Wealth quintile **Source** ✓Public ✓Private ✓Other source
Total fertility rate	DHS	Number of births a woman would have by the end of her reproductive life if she experienced the currently prevailing age-specific fertility rates	Age-specific fertility rates		**Background characteristics** ✓Residence (urban, rural) ✓Number of living children ✓Region ✓Education ✓Wealth quintile

Table 3 (continued)

Indicator	Source	Definition	Numerator	Denominator	Level of disaggregation
Maternal Mortality ratio	DHS	Pregnancy-related deaths during 2 months following a birth			None

Level of aggregation: HMIS is aggregated and analysed at all levels of the health system (health facility, district, regional and national), whereas DHS is only aggregated at a national level

Data sources: The numerator of the HMIS was collected from health facility registers, whereas the denominator was sourced from eligible targets of the population and housing census. In the DHS, the data source for both numerator and denominator was the survey itself.

Frequency of data collection: HMIS is on a monthly basis. DHS is collected every 5 to 6 years.

Health Organization 2014). With this assumption, it might be expected in the HMIS that a mother who delivered in a health facility would automatically receive PNC services before being discharged. On the other hand, PNC is assumed to be provided whenever the mother presents to a health facility following delivery. The fact that the HMIS takes into account the PNC services provided by community health workers also increases the coverage. This was indicated in the health and health-related indicator reports, for example the 2014 report (Federal Ministry of Health 2014a), where PNC is much higher than SBA. However, DHS 2011 (CSA II, 2012) reported that PNC coverage was remarkably lower than SBA. In the measurement of CAR, a mother who uses long-acting contraceptives is counted as a "repeat user" in the subsequent years. This operates under the assumption that she remains protected (Federal Ministry of Health 2014g), despite the possibility of the contraceptive being removed in another health facility.

The tenth revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10) defines *maternal death* as the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the *duration* and *site* of the pregnancy, from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes (World Health Organization 2011). The same source defines *pregnancy-related death* as the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the *cause* of death. To implement approaches to improve maternal health care (Rogo et al. 2006), it is important to obtain an accurate picture of the scope of the problem. Despite this necessity, the WHO described maternal mortality as one of the most challenging issues to manage in maternal health (Zahr and Wardlaw 2004). Unreliable data and wide margins of uncertainty make it difficult to come to solid conclusions (United Nations 2006). Many of the difficulties associated with monitoring maternal mortality arise from the fact that maternal deaths are relatively rare events (AbouZahr 2011). The commonly used indicator of maternal mortality is MMR, which counts maternal deaths per 100,000 live births and is designed to express direct or indirect obstetric risk (World Health Organization, UNICEF, 2014).

The DHS uses information from surviving sisters using the sisterhood method to estimate MMR. A DHS data quality assessment on MMR in selected countries has detailed the limitation of the sisterhood method. Since live births are considered a "denominator" for MMR, the exclusion of maternal deaths related to still births and abortions may affect its interpretation and could lead to overestimation (Stanton et al., 1997). The other limitations are underreporting and a lack of vital statistics. Our analysis also suggested that the potential to underestimate MMR exists. An M&E expert explained that in cases of maternal death where the deceased mother does not have a (living) sister, she would not be counted. The possibility of such downward estimations with the sisterhood method as described by Graham et al. (1989) is discussed by Trussell

and Rodriguez (1990). There could also be recall bias due to memory lapses as the reference period is 5 years preceding the survey (Boerma and Sommerfelt 1992). This risk could be compounded in Ethiopia, as study participants stated that recall bias in the Ethiopian context would be much higher because of sociocultural factors. Additionally, there could also be disinterest in reporting a sibling's death. A programme expert commented from real experience: "Since it is taboo to talk about maternal deaths in some parts of the community, the surviving sister might not report her sister's death." On the other hand, some experts agued there could also be some overestimation. For one thing, there is a possibility of double counting if the deceased mother has more than one sister living in different households. However, Trussell and Rodriguez explained that multiple reporting on sisters does not lead to any major bias since the sisterhood method is based on a proportional relationship (Trussell and Rodriguez 1990). Also, as the DHS data are based on information about maternal deaths during the first 2 months following a birth rather than within 42 days as defined by the WHO, the MMR might be overestimated particularly in urban areas where the exact date of death is expected to be reported. Most importantly, the DHS simply asks for the time of death relative to pregnancy and thus measures pregnancy-related death (Kenneth Hill et al., 2006) as opposed to maternal death, but it is still used as a measure of maternal mortality.

Data quality issues

Targets allow performance to be assessed and are useful tools for managing projects and evaluating their achievements (Arur et al. 2011). However, the M&E informants we spoke with noted *'In Ethiopia, the Federal Ministry of Health provides recognition for the best performing region/s; however, the rewards are based on "reported" performances aggregated from the respective districts and health facilities. The "performance only"-based reward along with "allocated targets" based on overambitious expectations derived from the eligible population may increase the risk of data integrity concerns in some cases in the HMIS.'*

The health system uses Lots Quality Assurance Sampling (LQAS) as the main data quality assurance method. It is used to estimate the quality of HMIS data using a sample of 12 data elements by comparing the results with a standard LQAS table. This is done by selecting data elements from the monthly report (submitted to higher levels) and then comparing the data with the sum in tally sheets and registers. If a high proportion of the numbers is the same, then the quality of the data is also assumed to be high (Federal Ministry of Health 2014c). The LQAS is an important quality indicator as it shows the consistency of data between tallies/registers and the reported data. However, without intensive and extensive data quality assessments, it remains a potential threat to the integrity of the data.

Information dissemination is crucial at all management levels of the health services, from the periphery (patient/client management) to the centre, for health system planning and management (Lippeveld et al. 2000). In Ethiopia, however, problems exist in both rolling out the HMIS and adequate staffing for obtaining quality information. Some experts interviewed for the study mentioned that quality RH services offered by private health facilities and development partners are missing in many instances as the reformed HMIS is not fully rolled out in these facilities. A regional M&E expert made this comment about staffing: "The HMIS data is collected by overloaded health workers as there are no specific personnel dedicated for data collection. This could lead to incomplete and inconsistent data in some health facilities." An M&E expert and a programme expert also added that although the Federal Ministry of Health (FMOH) delivers updated standard procedure, training and information user guides to health workers at all levels of the health system, there is a shortage of training due to the high turnover of health workers. A lack of motivation and poor understanding concerning the importance of data were also mentioned as factors contributing to low-quality data.

Data recording and reporting problems identified by the key informants include missing, incomplete or inaccurate data, double counting, skills shortage, weak technology capacity (especially in the case of electronic data entry), low awareness of the importance of recording and reporting, and delayed reporting to higher levels. Additionally, we noted that having too many, and too detailed indicators in some programme areas (like HIV/AIDS) in the revised HMIS monthly reporting format (Federal Ministry of Health 2014e) may compromise efforts to collect fewer, but more important, RH indicators.

The inadequacy of the quality assurance process was also identified as a problem. Some informants emphasised that while a performance review team, when established in health facilities, evaluates the monthly progress of the facility, it is weak in most health facilities and does not even exist in some. Together with the low level of attention by some health managers and the very weak communication between M&E and programme units, this has resulted in inadequate feedback processes and follow-up in some areas. The findings also indicate that some experts who are expected to analyse data and provide evidence at higher levels of the health system do not have sufficient analytic skills. It is a common misconception that data are collected for the purpose of reporting to the next level rather than for decision-making at local levels.

Suggested strategies

Modification of existing indicators and consolidation of all sources

Some of the identified indicator limitations could be resolved through the modification of existing indicators. For instance,

to avoid duplication and ambiguity in the measurement of CAR in the HMIS and to eliminate confusion between "new" and "repeat" acceptors, a suggested indicator name for "new acceptors" by the family planning programme effort index, '*acceptors new to modern contraception'* (MEASURE Evaluation n.d.-a), could be helpful. "Repeat acceptors" would also be better rephrased as '*repeat acceptors in lifetime but not within a fiscal year*'.

Complete vital registration systems are said to be preferred sources of data because they collect information as the events occur and they cover the entire population. Investments in vital registration systems to ensure correct reporting of births, maternal deaths and causes of maternal deaths are essential (Countdown, HMN, Unicef, World Health Organization, 2011). As mentioned above, the DHS currently reports pregnancy-related deaths. It reports deaths with no restriction on the cause of death as it is easier to measure from a practical perspective. However, with the existence of health facility records and vital registration (family folder) by the health extension workers at a community or health post level, relying only on the verbal, autopsy-based sisterhood method for measuring maternal mortality, would not be justifiable. One informant suggested enhancing the sample vital registration system, something that is being done in a few university-based research areas. Another expert commented that Ethiopia had established the 'Vital Events Registration Agency' in 2012 and it was officially launched on 8 August 2016. The expert added that 'while vital events (birth, death, marriage and divorce) are supposedly recorded within 90 days of their occurrence, all stakeholders should support this initiative.' In line with these initiatives, data from the three available sources (survey, health facility and community/health post) need to be consolidated to enable a more robust estimate of maternal mortality.

Adding indicators

Some of the identified indicator limitations could be resolved through the introduction of additional RH indicators to the Health Management Information System (HMIS) and the Demographic and Health Survey (DHS). We suggest the following indicators:

1. *Percentage of mothers who received standard obstetric services:* With the introduction of a minimal package of services to the measurement systems, this indicator would enable the HMIS to address shortfalls in the content of services by measuring which services were provided, who provided the services and what the outcome was.
2. *Percentage of pregnant mothers who received continuous (ANC, SBA and PNC) services in the course of a single pregnancy:* Continuous and complete maternal health service coverage could potentially improve the continuity of maternal health services. This indicator could show how many of those who started ANC completed all other maternal health services for the same pregnancy. This indicator is likely to improve the effectiveness of ANC much more than simply counting the visits. It could be included in both HMIS and DHS sources.
3. *Percentage of lives saved by assisted delivery compared to at-home or unassisted delivery*: A suggested indicator for the HMIS could help to weigh the effectiveness of SBA services. This could be computed by subtracting institutional maternal deaths from the number of maternal deaths in the community at large in reference to total deliveries as both indicators are included in the revised service delivery reporting format.
4. *Percentage of pregnant mothers provided with complete obstetric services (provided by a skilled health worker and in a health facility equipped with obstetric services)*: This could also be considered (in the HMIS) as a quality indicator for each visit although key informants in the study noted that the competency and commitment of health workers are already also cornerstone factors.
5. *Total maternal deaths:* It was noted by the experts that being able to generate maternal mortality-related indicators would be beneficial. This crude HMIS indicator can be computed from maternal deaths in the community (the sum of maternal deaths at home, at a health post or on the way to a health facility) plus institutional maternal deaths as these indicators are already part of HMIS.
6. *Average/median length of cumulative time a woman uses contraceptives within 5 years preceding the survey:* With regard to the measurement of contraceptive use, a shift from measuring the number of women to measuring the actual duration of contraception is suggested. We suggest this indicator should be part of the DHS report. Couple Years of Protection (CYP) in HMIS is related to this but its computation is based on contraceptive commodities rather than the actual use of contraceptives.
7. *Percentage of contraceptive users who continuously use for 6 months, a year or more than a year:* Measuring the duration of contraception would be a superior method to the current indicators, CAR and CPR, and would be more informative for population policies. This indicator can be introduced to both HMIS and DHS.

Conclusions and recommendations

Since the existing RH indicators focus on counting service recipients only, births and deaths and measurement of the quality and continuity of RH services are overlooked. Many of the limitations and data quality concerns in the measurement of RH indicators could be resolved without major

changes to the current information system. In this regard, the authors recommend the following:

1. Using updated, district-based target (denominator) data would help to adjust the estimated target projected from the population and housing census data.
2. Effectively implementing the "one report" principle promulgated by the Ministry of Health for all implementers would have the effect of reducing differences and duplications during reporting.
3. Including more quality and RH service continuity indicators in the HMIS would lead to improving the quality of the services.
4. Involving all partners in rolling out the HMIS would improve the quality and coverage.
5. The harmonising of data from HMIS, DHS and other sources for a single best estimate would avoid potential confusion.
6. Redefining some HMIS indicators would make the indicators more transparent and more self-explanatory and would help to improve data quality.

Acknowledgements We extend our gratitude to the Reproductive Health Program and the monitoring and evaluation experts of Ethiopia for their commitment and courage in providing us with detailed and up-to-date information, as well as the most recent public RH focused documents. The authors gratefully acknowledge the Federal Ministry of Health of Ethiopia for providing relevant information to the public in an organised manner. Swinburne University of Technology in Australia provided both technical and financial support for this study. Our special thanks go to Associate Professor Timothy Moore and Hannah Cramond for their editing support.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Funding This study was funded by Swinburne University of Technology, Australia.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Ethical approval was obtained from Swinburne University of Technology.

Informed consent Informed consent was obtained from all individual participants included in the study.

References

AbouZahr C (2011) New estimates of maternal mortality and how to interpret them: choice or confusion? Reproductive Health Matters 19:117–128. doi:10.1016/S0968-8080(11)37550-7

Abou-Zahr CLW et al. (2003) Antenatal care in developing countries: promises, achievements and missed opportunities. An analysis of trends, levels and differentials, 1990–2001. vol 618.2: 316. Organización Mundial de la Salud

Arur A, Mohammed-Roberts R, Bos E (2011) Setting targets in health, nutrition and population projects

Boerma JT, Sommerfelt AE (1992) Demographic and health surveys (DHS): contributions and limitations. World Health Stat Q 46: 222–226

Brende B, Høie B (2015) Towards evidence-based, quantitative sustainable development goals for 2030. Lancet 385:206–208. doi:10.1016/S0140-6736(14)61654-8

Charles Ngwena ED (2014) Strengthening the protection of sexual and reproductive health and rights in the African region through human rights. Pretoria University Law Press, South Africa

Countdown, HMN, Unicef, World Health Organization (2011) Monitoring maternal, newborn and child health: understanding key progress indicators

CSA II (2012) Ethiopia demographic and health survey 2011 Addis Ababa, Ethiopia and Calverton, Maryland, USA: Central Statistical Agency and ICF International

CSA OM (2001) Ethiopia demographic and health survey 2000 Addis Ababa, Ethiopia and Calverton, Maryland, USA: Central Statistical Agency and ORC Macro 41:91

CSA OM (2006) Ethiopia demographic and health survey 2006 Addis Ababa, Ethiopia and Calverton, Maryland, USA: Central Statistical Agency and ORC Macro

Federal Ministry of Health (2007) HMIS / M&E indicator definitions HMIS / M&E redesign: technical standards area 1 version 1.0. Federal Ministry of Health, Addis Ababa

Federal Ministry of Health (2014a) Ethiopia health and health related indicators 2013/2014 version 1. Federal Ministry of Health, Addis Ababa

Federal Ministry of Health (2014b) Ethiopia health management information system: postnatal care register. Federal Ministry of Health, Addis Ababa

Federal Ministry of Health (2014c) Health management information system (HMIS) recording and reporting procedure. Federal Ministry of Health, Addis Ababa

Federal Ministry of Health (2014d) Health management information system: delivery register. Federal Ministry of Health, Addis Ababa

Federal Ministry of Health (2014e) Health management information system: monthly, quarterly and annual service delivery reporting format, 2014. Federal Ministry of Health, Addis Ababa

Federal Ministry of Health (2014f) Health Managment information system: antenatal care register. Federal Ministry of Health, Addis Ababa

Federal Ministry of Health (2014g) HMIS indicator definitions: technical standards: area 1, revised health management information system, indicator definition 2014. Federal Ministry of Health, Addis Ababa

Graham W, Brass W, Snow RW (1989) Estimating maternal mortality: the sisterhood method. Stud Fam Plan 20:125–135

Hill K, Koenig M, Al-Sabir A, Jamil K, Raggers H (2006) How should we measure maternal mortality in the developing world? A comparison of household death and sibling history approaches. Bull World Health Organ 84:173–180

HMN, World Health Organization (2011) Country health information systems: a review of the current situation and trends. World Health Organization, Geneva

Lincetto O, Mothebesoane-Anoh S, Gomez P, Munjanja S (2006) Antenatal care opportunities for Africa's newborns: practical data, policy and programmatic support for newborn care in Africa

Lippeveld T, Sauerborn R, Bodart C (2000) Design and implementation of health information systems. World Health Organization, Geneva

MEASURE Evaluation (n.d.-a) Family planning program effort index. Family planning and reproductive health indicators database. http://

www.cpc.unc.edu/measure/prh/rh_indicators/specific/fp/family-planning-program-effort-index. Accessed Dec 20 2015

MEASURE Evaluation (n.d.-b) Health management information systems. https://www.measureevaluation.org/resources/training/materials/health-management-information-systems-hmis-1. Accessed Feb 17 2017

Rogo KO, Oucho J, Mwalali P (2006) Maternal mortality. In: Jamison DT (ed) Disease and Mortality in Sub-Saharan Africa

Sambo L (2011) Health systems and primary health care in the African region. The African Health Monitor 14:2–3

von Schirnding Y (2002) Health in sustainable development planning: the role of indicators. World Health Organization

Stanton C, Abderrahim N, Hill K, (1997) DHS maternal mortality indicators: an assessment of data quality and implications for data use. DHS analytical reports no. 4. Calverton, Maryland: Macro International Inc.

Trussell J, Rodriguez G (1990) A note on the sisterhood estimator of maternal mortality. Stud Fam Plan 21:344–346

United Nations (2006) The millennium development goals report 2006

United Nations (2015) The millennium development goals report 2015

United Nations (n.d.) Guidelines on reproductive health. United Nations task force on ICPD implementation. http://www.un.org/popin/unfpa/taskforce/guide/iatfreph.gdl.html. Accessed Nov 15 2015

Wagstaff A, Claeson M (2004) The millennium development goals for health: rising to the challenges. World Bank, Customer Service & Fulfillment, Po Box 960, Herndon, VA, 20172–0960

World Health Organization (1997) Selecting reproductive health indicators: a guide for district managers

World Health Organization (2002) WHO Programme to map best reproductive health practice. WHO antenatal care randomized trial: manual for the implementation of the new model. World Health Organization, Geneva

World Health Organization (2006) Reproductive health indicators: guidelines for their generation, interpretation and analysis for global monitoring

World Health Organization (2011) International statistical classification of diseases and related health problems: Tenth revision, edition 2010:201

World Health Organization (2014) WHO recommendations on postnatal care of the mother and newborn. World Health Organization

World Health Organization, UNICEF (2014) Trends in maternal mortality: 1990 to 2013: estimates by WHO, UNICEF, UNFPA, The World Bank and the United Nations Population Division: executive summary

Zahr CA, Wardlaw TM (2004) Maternal mortality in 2000: estimates developed by WHO, UNICEF and UNFPA. World Health Organization