Categorization of medical causes of maternal deaths and delays in care: Comparison between routine Maternal Death Surveillance and Response system and an obstetrician expert panel in Tanzania

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Ali Said ali.saidi@kbh.uu.se
Muhimbili University of Health and Allied Sciences School of Medicine
Corresponding Author
ORCiD: 0000-0002-9989-8273

Mats Malqvist
Uppsala University

Andrea B. Pembe
Muhimbili University of Health and Allied Sciences

Siriel Massawe
Muhimbili University of Health and Allied Sciences

Claudia Hanson
Karolinska Institutet

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Abstract

Background

To reduce high maternal mortality Tanzania introduced Maternal Death Surveillance and Response (MDSR) system in 2015 as recommended by World Health Organization. All health facilities are supposed to identify, notify and review all maternal deaths inorder to recommend quality improvement actions to prevent deaths in future. The system relies on consistent and correct categorization of causes of maternal deaths and three phases of delays. To assess its adequacy we compared the routine MDSR categorization of cause of deaths and care delays with those assigned by an obstetrician expert panel with additional information from Verbal Autopsy (VA).

Methods

Our cross-sectional study included 109 reported and reviewed maternal deaths from two regions in Tanzania for the year 2018. We abstracted the recorded underlying medical cause of death and reported delays of care from MDSR system records. We interviewed bereaved families using the standard World Health Organization VA questionnaire. The obstetrician expert panel assigned underlying medical cause of deaths based on information from medical files and VA according to International Classification of Disease to Death in Pregnancy Childbirth and Puerperium (ICD-MM).They assigned causes to nine ICD-MM groups and identified the three phases of delays. We used Cohen`s K statistic and proportional differences to compare causes of deaths and delays in care categorization.

Results

Ten deaths were excluded in analysis of underlying medical causes and 25 for delays. Expert panel and MDSR system assigned same underlying medical cause for 64.6% of deaths, K statistic 0.60. The agreement increased (80.8%) when causes were assigned by ICD-MM groups, K statistic 0.76. The obstetrician expert panel identified phase one delays
in 67.9%, phase two in 22.0% and phase three delays in 100% of the deaths while MDSR system identified delays in 50.0%, 11.9% and 92.9% respectively. The expert panel found human errors in management in 93.1% while MDSR system reported in 67.9% of deaths.

**Conclusion**

The MDSR committees performed reasonably well in assigning the underlying cause of deaths. The obstetrician expert panel found more delays to care than what was reported in MDSR system indicating difficulties within MDSR teams to critically review.

**Background**

In the past decade, worldwide Maternal Mortality Ratio (MMR) has decreased during the period when the international community was striving to attain the Millennium Development Goal 5 (1, 2). However, to reach the ambitious Sustainable Development Goal 3 accelerated and concerted efforts are needed (1, 3). Currently, the MMR in Tanzania is still one of the highest in the world, with most deaths occurring during intrapartum and immediate postnatal period (4, 5). To design targeted interventions, data are needed on cause of death as well as underlying factors of delays to care seeking. For this purpose the World Health Organization (WHO) has conceptualised the Maternal Death Surveillance and Response (MDSR) system to ensure that local data are available in timely fashion to steer efforts to reduce MMR.

The MDSR system includes identification, notification and review of maternal deaths to stimulate learning from what went wrong. Typically a team of health professionals and local managers review circumstances of deaths, underlying (sometimes called primary medical) causes and contributing factors such as delays in care seeking and provision. The three-delay concept provides a conceptual framework to categorize delays in maternal death (6–9). After completing reviews with analysis and interpretation of data, the team elaborates recommendations for action (10). The action plans are tailored to address
specific underlying medical causes of death and the contributing non-medical factors. To decide on the most adequate strategies, it is important for the MDSR system to record correct and consistent causes of death according to ICD-MM (11).

Medical files are widely used to determine the underlying causes of facility maternal deaths. In view of poor documentation of medical files in health facilities (12–14) or in instances when medical records are not available, such as community death (15) verbal autopsy (VA), a standardised interview with bereaved families, is increasingly viewed as an alternative method (16, 17). Also, the use of multiple sources may provide a more complete understanding of the circumstances of death and its causes.

Accurate categorizations of causes of death facilitate planning of recommendations that are specific to prevention of maternal death and reduce possibility of underestimation or overestimation of data. While the cause of death assignment by health professionals as part of MDSR reviews is commonly preferred, challenges are reported. A study from Malawi revealed poor agreement (K statistic 0.219) in categorization of medical causes of maternal death between health care providers and researchers. Health care providers failed to assign an underlying cause of death in 30.2% of cases and indicated immediate causes (condition leading directly to death) such as hypovolemic shock to be the underlying cause (18). A study carried out in five sub-Saharan African countries, suggested that particularly unanticipated complication of management or abortion complications are misclassified (19). Mgawadere reported significant differences in categorization of causes of death between researcher panel and health providers. The researcher panel of experts categorization led to 18.6% lower proportion of indirect maternal deaths and also re-categorized all contributing factors (20).

In view of the importance of correct information of cause of deaths as well as contributing factors to inform strategies, we sought to 1) estimate the completeness of reporting of
facility maternal deaths and 2) compare categorization of medical causes and 3) three phases of delays to maternal deaths between MDSR system-introduced since 2015 in Tanzania throughout the country (21) – and an expert panel of independent obstetricians using ICD-MM. We aimed by this to identify existing gaps in categorizing correct underlying medical causes and three phases of delays to derive recommendations to improve the MDSR.

Methodology

Study design

A cross-sectional study including 109 reported and reviewed maternal deaths from two regions in Tanzania that occurred between 1\textsuperscript{st} January and 31\textsuperscript{st} December 2018 was conducted. Routine MDSR categorization of cause of deaths and care delays was compared with those assigned by an independent expert panel of obstetricians with additional information from VA. To compute the completeness of maternal deaths reported by the MDSR we used the number of infants that received Bacillus Calmette-Guerin (BCG) vaccine, as a proxy for live births as previously recommended, (22) to calculate the MMR for the two regions in 2018.

Study setting

The study was conducted in Lindi and Mtwara regions of Southern Tanzania with a total population of about 2 million (23). The two regions have two regional referral hospitals, 12 district hospitals, three private/mission hospitals, 40 health centres and 399 dispensaries. The MMR in Lindi and Mtwara was 456 and 579 per 100,000 live births in 2013 (24). The fertility rate is one of the lowest (3.8) in Tanzania. Most women deliver in facilities, 80.8% and 81.3% in Lindi and Mtwara, respectively. Caesarean section rate is 6.0% in Lindi and 10.3% in Mtwara (5).
The MDSR system in Tanzania and categorization of cause of death

Each health facility that provides delivery services in Tanzania has a standard MDSR committee as stipulated in the guideline (21). In regional and district hospitals, where most deaths occur, MDSR committee is composed of a multidisciplinary team of clinical and non-clinical staff such as obstetrician (if available), medical doctors, clinical officers, nurses and midwives from maternity ward, facility management, laboratory personnel and other supporting staff. The committee meets within seven days after a suspected maternal death has occurred. Before the meeting, a designated person prepares a narrative summary using information from medical files, interviews of health care providers and relatives who cared for the patient. There is no clear guide on how and which relatives should be interviewed. During the meeting the summary is presented and discussed and when necessary more information is obtained from medical files or health care providers who cared for the patient. Findings from the meeting are summarised in a maternal death reporting form which includes demographic characteristics, medical information, underlying medical cause of deaths, description of contributing non-medical factors along the three phases of delays and a plan of action (21). The MDSR guideline recommends the underlying medical cause of death to be categorized following ICD 10 rules but the training and the guideline does not provide a formal training on this. The reporting form in MDSR guideline has a short list of example of causes and ICD 10 codes to be used during reporting. (See Annex 1)

Outcomes

Our main outcome was the underlying medical cause of death defined as disease condition that started chain of events that led to death e.g. Postpartum Haemorrhage (PPH) (11). Underlying causes of deaths are grouped into nine groups that are mutually exclusive,
totally inclusive and descriptive of all underlying causes of maternal deaths (Box 1)

| Type                          | Group number and name                                                                 |
|-------------------------------|---------------------------------------------------------------------------------------|
| Direct maternal deaths        | 1. Pregnancy with abortive outcome                                                     |
|                               | 2. Hypertensive disorders in pregnancy, childbirth and the puerperium                  |
|                               | 3. Obstetric Haemorrhage                                                              |
|                               | 4. Pregnancy related infection                                                         |
|                               | 5. Other obstetric complications                                                       |
|                               | 6. Unanticipated complications of management                                           |
| Indirect maternal deaths      | 7. Non-obstetric complications                                                         |
| Unspecified                   | 8. Unknown/undetermined                                                                |
| Death during pregnancy birth and puerperium | 9. Coincidental causes                                                               |

Box 1: ICD MM groups of causes

As stipulated in Tanzania MDSR guideline, delays in health seeking or provision of care deemed to have contributed to the maternal deaths were grouped using the three delays model, stipulating delays 1) to deciding to seek care 2) to reach care including transport and 3) to receive appropriate care in facilities (21). Several delays may have contributed to a death. Phase one delays are delays at household and personal level that lead to late or lack of seeking care. It includes the time from onset of disease at home until decision to seek care is made by the patient, family or both. Phase two delays are concerned with access to health care such as availability of health facility, roads and transport issues, and constitute time from when decision to seek care is made until arrival at a proper health facility. Phase three delays occurred in health facilities and are more concerned with time, equipment and supplies, structure, management errors, human resource and referral system, and constitutes time until adequate treatment or care begins.

Data sources and measurements

Data collection followed three steps: i) abstracting information from MDSR documents ii) performing VA, and iii) the independent obstetrician panel review.

The first author AS, in close collaboration with regional Reproductive and Child Health Coordinators, abstracted information using a pre-defined checklist from maternal deaths narrative summaries, death review report forms and district monthly death report
summaries (date of death, age, facility, village and cause of death).
The field team (AS and VA interviewers) then traced families using demographic information such as names of the deceased, place of death, district and date of death, home address, name of village/street leader, name of husband/partner and other information, for VA interviews.

VA interviews were conducted using the translated standard questionnaire provided by WHO (25). The questionnaire was piloted and the translation were reviewed and corrected accordingly. In addition to the standard inquiries, questions relating to the three phases of delays were added.

The field team commenced the process of finding families for VA interview by visiting and enquiring at facility where death occurred or where the deceased attended her antenatal clinic. They were then taken to the family through local government leaders. At the family`s home, after being introduced they explained in detail the purpose of VA. Then one of the interviewers identified person (s) that was (were) present during illness and death and conducted VA with them.

Using the VA questionnaire as well as copies of available medical files a group of experts, consisting of two experienced obstetricians in MDSR from Muhimbili University of Health and Allied Sciences and one from Mtwara regional hospital reviewed all maternal deaths. The author, AS, was among the panel members and had previously been trained on ICD-MM. The panel members neither conducted the VA interviews nor documented any information used by the reviews.

First, the expert panel went through VA questionnaire and determined the underlying cause from the information by consensus. Second, the panel went through the medical files and reviewed all available information. Based on these two sources, the panel determined the i) underlying cause of death including the ICD coding, ii) contributing
medical causes and iii) three phases of delays by consensus (11).

Quantitative variables

Data were processed using MS Excel and then transferred to SPSS computer program version 25. Proportions of each underlying medical cause categorized by MDSR system and the expert panel of obstetricians were computed. The underlying medical cause and differences between the routine MDSR system and obstetricians panel were tabulated. As the routine MDSR system used a shortlist of ICD codes while the expert panel used the full number of ICD-MM the comparison had to use a pragmatic approach. For example, when the obstetrician panel categorized a death to be caused by PPH due to atony, coagulopathy or retained placenta, then this was considered to be in agreement if MDSR system categorized the same death as PPH (Non traumatic). Also PPH (Traumatic) for MDSR system was decided to be in agreement if obstetrician panel categorized the same case as PPH (vaginal tear, cervical tear, uterine tear during caesarean section excluding uterine rupture).

Statistical methods

Cohen`s K statistic was used to determine level of agreement in categorizing the underlying causes. We defined < 0 as no agreement, 0-0.2 as slight agreement, 0.21-0.4 as fair, 0.41-0.6 as moderate, 0.61-0.8 as substantial and 0.81-1 as almost perfect agreement (26). Agreement between the obstetricians` panel and the MDSR system on the three delays was calculated by determining percentage difference between the two groups.

Results

In the year 2018, a total of 132 maternal deaths were reported in the study regions. According to District Health Information System, the total number of children that
received BCG vaccine (as a proxy for live-births) for that year in the two regions was 96,265. Thus according to the MDSR system, the MMR was 137 per 100,000 live births.

Our analysis included 109 deaths (Fig. 1). VA was performed for 106 deaths (92.9%) and medical files were provided from 91 deaths (83.5%). Piloting of the approach was done based on seven maternal deaths which were later excluded from this analysis. Of the 132 deaths, 10 were community deaths and no clinical record was available. The recording of one death was so minimal that no information to trace the family was available. Two facility deaths were identified during the visits to the community. Furthermore one more death was reported by the district health office but not reported by the routine MDSR system. (Fig. 1)

More the half (59.6%) of women who died were 30 years and above, 58.7% had primary education, 69.7% were married/living with partner and 63.3% were peasants. Most of women were sick for less than a day (47.7%) and died within 24 hours of delivery (51.4%). More than three quarters died in the postpartum period, more than half (70.6%) had a live birth before death and 60.2% were delivered by caesarean section. (Table 1)

Table 1: Demographic and medical characteristics of the Maternal Deaths (N=109)
### Demographic and medical characteristics

|                                | Frequency   | Percent |
|--------------------------------|-------------|---------|
| **Age groups**                 |             |         |
| < 20                           | 10          | 9.2     |
| 20-29                          | 34          | 31.2    |
| 30-39                          | 54          | 49.5    |
| 40 and above                   | 11          | 10.1    |
| **Education level***           |             |         |
| No formal education            | 23          | 21.1    |
| Primary education              | 64          | 58.7    |
| Secondary education            | 15          | 13.8    |
| Higher education               | 4           | 3.7     |
| **Occupation***                |             |         |
| Unemployed                     | 3           | 2.8     |
| Employed                       | 7           | 6.4     |
| House wife                     | 15          | 13.8    |
| Self employed                  | 4           | 3.7     |
| Petty trader                   | 9           | 8.3     |
| Peasant                        | 69          | 63.3    |
| **Marital Status***            |             |         |
| Single/Divorced                | 31          | 28.4    |
| Married/cohabiting             | 76          | 69.7    |
| **Duration of sickness before death (days)*** |   |         |
| <1 day                         | 52          | 47.7    |
| 1-7                            | 41          | 37.6    |
| 8-14                           | 10          | 9.2     |
| >14                            | 3           | 2.8     |
| **Place of delivery /abortion*** |         |         |
| Hospital                       | 74          | 67.9    |
| Health centre                  | 14          | 12.8    |
| Dispensary                     | 2           | 1.8     |
| Home                           | 5           | 4.6     |
| On the way to facility         | 2           | 1.8     |
| **Place of death**             |             |         |
| Hospital                       | 95          | 87.2    |
| Health Centre                  | 8           | 7.3     |
| Dispensary                     | 2           | 1.8     |
| On the way during referral     | 4           | 3.7     |
| **Timing of death**            |             |         |
| Antepartum                     | 10          | 9.2     |
| Intrapartum                    | 9           | 8.3     |
| Postpartum                     | 90          | 82.6    |
| **Died within 24hrs of delivery/abortion*** |   |         |
| Yes                            | 56          | 51.4    |
| No                             | 34          | 31.2    |
| **Delivered live baby*****     |             |         |
| Yes                            | 65          | 70.6    |
| No                             | 27          | 29.4    |
| **Mode of delivery***          |             |         |
| Spontaneous Vaginal Delivery   | 36          | 39.2    |
| Caesarean Section              | 56          | 60.2    |

*3 Maternal Deaths had no information available and VA was not done.

**12 died with baby in uterus and baby never delivered and 5 abortion/ectopic

PPH (traumatic and non-traumatic) was the most common cause of death categorized by both groups. Obstetrician panel and MDSR system categorized the same underlying causes for 64.6% (64/99) of maternal deaths that were compared (K statistic was 0.60, moderate agreement). (Table 2)

Table 2: Categorization of underlying medical causes and ICD codes by obstetrician experts and MDSR system (N=99)
| Underlying medical cause of death | Obstetricians | Obstetricians ICD codes | MDSR | Both |
|----------------------------------|--------------|-------------------------|------|------|
| Eclampsia                        | 19           | O15.0, O15.1, O15.2     | 15   | 14   |
| PPH (non-traumatic)              | 18           | O72.0, O72.1, O72.3     | 15   | 12   |
| PPH(traumatic)                   | 8            | O71.3, O71.4, O71.8, O71.9 | 11   | 6    |
| PPH                             | 6            | O72                      | 8    | 5    |
| High Spinal anaesthesia         | 7            | O74.2                     | 6    | 5    |
| Puerperal Sepsis                | 6            | O85                      | 7    | 5    |
| Ruptured uterus                 | 7            | O71.1                     | 2    | 1    |
| Unsafe abortion                 | 3            | O05.0                     | 2    | 2    |
| Severe Anaemia                  | 3            | O99.0                     | 4    | 3    |
| Peripartum Cardiomyopathy       | 4            | O90.3                     | 2    | 2    |
| Ectopic Pregnancy               | 2            | O00                      | 2    | 2    |
| Obstetric embolism              | 2            | O88                      | 3    | 1    |
| Severe Preeclampsia             | 2            | O14.1                     | 1    | 1    |
| Burn Wounds                     | 1            | J22                      | 1    | 1    |
| Heart Disease                   | 1            | I05.9                     | 1    | 1    |
| Septic abortion                 | 1            | O03.0                     | 1    | 1    |
| Severe Pneumonia                | 1            | J15.8                     | 1    | 1    |
| Pneumocystic Carnii Pneumonia   | 1            | B20.6                     | 1    | 1    |
| Obstructed labour               | 0            | O65                      | 4    | 0    |
| Others                          | 7            | O71.5, B45.1, B50.8, O45.0, O03.1 | 12   | 0    |
| **Total**                       | **99**       | **99**                   | **64** | **64** |

Others Obstetricians: (Bladder Injury, Meningitis, Severe malaria, Undetermined, Abruptio placenta, Incomplete abortion)

Others MDSR (Brain hypoxia, haemorrhagic shock, Congestive cardiac failure, HELLP syndrome, Intracerebral haemorrhage and postural hypotension)

Fifteen deaths caused by hypertensive disorders in pregnancy childbirth and puerperium were categorized in this group by both obstetrician experts and MDSR system. The MDSR system categorized two of these deaths in group 3 (obstetric Haemorrhage), two in group 4 (pregnancy-related infection), one in group 5(other obstetric complications) and one group7 (non-obstetric complications). Overall, out of 99 deaths that were compared, 80 (80.8%) were in the same ICD-MM group. (Table 3)

Table 3: The level of agreement of the ICD MM groups between obstetrician experts and MDSR system (N=99)
**ICD MM GROUPs FROM MDSR SYSTEM**

| ICD MM GROUPs FROM EXPERTS | 1. Pregnancy with abortive outcome | 2. Hypertensive disorders in pregnancy | 3. Obstetric Haemorrhage | 4. Pregnancy related infection | 5. Other Obstetric complications | 6. Unanticipated Complications Management | 7. Non obstetric complications | 8. Unknown/undetermined | 9. Coincidental causes |
|----------------------------|-----------------------------------|--------------------------------------|--------------------------|--------------------------------|--------------------------------|---------------------------------|--------------------------|------------------------|----------------------|
| 1. Pregnancy with abortive outcome | 6 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2. Hypertensive disorders in pregnancy | 0 | 15 | 2 | 2 | 1 | 0 | 1 | 0 | 0 |
| 3. Obstetric Haemorrhage | 1 | 1 | 35 | 0 | 2 | 0 | 0 | 0 | 0 |
| 4. Pregnancy related infection | 0 | 0 | 0 | 5 | 1 | 0 | 0 | 0 | 0 |
| 5. Other Obstetric complications | 0 | 0 | 0 | 0 | 1 | 6 | 0 | 1 | 0 |
| 6. Unanticipated Complications of Management | 0 | 0 | 0 | 0 | 0 | 5 | 1 | 1 | 0 |
| 7. Non obstetric complications | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 0 |
| 8. Unknown/undetermined | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 |
| 9. Coincidental causes | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

K statistic value 0.76 with P value 0.000

The obstetrician panel identified more delays in all three categories than the MDSR committees. The MDSR committees indicated phase-three delays in 78 (92.9%) and the obstetricians panel in 101 (100%) of maternal deaths respectively. There was high agreement in identification of phase-three delays (92.4%) while we observed differences in specifying a phase-two delay (Table 4).

Table 4: Comparison of identification of three delays to maternal deaths between obstetrician experts and MDSR system

| Phases of delays   | Obstetricians (N=109) | MDSR systems (N=84)** | Agreement (%) |
|--------------------|-----------------------|-----------------------|---------------|
|                    | Frequency (%)         | Frequency (%)         |               |
| Phase one delay    | 74(67.9)              | 42(50.0)              | 32(38.1)      |
| Phase two delay    | 24(22.0)              | 10(11.9)              | 4(4.8)        |
| Phase three delay* | 101(100)              | 78(92.9)              | 73(92.4)      |
*Obstetrician experts could not identify delays for 8 maternal deaths in health facility because there were no medical files and VA had no information on third delays

**Missing information of the delays identified in MDSR system for 25 maternal deaths

“Delays in decision-making” was the predominant phase-one delay according to the obstetrician panel (77.0%) and MDSR committee (54.8%). In phase two delays, MDSR committees identified more (60.0%) “delayed arrival to health facility” than obstetricians (41.7%). The obstetricians indicated that 93.1% of maternal deaths had human errors and mismanagement compared to 67.9% by MDSR committees. (Table 5)

Table 5: Comparison of identified delays to maternal deaths between obstetrician experts and MDSR system

| Delay                                      | Obstetricians Frequency (%) | MDSR system Frequency (%) |
|--------------------------------------------|-----------------------------|---------------------------|
| **Phase one delays**                       |                             |                           |
| Delay in decision making                   | N=74                        | N=42                      |
| Delayed referral from home                 | 57 (77.0)                   | 23 (54.8)                 |
| Failure to recognize problem              | 25 (33.8)                   | 16 (38.1)                 |
| Unwillingness to seek care                | 15 (20.3)                   | 6 (14.3)                  |
| Traditional practices                      | 4 (5.4)                     | 4 (9.5)                   |
| Poverty                                    | 2 (2.7)                     | 1 (2.4)                   |
| Delay in starting antenatal care          | 17 (23.0)                   | 10 (23.8)                 |
| **Phase two delays**                       | N=24                        | N=10                      |
| Delayed arrival to health facility        | 10 (41.7)                   | 6 (60.0)                  |
| Lack of money for transport               | 10 (41.7)                   | 2 (20.0)                  |
| Lack of transport from home               | 10 (41.7)                   | 1 (10.0)                  |
| No facility within reasonable distance    | 4 (16.7)                    | 1 (10.0)                  |
| Bad roads                                  | 2 (8.3)                     | 0 (0.0)                   |
| **Phase three delays**                     | N=101                       | N=78                      |
| Human error or mismanagement              | 94 (93.1)                   | 53 (67.9)                 |
| Delayed management after admission        | 77 (76.2)                   | 30 (38.5)                 |
| Inadequate skills of the provider         | 64 (63.4)                   | 44 (56.4)                 |
| Delayed arrival from referring facility   | 44 (43.6)                   | 21 (26.9)                 |
| Suboptimal antenatal care                 | 37 (36.6)                   | 26 (33.3)                 |
| Lack of supplies and equipment            | 10 (9.9)                    | 34 (43.6)                 |

Discussion

Main findings

In this study we assessed the reliability of the MDSR system in Tanzania by comparing it’s categorization of underlying causes of maternal deaths and care delays with those assigned by an independent expert panel of obstetricians. The two groups assigned the same underlying medical cause for 64.6% of deaths. The agreement was higher (81%) when ICD-MM groups were compared. The expert panel identified phase-one delays in
68%, phase-two in 22% and phase-three in 100% of the deaths while MDSR system identified delays in 50%, 12% and 93%, respectively. The expert panel found that human errors in management had occurred in 93% of deaths while the MDSR system reported errors in 68% of deaths. The MMR in the two regions was estimated at 137 per 100,000 live births.

Assigning underlying cause and Group of causes

Both, the obstetricians` panel and the MDSR system assigned PPH as the most common underlying cause of death. Overall there was high agreement in categorizing the underlying cause of death and the ICD-MM group of causes with high K statistic of 0.76. This high agreement is in contrast with other studies that have shown significant differences when researcher assigned causes of death compared to health care providers (18-20, 27). The high agreement in this study could be due to the fact that the MDSR committees were trained to use an ICD 10 shortlist in the guideline.

Even though most deaths were categorized in the same causes, the routine the MDSR system still reported some contributing causes such as hypoxia, intracerebral hemorrhage, and hemorrhagic shock as underlying causes. This also has been observed in other studies where providers indicated the contributing or immediate causes as the underlying causes, so for example in Malawi (19). The findings from our study and others highlight the importance of training providers of the definition of underlying cause of death. The provision of a shortlist, as available in Tanzania MDSR guideline may assure quality.

Identifying the three delays

The obstetrician expert panel identified more delays in phase one (68%) and phase three delays (100%) compared to the MDSR system. It is of note that the MDSR system indicated no phase-three delays (provider factors) during review of six maternal deaths while the
obstetrician panel identified phase-three delays in all deaths. It was not clear whether the MDSR system could not identify the delays or there was an effort to shift blame to the deceased. The culture of blame to health care providers or relatives is one of the major obstacles in maternal death reviews (28, 29). The obstetrician panel indicated phase-three delays in form of errors in management, substandard decision-making, mismanagement and poor skills in performing medical procedures. These might have led to complications and ultimately death. In contrast, the routine MDSR system was less able to indicate such cases. In most cases MDSR members did not report errors in management that led to death. Other studies have proposed that most maternal deaths occur due to delays in medical care while delays in seeking care are becoming comparably less important (27, 30-33). Since Tanzania is seeing increased facility utilization and facility delivery by pregnant women (5) it is imperative for health care providers to identify substandard care that can be addressed to save lives.

Maternal death data

The two regions reported a total of 132 (122 from facility and 10 from community) maternal deaths for the year 2018. This corresponds to a MMR of 137 per 100,000 live births which falls short of most recent national estimates of 524/100,000 (4). It points to under-reporting of maternal deaths most likely due to missed deaths in the community. Underreporting of deaths was also revealed during the field activities as we identified three more facility deaths that were not reported to higher levels of the health system. Furthermore, four of the deaths had no records in facilities where they were reported to have originated and had not been reviewed. This shows existing inconsistencies in identification, notification and reporting of maternal deaths in facilities. Studies from other low and middle income countries report similar problems of incomplete or late notification of maternal deaths (34, 35).
Strength and Limitations

The main strength of this study is the use of an expert panel consisting of experienced obstetricians that have knowledge of both ICD-MM and MDSR. All three obstetricians received explicit training and have taken part in MDSR in their home institutions. The study used data previously documented, thus the committees did not have a prior knowledge of the study which removed a social desirability bias if data collection would have been done prospectively. The fact that the expert panel used both VA and medical files ensured that they have enough information to identify the underlying cause and the delays. It is to note, that this study is among the first that also compared the analysis of the circumstances of death using the three-delay model. Most other studies have compared only the underlying and contributing medical causes.

The main limitation of the study is the fact that there were multiple MDSR committees that reviewed the deaths. This could pose a problem for Cohen`s K statistic which is recommended for comparing two raters. But each death was reviewed by one MDSR committee and one panel, so it is still a two-way comparison for each case. Also, the nature of the study led to missing of some data due to lost documentation, but the VA helped in filling information gap in these cases.

Another limitation is that only facility deaths were included. While community deaths ought to be reported, the MDSR system is not clear on how these deaths are to be reviewed. In addition, there are no summaries, review information or any other information on circumstances available which we would have been needed to include these deaths in our study. It is important to note that the distribution of causes of deaths thus comes thus from a facility population which is not representative of the total population.
Conclusion

The MDSR committees performed reasonably well in assigning the underlying cause of deaths according to ICD-MM in contrast to what other studies have indicated. The obstetrician panel found more delays to care than what was reported in the MDSR system indicating the difficulties within MDSR teams to critically review maternal deaths. The MDSR committee members should have training and support in identifying sub-standards of care for improvement during death reviews.

List Of Abbreviations

| Abbreviation | Description |
|--------------|-------------|
| ICD-MM       | International Classification of Disease on death during pregnancy childbirth and puerperium |
| MDSR         | Maternal death Surveillance and Response |
| MMR          | Maternal Mortality Ratio |
| PPH          | Postpartum Hemorrhage |
| VA           | Verbal Autopsy |
| WHO          | World Health Organization |

Declarations

**Ethical clearance and consent to participate**

Ethical clearance was obtained from Muhimbili University of Health and Allied Sciences ethical board. Permissions were obtained from Ministry of Health Community Development Gender Elderly and Children, President’s Office Regional Administration and Local Government, Regional Medical Officers, District Medical Officers and facility In-charges. Interviews were conducted in a calm place with enough audio secrecy and it was tape recorded with the respondents’ consent. A verbal and written consent was signed by respondents before VA interview. The respondents were assured they can stop and drop out anytime during interview. During the interview some respondents became emotional and started crying. The interviewers were explained to understand and let respondent grieve without interference since they were not trained on psychological support. The interview was halted until the respondent stopped the emotional response and was then asked if they wanted to continue with the interview. All agreed to continue.
Consent for publication

Not applicable.

Availability of data and materials

Datasets used and/or analysed during the current study are available from the first author on request.

Competing interests

The authors declare that they have no competing interests.

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Authors` contribution

All authors were involved during the planning of this study. AS did all field activities, data entry, management and analysis with close supervision of CH, SM and ABP. CH and MM helped with guidance of analysis of data, and were involved in all stages of the study. AS prepared the first draft. All authors read and approved the final manuscript.

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Authors` information

Ali Said (ali.saidi@kbh.uu.se, saidialli2011@gmail.com)

Department of Women’s and Children’s Health, Uppsala University, Uppsala Sweden

Muhimbili University of Health and Allied Sciences, Dares Salaam, Tanzania
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Annex 1

Annex 1: MDSR Maternal death reporting form
This is the form used to report maternal death information in the MDSR system after review.

| 1. Name of Reporting Health Facility | 2. Facility unique ID number (YYYY/Number) | 3. Address of the deceased Ward Division District Region |
|-------------------------------------|-----------------------------------------|---------------------------------|
|                                      |                                         |                                 |

Deceased Information

| 4. Date of Death (DD/MM/YYYY) | 5. Age at death: __ Years | 6. Gravidity ______ |
|------------------------------|---------------------------|---------------------|
7. Parity ________  
8. Marital status *(circle what applies. Only one response allowed)*
   1. Married
   2. Single
   3. Widowed
   4. Cohabiting
   5. Separated
   6. Divorced

9. Level of education *(circle what applies)*
   1. None
   2. Primary
   3. Secondary
   4. Higher education
   5. Unknown

10. Occupation ________________  
11. Admission at the health facility
    Date (DD/MM/YY) ____________
    Time ____________

Antenatal Care (ANC)

12. Attended ANC?  
   1. Yes  
   2. No  
   3. Not known

13. Where was the ANC done?  
   1. Dispensary
   2. Health centre
   3. Hospital
   4. Other (specify) ________
   5. Had not attended yet

14. Number of ANC visits  
   Not applicable (Had not attended yet)

15. Basic package of services provided on ANC *(Circle what applies)*
   1. Syphilis screening
   2. Hgb.
   3. HIV status
   4. Blood group
   5. BP measurement during the follow up
   6. Urinalysis
      1. Yes  
      2. No  
      3. Unknown
| 1. Fe/FoL supplementation | 1. Yes 2. No 3. Unknown |
|---------------------------|-------------------------|
| 2. TT immunization        | 1. Yes 2. No 3. Unknown |
| 16. Diagnosis on admission (circle what is appropriate) | |
| 1. Normal labour | 10. Ectopic pregnancy |
| 2. Eclampsia | 11. Previous C/S scar |
| 3. Hypertensive disorders without eclampsia | |
| 4. Nursing mother | 12. Violence |
| 5. HIV/AIDS | 13. Obstructed labour |
| 6. Antepartum haemorrhage | 14. Severe malaria |
| 7. Postpartum haemorrhage | 15. Ruptured uterus |
| 8. Incomplete abortion | 16. Anaemia |
| 9. Sepsis | 17. IUFD |
| 17. Name and Place of Delivery-abortion (circle what applies) | |
| 1. Hospital | 5. Delivery before arrival |
| 2. Health centre | 6. Home |
| 3. Dispensary | 7. Not applicable (in case of undelivered) |
| 4. Maternity home | |
| 18. Date of death (DD/MM/YYYY) | 18 b. Place of Death (circle what applies) |
| _______________ | 1. at home |
| 2. at dispensary | 4. at Hospital |
| 3. at health centre | 5. on transit to facility |
| 19. Duration from onset of complication to time of death | 6. Other specify |
| _______________ | 20. When did death occur |
| ____________ (hours/days) | 1. Before |
21. Timing in relation to pregnancy

|   |   |
|---|---|
| 1 | Antepartum |
| 2 | Intrapartum |

### Delivery and related information

#### 22. Mode of delivery

|   |   |
|---|---|
| 1 | Spontaneous vertex delivery |
| 2 | Emergency C/S |
| 3 | Elective C/S |
| 4 | Vacuum extraction |
| 5 | Breech delivery |
| 6 | Laparotomy/Hysterotomy |
| 7 | Other ___________________ |
| 8 | Not applicable (had not delivered) |

#### 23. Delivery attendant

|   |   |
|---|---|
| 1 | Nurse/midwife |
| 2 | Medical Officer |
| 3 | Obstetrician |
| 4 | AMO |
| 5 | Clinical officer |
| 6 | Assistant Clinical officer |
| 7 | Traditional birth attendant |
| 8 | Other ____________ |
| 9 | Not applicable (had not delivered) |

#### 24. In case of caesarean section/laparotomy/Hysterotomy (fill in or circle what applies)

|   |   |
|---|---|
| 1 | Indication of surgery ________________________________ |
| 2 | Duration of surgery: a. one hour or less b. More than one hr |
| 3 | Type of anaesthesia used: a. General b. Spinal c. Not recorded |
| 4 | Time from decision to performing surgery…….hrs ……..mins |
| 5 | Not a C-section/laparotomy |

#### 25 Pregnancy

|   |   |
|---|---|
| 1 | Live baby |
| 2 | Fresh still birth |

---
| Outcome (circle what applies) | 3. Macerated stillbirth | 4. Ectopic |
|------------------------------|------------------------|-----------|
|                              | 5. Abortion            |           |

26. Was a post mortem done?  
1 = Yes  
2 = No  

What was the diagnosis?

---

**Cause of death**

| Direct cause (Circle what applies. Only one choice allowed) |
|-------------------------------------------------------------|
| 00 Ectopic pregnancy |
| 014.1 Severe pre eclampsia |
| 015 Eclampsia |
| 085 Puerperal sepsis |
| 064 Obstructed labour-Malposition/Malpresentation |
| 065 Obstructed labour-Maternal pelvic abnormality |
| 066 Obstructed labour-Other causes |
| 044.1 Placenta praevia |
| 045.0 Abruptio placentae |
| 071 PPH- Trauma |
| 072 PPH- Non traumatic |
| 008 Abortion |
| 074 Anaesthetic complication |
| 088 Embolism |

| Indirect cause |
|----------------|
| 099.0 Anaemia |
| 098.6 Malaria |
| 098.7 HIV and AIDS |
| 093.3 Cardiomyopathy |
| T65 Herbal intoxication |
29. Other causes

| Code | Description                                      |
|------|--------------------------------------------------|
| O95  | Unspecified or unknown cause of death            |

30. Underlying medical conditions that could have contributed to the death

| Description                                                                 |
|-----------------------------------------------------------------------------|
| [Blank]                                                                     |

31. Contributory factors and non-medical causes of death (Tick all that apply)

**Delay 1**
- Traditional practices
- Family poverty
- Failure of recognition of the problem
- Delay in starting antenatal care

**Delay 2**
- Delayed arrival to referred facility
- Lack of money for transport

**Delay 3**
- Sub optimal antenatal care
- Delayed arrival to next facility from another facility on referral
- Delayed or lacking supplies and equipment (specify) ________________
- Delayed management after admission
- Human error or mismanagement (specify) ________________
- Inadequate skills of provider (specify) ________________

**Others**

(specify)
32. Could this death have been avoided?

| Yes | No |
|-----|----|

Comment

33. List the avoidable factors, missed opportunities or substandard care – why did this happen?

34. Summarize the case

Figures
132 total maternal deaths
- 119 facility deaths reported
- 3 facility deaths identified in the field
- 10 community deaths reported

Excluded maternal death
10 community deaths
7 deaths done in pilot study
1 death No information for tracing

114 facility deaths planned for VA

8 deaths VA not done
- 4 death due to lack of demographic information
- 4 could be traced even in the facility

106 deaths VA done
91 death medical files available
88 deaths have both file and VA done
18 deaths have no file but VA done
3 deaths no VA done but file available
109 total deaths included in analysis with files or VA or both

Figure 1
Flow chart of maternal deaths included in the study