Maternal mortality: near-miss events in middle-income countries, a systematic review

Anke Heitkamp, Anne Meulenbroek, Jos van Roosmalen, Stefan Gebhardt, Linda Vollmer, Johanna I de Vries, Gerhard Theron & Thomas van den Akker

Objectives To describe the incidence and main causes of maternal near-miss events in middle-income countries using the World Health Organization’s (WHO) maternal near-miss tool and to evaluate its applicability in these settings.

Methods We did a systematic review of studies on maternal near misses in middle-income countries published over 2009–2020. We extracted data on number of live births, number of maternal near misses, major causes of maternal near miss and most frequent organ dysfunction. We extracted, or calculated, the maternal near-miss ratio, maternal mortality ratio and mortality index. We also noted descriptions of researchers’ experiences and modifications of the WHO tool for local use.

Findings We included 69 studies from 26 countries (12 lower-middle- and 14 upper-middle-income countries). Studies reported a total of 50,552 maternal near misses out of 10,450,482 live births. Median number of cases of maternal near miss per 1000 live births was 15.9 (interquartile range, IQR: 8.9–34.7) in lower-middle- and 7.8 (IQR: 5.0–9.6) in upper-middle-income countries, with considerable variation between and within countries. The most frequent causes of near miss were obstetric haemorrhage in 19/40 studies in lower-middle-income countries and hypertensive disorders in 15/29 studies in upper-middle-income countries. Around half the studies recommended adaptations to the laboratory and management criteria to avoid underestimation of cases of near miss, as well as clearer guidance to avoid different interpretations of the tool.

Conclusion In several countries, adaptations of the WHO near-miss tool to the local context were suggested, possibly hampering international comparisons, but facilitating locally relevant audits to learn lessons.

Abstracts in العربية, 中文, Français, Русский and Español at the end of each article.

Introduction

Women are at risk of developing severe morbidity and mortality during pregnancy, childbirth and postpartum, especially in low-income and middle-income countries where 99% of all maternal deaths occur. Improvement of maternal health is urgently needed and one of the sustainable development goals is to reduce the global maternal mortality ratio to less than 70 per 100,000 live births by 2030.

In addition to maternal mortality, severe maternal morbidity is used as an indicator of quality of maternity care. Measuring and comparing outcomes of severe maternal morbidity studies have been difficult because of the use of different identification criteria. In 2009, the World Health Organization (WHO) developed the maternal near-miss tool to introduce a universal approach to comparing the quality of maternity care between different countries. Maternal near miss is defined by WHO as “a woman who nearly died but survived a complication that occurred during pregnancy, childbirth or within 42 days of termination of pregnancy.” Maternal near miss occurs more that occurred during pregnancy, childbirth or within 42 days of termination of pregnancy.

Several studies, however, have demonstrated difficulties in applying the tool. Box 1 shows the WHO maternal near-miss criteria for determining life-threatening conditions and additional criteria for baseline assessment of quality of care. Among the requirements to meet the various criteria of the tool are: advanced laboratory diagnostic tests; large numbers of units of blood in transfusion as the threshold to identify severe haemorrhage; and intensive clinical monitoring. Some of these requirements cannot easily be met in low-resource settings due to limited diagnostic capacity and reduced options for medical intervention in these settings, which may lead to underestimation of the incidence of maternal near miss. Researchers in sub-Saharan Africa have suggested adaptations of the maternal near-miss tool for use in low-income countries. But even in high-income countries, where sufficient resources should be available, there has been discussion about what the appropriate inclusion criteria for maternal near miss should be. Identification of maternal near miss was found to be compromised by incomplete documentation in the medical records to establish whether maternal near-miss criteria were met.

Reports about the incidence of maternal near miss have been published for several high- and low-income countries, and the applicability of the WHO maternal near-miss tool has been evaluated in several of these. However, data are lacking about maternal near miss in middle-income countries. We therefore made a systematic review of the incidence and main causes of maternal near miss in middle-income countries. We also aimed to evaluate qualitative findings documented by researchers with regard to applicability of the tool and suggest possible adaptations of the WHO maternal near-miss approach for middle-income settings.
Methods

We conducted the review according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guideline, and registered with the International Prospective Register of Systematic Reviews (CRD42021232735).

Study selection

We performed a search of online databases for articles on maternal near miss in middle-income countries published between 1 January 2009 and 12 November 2020 without language restrictions. The earlier date was chosen since 2009 is the year when the WHO maternal near-miss approach was first published. Retrospective studies that used data from before 2009 were included only if they made use of the WHO definition for maternal near miss.

We used the keywords “severe acute maternal morbidity,” “maternal near miss” and “middle income country.” Since PubMed® does not provide medical subject headings terms for country income groups, we first determined which countries were classified as middle-income and inserted each country name as a separate term in the search strategy. The search was last run in November 2020 in the online databases PubMed®, Embase®, Web of Science, Cochrane Library, Emcare and Academic Search Premier. In addition, we searched the following regional databases: Index Medicus for the Eastern Mediterranean Region; Index Medicus for South-East Asia Region, Latin America and the Caribbean; African Index Medicus; IndMED; and Global Health Library. More details of the search strategy are in the data repository.

We included studies that met all four inclusion criteria: (i) articles about maternal near miss as defined by WHO; (ii) data on the incidence of maternal near miss per 1000 live births and the main causes; (iii) describing countries meeting the World Bank classification for middle income; and (iv) reporting the specific criteria used to identify maternal near miss and experiences with applying the WHO maternal near-miss criteria, including possible modifications of the WHO maternal near-miss tool for local use. We included studies containing multiple countries only if outcomes per country could not be found elsewhere. If multiple studies published data on the same country, all of them were reviewed and included. We used the World Bank classifications by gross national income per capita to determine country income groups. As the classification of several countries changed over the search dates, we included studies if countries were middle-income in the year of publication, as classified by the World Bank at that time.

We excluded studies that: (i) did not apply WHO maternal near miss definitions; (ii) only focused on one specific disease or risk factor without providing overall data on maternal near miss; (iii) were comments, abstracts, secondary analysis or surveys of existing studies; (iv) only focused on neonatal outcomes; or (v) only described the process of health care or methods of identifying maternal near miss without providing incidence or most frequent causes, and without providing qualitative findings with regard to applicability and adaptations of the tool.

Two independent researchers screened all citations initially for relevance based on title and abstract and selected studies for inclusion after reading the full-text papers. Disagreements were resolved in a discussion between these two reviewers to reach a consensus. In case no consensus could be reached, the reviewers consulted a third researcher to reach an agreement on inclusion of articles.

Data extraction

We extracted data on the number of live births, number of cases of maternal near miss and number of maternal deaths. Where available, we noted the following indicators: maternal near-miss ratio (number of cases of maternal near miss per 1000 live births), maternal mortality ratio (number of maternal deaths per 100 000 live births), ratio of maternal near miss to maternal death (number of cases of maternal near miss ÷ the number

Box 1. Inclusion criteria in the WHO near-miss approach for maternal health

Life-Threatening conditions (near-miss criteria)

- Cardiovascular dysfunction: shock; cardiac arrest (absence of pulse or heartbeat and loss of consciousness); use of continuous vasoactive drugs; cardiopulmonary resuscitation; severe hypoperfusion (lactate > 5 mmol/L or > 45 mg/dL); severe acidosis (pH < 7.1)
- Respiratory dysfunction: acute cyanosis; gasping; severe tachypnoea (respiratory rate > 40 breaths per minute); severe bradyneopha (respiratory rate < 6 breaths per minute); intubation and ventilation not related to anaesthesia; severe hyperoxaemia (oxygen saturation < 90% for ≥ 60 minutes or PaO2/FiO2 < 200)
- Renal dysfunction: oliguria non-responsive to fluids or diuretics; dialysis for acute renal failure; severe acute azotaemia (creatinine ≥ 300 μmol/mL or ≥ 3.5 mg/dL)
- Coagulation or haematological dysfunction: failure to form clots; massive transfusion of blood or red cells (≥ 5 units of blood); severe acute thrombocytopenia (< 50,000 platelets/mL)
- Hepatic dysfunction: jaundice in the presence of pre-eclampsia; severe acute hyperbilirubinaemia (bilirubin > 100 μmol/L or > 6.0 mg/dL)
- Neurological dysfunction: prolonged unconsciousness (lasting ≥ 12 hours) or coma (including metabolic coma); stroke; uncontrollable fits or status epilepticus; total paralysis
- Uterine dysfunction: uterine haemorrhage or infection leading to hysterectomy

Severe maternal complications (additional categories for baseline assessment of quality of care)

- Severe postpartum haemorrhage
- Severe pre-eclampsia
- Eclampsia
- Septis or severe systemic infection
- Ruptured uterus
- Severe complications of abortion

Critical interventions or intensive care unit use (additional categories for baseline assessment of quality of care)

- Admission to intensive care unit
- Interventional radiology
- Laparotomy (includes hysterectomy; excludes caesarean section)
- Use of blood products

PaO2/FiO2: ratio of arterial oxygen partial pressure to fractional inspired oxygen; WHO: World Health Organization.
Source: WHO, 2011.
of maternal deaths) and mortality index
[number of maternal deaths + (number of
cases of maternal near miss + number of
maternal deaths) × 100]. If indicators
were missing for any study, we calculated
the values from the available data. We
also extracted data on the most frequent
organ dysfunction and the most frequent
cause of maternal near miss. When
studies included qualitative comments
on the methods of using the WHO ma-
ternal near-miss approach, we noted any
modifications to the WHO tool applied
in the studies and any problems reported
by the study researchers. When articles
described the use of multiple methods to
determine maternal near miss, we only re-
ported data concerning use of the WHO
maternal near-miss tool.

Data analysis
We subdivided the countries for analysis
into lower-middle income and upper-
middle income according to the World
Bank categories. 19, 20 We report the
number of studies and the frequency
of causes of near miss as numbers and
percentages. We calculated the median
values and interquartile range (IQR) of
maternal indicators if the data were
not normally distributed. We performed
statistical analysis using SPSS version
24.0 (IBM Corp., Armonk, United States
of America).

We estimated risk of bias in indi-
vidual studies by quality assessment of
studies. Studies were considered to be
of acceptable quality if: (i) there was a
clear description of the study population
with a minimum of 100 live births over a
period of at least 3 months; (ii) new cases
of maternal near miss were identified in
daily audits or rounds by trained medical
staff; and (iii) the setting was an entire
delivery unit rather than only one intensive
care unit. The two reviewers who selected
the studies did the quality assessment.
We amended the Newcastle–Ottawa
scale 21 for this study by coding the item
Selection of the non-exposed cohort as
not applicable (NA). The maximum
quality score was therefore 8 instead of
the original score 9 in the Newcastle–Ot-
tawa Scale; more details are in the data
repository. 22

Ethical approval
Ethical approvals were obtained from the
Health Research Ethics Committee
(HREC), Faculty of Health Sciences, Stel-
enbosch University, on 3 October 2018
(Project ID: 1427, HREC Reference #: S18/02/023) and from the Provincial
Health Authority, the chief executive of-
cler of Tygerberg Hospital and the heads
of respective departments.

Results
The search resulted in 996 records. After
removal of duplicates, we screened 973
articles based on title and abstract, after
which 138 articles were retrieved for full-
text evaluation. Of these, we excluded 76
articles (39 of which did not apply the
WHO maternal near-miss tool; Fig. 1).
For the final review we included 62
articles. 23–83 Our quality assessment of
the articles showed the following scores:
eight articles with score 4; 15 articles with
score 5; 26 articles with score 6 and 13 ar-
ticles with score 7. No articles described
possible missing data in the follow-up
period which resulted in none of the
articles having a maximum score of 8.

The included articles reported data
from 69 studies in 26 countries (12
lower-middle-income countries and 14
upper-middle-income countries). Two
of the articles 23, 81 presented data on
multiple countries. Of the 69 studies,
40 (58%) were done in lower-middle-
income countries and 29 (42%) in
upper-middle-income countries. Half
(35 studies) of them, were conducted in
one or more tertiary health-care facility.
General descriptions of the studies and
differences in methods are summarized in
Table 1 (available at: https://www.who.
doi: http://dx.doi.org/10.2471/BLT.21.285945
middle-income countries

Systematic reviews
Fig. 1. Flowchart of studies included in the systematic review of maternal near miss in
middle-income countries

Table 1. Differences in methods and quality scores of the articles included in the systematic
review of maternal near miss in middle-income countries

| Study | Quality score | Quality assessment |
|-------|--------------|-------------------|
| Study 1 | 7 | Applied WHO tool |
| Study 2 | 6 | Did not apply WHO tool |
| Study 3 | 5 | Reported use of WHO tool |
| Study 4 | 4 | Did not report use of WHO tool |

Incidence
The incidence and causes of maternal
near miss in middle-income countries are
presented in Table 2. The studies reported
a total of 50 552 maternal near misses out
of the total live births of 10 450 482. Over-
all, the median maternal near-miss ratio in
these middle-income countries was 9.6 per 1000 live births (IQR: 7.0–23.3).
In lower-middle-income countries the
median maternal near-miss ratio was
15.9 per 1000 live births (IQR: 8.9–34.7),
ranging from 4.0 in an Indian govern-
ment tertiary care centre 27 to 198.0 in a
private tertiary care centre in Nigeria. 28
For upper-middle-income countries, the
median maternal near-miss ratio was 7.8
per 1000 live births (IQR: 5.0–9.6), rang-
ing from 2.2 in two Malaysian tertiary
hospitals 23 to 54.8 in Brazil. 24

Studies reported a total of 2917
maternal deaths. The median maternal
mortality ratio for all middle-income
countries was 163 per 100 000 live births
(IQR: 52–367), with a median of 306 per
100 000 live births (IQR: 162–666) in
lower-middle-income countries versus
62 per 100 000 live births (IQR: 9–105)
Table 2. Incidence and causes of maternal near miss in middle-income countries

| Author                     | Setting                                | No. of live births | No. of cases of maternal near miss | Maternal near misses per 1000 live births | Most frequent organ dysfunction | Maternal deaths | Ratio of maternal near miss to maternal death | Mortality index, % |
|----------------------------|----------------------------------------|--------------------|------------------------------------|------------------------------------------|----------------------------------|-----------------|-----------------------------------------------|-------------------|
| **Lower-middle-income countries** |                                        |                    |                                    |                                          |                                  |                 |                                               |                   |
| Ps et al., 2013⁵³           | India                                  | 7 330              | 131                                | 179                                      | NR                               | 23              | 313                                           | 5.6               | 14.9             |
| Tunçalp et al., 2013⁵⁶      | Ghana                                  | 3 206              | 94                                 | 286                                      | Coagulation or haematological dysfunction | 37              | 1 154                                        | 2.5               | 28.2             |
| Kaur et al., 2014⁵⁵         | India                                  | 6 008              | 140                                | 233                                      | NR                               | 16              | 266                                           | 8.8               | 10               |
| Kushwah et al., 2014⁵⁶      | India                                  | 5 219              | 63                                 | 68                                       | NR                               | 47              | 901                                          | 1.3               | 42.9             |
| Luexay et al., 2014⁵⁶       | Lao People’s Democratic Republic        | 1 123              | 11                                 | 98                                       | Respiratory                      | 2               | 179                                           | 5.5               | 15.3             |
| Nacharajuh et al., 2014⁵⁵  | India                                  | 2 385              | 22                                 | 92                                       | NR                               | 3               | 114                                           | 11.0              | 8.3              |
| Pandey et al., 2014⁵⁶       | India                                  | 5 273              | 633                                | 1200                                     | NR                               | 247             | 45                                           | 2.6               | 27.2             |
| Balakhi et al., 2015⁵⁶      | India                                  | 688                | 51                                 | 74.1¹                                   | NR                               | 10              | 1                                            | 5.1               | 16.4             |
| Bashour et al., 2015⁵⁶      | Egypt                                  | 2 641              | 32                                 | 12.1                                     | Coagulation or haematological dysfunction | 3               | 114                                           | 11.0              | 8.6              |
| Mazhar et al., 2015⁵⁶       | Pakistan                               | 12 729             | 94                                 | 70                                       | Cardiovascular                   | 38              | 299                                          | 2.5               | 28.7             |
| Sangeeta et al., 2015⁵⁶     | India                                  | 6 767              | 27                                 | 40                                       | Coagulation or haematological dysfunction | 13              | 188                                          | 3.4               | 22.8             |
| Abha et al., 2016⁵⁶         | India                                  | 13 895             | 211                                | 15.2                                     | Coagulation or haematological dysfunction | 102             | 734                                          | 2.1               | 32.9             |
| Ansari et al., 2016⁵⁶       | Pakistan                               | 1 035              | 76                                 | 73.4¹                                   | Cardiovascular                   | 7               | 676                                          | 10.9              | 8.4              |
| De Muco et al., 2016⁵⁶      | Honduras                               | 613                | 10                                 | 163¹                                    | NR                               | 1               | 163                                          | 10.0              | 9.1¹             |
| De Muco et al., 2016⁵⁶      | Nicaragua                              | 474                | 4                                 | 84¹                                     | NR                               | 0               | 0                                            | 0                 | 0                |
| Kulkarni et al., 2016⁵⁶     | India                                  | 14 508             | 525                                | 362                                      | Coagulation or haematological dysfunction | 7               | 448                                          | 5.6               | 9.6              |
| Oladapo et al., 2016⁵⁶      | Nigeria                                | 91 724             | 1451                               | 15.8                                     | NR                               | Obstetric haemorrhage | 998             | 1 088                              | 2.5               | 40.8             |
| Parmar et al., 2016⁵⁶       | India                                  | 1 929              | 40                                 | 207                                      | NR                               | NR              | 2                                            | 933               | 2.2              | 31.0             |
| Rathod et al., 2016⁵¹       | India                                  | 22 092             | 167                                | 76                                       | Coagulation or haematological dysfunction | 66              | 298                                          | 3.4               | 29.7             |
| Ray et al., 2016⁵³          | India                                  | 4 038              | 218                                | 540                                      | NR                               | Hypertensive disorders | 17              | 421                                          | 13.0              | 7.17             |
| Tanimia et al., 2016⁵⁰      | Papua New Guinea                       | 13 338             | 121                                | 9.1                                      | NR                               | Obstetric haemorrhage | 9               | 67                                             | 13.5              | 6.8              |
| Bolinga et al., 2017⁵⁸      | Papua New Guinea                       | 6 019              | 153                                | 25.4                                     | NR                               | Postpartum haemorrhage | 10              | 166                                          | 15.3              | 6.8              |
| Chandak & Kedar, 2017⁵²     | India                                  | 12 757             | 137                                | 10.7                                     | Cardiovascular                   | Eclampsia | NR                                          | 10.5              | 18.5¹             |
| Mbuchi et al., 2017⁸⁰       | Nigeria                                | 262                | 52                                 | 198.0                                    | NR                               | Hypertensive disorders | 5               | 1 908                                      | 11.4              | 8.8              |

(continues...)
## Maternal near miss in middle-income countries

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| Author | Setting | No. of live births | No. of cases of maternal near miss | Maternal near misses per 1000 live births | Most frequent organ dysfunction | Most frequent cause of maternal near miss | No. of maternal deaths | Maternal deaths per 100 000 live births | Ratio of maternal near miss to maternal death | Mortality index, % |
|--------|---------|--------------------|-----------------------------------|------------------------------------------|----------------------------------|-------------------------------------------|-----------------------|------------------------------------------|---------------------------------------------|------------------|
| Tallapureddy et al., 2017 | India | 3 784 | 32 | 8.3 | Coagulation or haematological dysfunction | Haemorrhage | 6 | 159 | 5.3 | 158 |
| Oppong et al., 2019 | Ghana | 8 433 | 288 | 34.2 | Cardiovascular | Pre-eclampsia and eclampsia | 62 | 735 | 4.6 | 21.7 |
| Panda et al., 2018 | India | 1 349 | 89 | 66.0 | NR | Severe pre-eclampsia | 8 | 593 | 11.1 | 8.2 |
| Reena & Radha, 2018 | India | 3 451 | 32 | 9.3 | Coagulation or haematological dysfunction | Severe pre-eclampsia | 5 | 145 | 6.4 | 13.5 |
| Chaudhuri & Nath, 2019 | India | 4 081 | 175 | 40.0 | Vascular dysfunction | Hypertensive disorder (eclampsia) | 23 | 564 | 7.7 | 115 |
| Chhabra et al., 2019 | India | 38 111 | 261 | 6.9 | Coagulation | Hypertensive disorder | 166 | 436 | 1.6 | 23 |
| El Agwany, 2019 | Egypt | 28 877 | 170 | 5.9 | Coagulation | Haemorrhage | 14 | 50 | 12.2 | 7.5 |
| Gabbur et al., 2019 | India | 6 053 | 100 | 16.4 | NR | Postpartum haemorrhage | 13 | 215 | 7.7 | 88.5 |
| Herklots et al., 2019 | United Republic of Tanzania | 22 011 | 256 | 11.6 | Coagulation or haematological dysfunction | NR | 79 | 359 | 3.2 | 240 |
| Jayaratnam et al., 2019 | Timor-Leste | 4 529 | 39 | 8.0 | NR | Eclampsia or postpartum haemorrhage | 30 | 662 | 1.3 | 430 |
| Mansuri & Mall, 2019 | India | 21 491 | 247 | 11.5 | NR | Eclampsia or pre-eclampsia | 79 | 367 | 3.1 | 242 |
| Karim et al., 2020 | Pakistan | 3 360 | 54 | 16.0 | NR | Adherent placenta | 8 | 238 | 6.8 | 129 |
| Lilungulu et al., 2020 | United Republic of Tanzania | 3 480 | 124 | 36.0 | NR | Haemorrhage | 16 | 460 | 7.8 | 114 |
| Owolabi et al., 2020 | Kenya | 36 162 | 260 | 7.2 | NR | Postpartum haemorrhage | 13 | 36 | 20.0 | 48 |
| Samuels & Ocheke, 2020 | Nigeria | 2 357 | 86 | 36.5 | NR | Hypertensive disorders | 19 | 806 | 4.5 | 81.9 |
| Ugwu et al., 2020 | Nigeria | 2 236 | 60 | 26.8 | Cardiovascular | Severe haemorrhage | 28 | 1251 | 2.1 | 318 |

### Upper-middle-income countries

| Author | Setting | No. of live births | No. of cases of maternal near miss | Maternal near misses per 1000 live births | Most frequent organ dysfunction | Most frequent cause of maternal near miss | No. of maternal deaths | Maternal deaths per 100 000 live births | Ratio of maternal near miss to maternal death | Mortality index, % |
|--------|---------|--------------------|-----------------------------------|------------------------------------------|----------------------------------|-------------------------------------------|-----------------------|------------------------------------------|---------------------------------------------|------------------|
| Cecatti et al., 2011 | Brazil | 14 418 | 194 | 13.5 | NR | NR | 18 | 125 | 10.7 | 8.5 |
| Morse et al., 2011 | Brazil | 1 069 | 10 | 9.4 | NR | Severe pre-eclampsia | 3 | 280 | 3.3 | 23 |
| Lotufo et al., 2012 | Brazil | 9 683 | 43 | 4.4 | NR | Haemorrhage | 5 | 52 | 8.6 | 104 |
| Jabir et al., 2013 | Iraq | 25 472 | 129 | 5.1 | Cardiovascular | Obstetric haemorrhage | 16 | 63 | 9.0 | 110 |
| Shen et al., 2013 | China | 18 104 | 72 | 4.0 | NR | Postpartum haemorrhage | 3 | 16 | 23.0 | 42 |
| Dias et al., 2014 | Brazil | 23 894 | 243 | 10.2 | NR | NR | 7 | 29 | 34.7 | 28 |
| Galvão et al., 2014 | Brazil | 16 243 | 76 | 4.7 | NR | Hypertensive disorders | 17 | 105 | 4.5 | 18 |
| Bashour et al., 2015 | Lebanon | 1 171 | 5 | 4.3 | Hepatic dysfunction | Multiple causes | 0 | 0 | 0 | NR |
| Madeira et al., 2015 | Brazil | 5 841 | 56 | 9.6 | NR | Hypertensive disorders | 10 | 171 | 5.6 | 15.2 |
| Naderi et al., 2015 | Islamic Republic of Iran | 19 908 | 501 | 25.2 | NR | Severe pre-eclampsia | 2 | 10 | 200 | 0.0 |

(Continued...)
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| Author                              | Setting                  | No. of live births | No. of cases of maternal near miss | Maternal near misses per 1000 live births | Most frequent organ dysfunction | Most frequent cause of maternal near miss | No. of maternal deaths | Maternal deaths per 100 000 live births | Ratio of maternal near miss to maternal death | Mortality index, % |
|-------------------------------------|--------------------------|--------------------|------------------------------------|------------------------------------------|-----------------------------------|------------------------------------------|------------------------|----------------------------------------|-----------------------------------------------|------------------|
| Oliveira & Da Costa, 2015          | Brazil                   | 19940              | 255                                | 12.8                                     | NR                               | Hyper tension disorders                  | NR                     | 280                                    | 4.5                                            | 18               |
| Soma-Pillay et al., 2015           | South Africa             | 26614              | 114                                | 4.3                                      | Vascular                         | Obstetric haemorrhage                   | NR                     | 71                                     | 7.1                                            | 14               |
| Cecatti et al., 2016               | Brazil                   | 82 144             | 770                                | 9.37                                     | NR                               | Hyper tension disorders                  | NR                     | 170                                    | 5.5                                            | 15.4             |
| De Mucio et al., 2016              | Colombia                 | 334                | 3                                 | 9.0                                      | NR                               | Hyper tension disorders                  | NR                     | 0                                      | 0                                              | 0                |
| De Mucio et al., 2016              | Dominican Republic       | 133                | 3                                 | 22.6                                     | NR                               | Hyper tension disorders                  | NR                     | 0                                      | 0                                              | 0                |
| De Mucio et al., 2016              | Ecuador                  | 228                | 2                                 | 8.9                                      | NR                               | Severe pre-eclampsia                    | NR                     | 0                                      | 0                                              | 0                |
| De Mucio et al., 2016              | Paraguay                 | 334                | 2                                 | 6.0                                      | NR                               | Severe postpartum haemorrhage            | NR                     | 1                                      | 29.9                                           | 2.0              |
| De Mucio et al., 2016              | Peru                     | 315                | 11                                | 35.0                                     | NR                               | Severe postpartum haemorrhage            | NR                     | 0                                      | 0                                              | 0                |
| Ghazivakili et al., 2016           | Islamic Republic of Iran | 38 663             | 192                                | 5.0                                      | Cardiovascular                    | Coagulation or haematological dysfunction| NR                     | 18                                     | 2.4                                            | 35               |
| Mohammadi et al., 2016             | Islamic Republic of Iran | 12 965             | 82                                | 6.3                                      | NR                               | Severe postpartum haemorrhage            | NR                     | 9                                      | 23.5                                           | 4.1              |
| Norhayati et al., 2016             | Malaysia                 | 21 579             | 47                                | 2.2                                      | NR                               | Severe postpartum haemorrhage            | NR                     | 9                                      | 2.4                                            | 35               |
| Akrawi et al., 2017                | Iraq                     | 17 353             | 142                               | 8.2                                      | Cardiovascular                    | Coagulation or haematological dysfunction| NR                     | 63                                     | 12.9                                           | 72               |
| Iwu et al., 2018                    | South Africa             | 19 222             | 112                               | 5.8                                      | NR                               | Hyper tension disorders                  | NR                     | 68                                     | 8.6                                            | 10.4             |
| Oliveira Neto et al., 2017         | Brazil                   | 8 065              | 60                                | 7.4                                      | Hepatic dysfunction               | Hyper tension disorders                  | NR                     | 62                                    | 13.0                                           | 77               |
| De Lima et al., 2019               | Brazil                   | 1 002              | 55                                | 54.8                                     | Respiratory                       | Hyper tension disorders                  | NR                     | 99                                     | 11.0                                           | 8.3              |
| Mu et al., 2019                     | China                    | 9 051 638          | 37 060                            | 4.1                                      | Coagulation dysfunction            | Hyper tension disorders                  | NR                     | 41                                    | 97.5                                           | NR               |
| Heemelaar et al., 2020             | Namibia                  | 37 106             | 298                               | 8.0                                      | Coagulation or haematological dysfunction| Hyper tension disorders                  | NR                     | 62                                    | 13.0                                           | 92.8             |
| Ma et al., 2020                     | Namibia                  | 542 109            | 3 308                             | 5.9                                      | Coagulation or haematological dysfunction| Hyper tension disorders                  | NR                     | 62                                    | 13.0                                           | 92.8             |
| Verschueren et al., 2020           | Suriname                 | 9 114              | 71                                | 7.8                                      | Coagulation or haematological dysfunction| Hyper tension disorders                  | NR                     | 110                                    | 71                                              | 120              |

NR: not reported.

1 Maternal near miss ratio.

2 Most frequent causes of maternal near miss; terminology as used in the original article.

3 Maternal mortality ratio.

4 Ratio of number of maternal misses to the number of maternal deaths.

5 Mortality index = [number of maternal deaths / (number of cases of maternal near miss + number of maternal deaths) × 100].

6 We calculated the value shown using formulae shown in the main text.

7 Severe maternal outcome.

8 Potentially life-threatening conditions.

9 Per number of births.

10 Severe acute maternal morbidity.

11 Multiple causes: placenta praevia, placenta accreta, placenta increta, placenta percreta, hepatic disease.

12 Number of pregnant women.
in upper-middle-income countries. The median mortality index in middle-income countries was 13.5% (IQR: 8.4–24.0%), ranging from 15.8% (IQR: 9.0–28.5%) for lower-middle-income countries to 10.7% (IQR: 7.3–15.4%) for upper-middle-income countries.

Causes
Hypertensive disorders of pregnancy and obstetric haemorrhage were the commonest causes of maternal near miss. In the lower-middle-income countries, the most frequent cause of near misses was haemorrhage (including reported severe postpartum haemorrhage, obstetric haemorrhage, postpartum haemorrhage, haemorrhage and placenta praevia), reported in 18 out of 40 studies (45%) from 10 countries. Hypertensive disorders of pregnancy (including severe pre-eclampsia and eclampsia) were the cause of near miss in 15 studies (38%) from four countries. In the upper-middle-income countries, hypertensive disorders of pregnancy were the commonest cause of maternal near miss in 15 out of 29 studies (52%) from six countries. Obstetric haemorrhage was reported as the commonest cause in eight studies (29%) from seven countries. In both lower-middle- and upper-middle-income countries, the main identified organ failure was coagulation or haematological dysfunction (which included haemorrhage with a minimum of 5 units of blood for transfusion and a platelet count < 50,000 platelets/mL). Cardiovascular organ dysfunction (shock, cardiac arrest) was the second most common organ failure.

Adaptations
Adaptations to the maternal near-miss tool were suggested in 33 out of 69 (48%) studies. These modifications and difficulties in applying the WHO maternal near-miss tool are described in Table 3. Seven studies recommended reducing the threshold for defining major haemorrhage from 5 units of blood required for transfusion to 4 units, or even 3 units, or even 2 units, to account for limited availability of blood. Other additions to the maternal near-miss tool suggested by researchers were: a definition of shock and sepsis (obstetric and non-obstetric); estimation of blood loss; bedside clotting time; severe anaemia; use of vasoactive drugs; assessing keto-acids in urine; and application of an oxygen face mask. In five studies, researchers recommended inclusion of admission to an intensive care unit as a criterion. Moreover, additional diagnoses to the current six life-threatening conditions criteria were advised, such as: placental abruption; medical and surgical disorders; diabetic keto-acidosis; acute collapse or thromboembolism; and non-pregnancy-related infections.

Some studies reported problems with applying the tool, including under-estimation of maternal near miss by using only criteria based on organ dysfunction; and difficulties with identifying women with near miss because the necessary equipment and facilities were unavailable or due to time pressure in clinical emergencies. Researchers also reported that difficulties with categorization of the WHO maternal near-miss criteria and different interpretations of the tool would make comparisons problematic.

Discussion
The WHO maternal near-miss tool facilitated evaluation of the maternal near-miss ratio in 26 middle-income countries. The main reported causes of maternal near miss were hypertensive disorders in pregnancy and obstetric haemorrhage. The maternal near-miss ratios were considerably higher in lower-middle- than upper-middle-income countries (median: 15.9 versus 7.8 per 1000 live births). This finding is not unexpected due to differences in countries’ resources, but is an important finding about the validity of the maternal near-miss approach. Lower-middle-income countries also had considerably higher maternal mortality ratios and mortality indices than upper-middle-income countries.

The median maternal near-miss ratios per 1000 live births in middle-income countries in our study were higher than those in previous studies of high-income countries (for example, 1.8 in Ireland and 2.0 in Italy) and lower than those in low-income countries (for example, 17.0 in Ethiopia, 8.8 in Somalia and 23.6 in United Republic of Tanzania). These differences might in part be explained by differences in quality of care, reflected by the mortality index, where the higher the index, the more women with life-threatening conditions die. Comparisons of maternal near-miss ratios and sharing lessons learnt from audits in different regions or countries might benefit maternal health worldwide.

Monitoring maternal near misses and maternal deaths showed differences not only among middle-income countries but also across different settings of the same countries. Differences between rich and poor or urban versus rural populations are often large in middle-income countries. Outcomes will differ depending on the quality of care and socioeconomic circumstances in different regions.

Adaptations to the WHO maternal near-miss tool have previously been considered for high- and low-income countries. We found that various adaptations of the WHO tool were also suggested by researchers in middle-income countries, depending on the setting. Adaptation of the tool hampers comparisons across different settings, but may sometimes be necessary to prevent under-reporting of severe morbidity. Several of the included studies recommended reducing the threshold for defining major haemorrhage, or making additions to the WHO criteria. Researchers in our study mentioned the limitations of under-reporting maternal near miss using the current WHO criteria based on organ dysfunction. These limitations, however, have also been reported in both low- and high-income countries. While some studies limited the organ-dysfunction criteria only to life-threatening conditions, other studies added up to six diagnoses of severe maternal complications or critical interventions from the list of WHO criteria in Box 1. Moreover, in the original search, we had to exclude 39 studies applying different criteria that were too far from the original WHO criteria and seven studies whose criteria were unclear.

The issues mentioned above show that the maternal near-miss tool is helpful in recognizing severe morbidity, but may benefit from adaptations to be locally applicable. The major aim of the tool is that lessons for clinical care are drawn. Only including cases of maternal near miss that occur in tertiary level hospitals does not provide a comprehensive picture of maternal near miss in a country. Especially in middle-income countries, differences in quality of care in facilities are large between richer and poorer populations, those living in urban versus rural areas and those using public versus private facilities. The WHO criteria can be seen as a package of minimum criteria that should be in place to provide appropriate care. These minimum criteria...
### Table 3. Difficulties reported and modifications applied to the World Health Organization maternal near-miss tool in middle-income countries

| Author                  | Setting                           | Modifications applied in study                                                                 | Comments and problems reported by study researchers                                                                 |
|-------------------------|-----------------------------------|--------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| **Lower-middle-income countries** |                                   |                                                                                                |                                                                                                                    |
| Kaur et al., 2014        | India, Himachal Pradesh            | Addition of items to clinical criteria (severe pre-eclampsia, eclampsia)<sup>a</sup>            | NA                                                                    |
|                          |                                   | Addition of item to laboratory criteria (sepsis)<sup>b</sup>                                    | Maximum units of blood available in study institute were 3 units as blood bank was not well supplied. Researchers believed that WHO's criterion of receiving 5 or more units of blood was less applicable in a resource-poor institute. |
| Kushwah et al., 2014     | India, Madhya Pradesh              | Addition of item to management criteria (intensive care unit admission)                        | Researchers concluded that maternal near misses could have been underestimated by application of the WHO definition of maternal near miss, which relies on good laboratory and management-based criteria. Adaptation of near-miss criteria for low-resource settings may benefit lower-middle-income countries where health services are also poorly resourced. |
| Luexay et al., 2014      | Lao People’s Democratic Republic   | Simplified modification of WHO tool for use in the community<sup>c</sup>                       | NA                                                                    |
| Pandey et al., 2014      | India                             | Omission of markers from laboratory criteria (pH; PaO2/FiO2)                                     | Researchers concluded that maternal near misses could have been underestimated by application of the WHO definition of maternal near miss, which relies on good laboratory and management-based criteria. Adaptation of near-miss criteria for low-resource settings may benefit lower-middle-income countries where health services are also poorly resourced. |
| Sangeeta et al., 2015    | India                             | Lowering threshold for use of blood products to 2 units of blood                               | NA                                                                    |
| Kulkami et al., 2016     | India, Maharashtra                | Addition of item to clinical criteria (anaemia)<sup>d</sup>                                    | Data collection in accordance with WHO maternal near-miss guidelines, adjusted for local factors, is possible in a busy maternity unit in a resource-poor setting. Researchers concluded that such data have the potential to improve early detection of life-threatening conditions and hence obstetric outcomes. |
| Parmar et al., 2016      | Papua New Guinea                  | Omission of markers from laboratory criteria (pH; lactate; glucose and keto-acids in urine; PaO2/FiO2) | Researchers noted that the WHO classification was remarkable for identifying the most serious cases with higher risk of death. However, the WHO classification showed a high threshold for detection of maternal near miss. Researchers therefore concluded that the method was missing a significant proportion of women with conditions such as pre-eclampsia and eclampsia. Papua New Guinea’s resource-poor setting lacks the capacity to perform some of the WHO-recommended laboratory investigations such as pH and lactate. Researchers noted that use of locally relevant criteria was also important to avoid underestimation of the true burden of maternal near miss as previously reported in other resource-poor settings. |
| Parmar et al., 2016      | India                             | Lowering threshold for use of blood products to 3 units of blood                               | NA                                                                    |
| Bolnga et al., 2017      | Papua New Guinea                  | Addition of criteria (continuous use of vasoactive drugs; intensive care unit admission)       | Researchers concluded that low-resource settings interventions need to be developed with the local context in mind. |
| Panda et al., 2018       | India, Odisha                     | Addition of items to clinical criteria (haemorrhage; hypertensive disorders; abortion; sepsis) | Researchers noted that the WHO classification was remarkable for identifying the most serious cases with higher risk of death. However, the WHO classification showed a high threshold for detection of maternal near miss. Researchers therefore concluded that the method was missing a significant proportion of women with conditions such as pre-eclampsia and eclampsia. Papua New Guinea’s resource-poor setting lacks the capacity to perform some of the WHO-recommended laboratory investigations such as pH and lactate. Researchers noted that use of locally relevant criteria was also important to avoid underestimation of the true burden of maternal near miss as previously reported in other resource-poor settings. |
| El Agwany, 2019          | Egypt                             | NA                                                | Researchers could not apply the criteria due to lack of resources.                                                   |
| Gabbur et al., 2019      | India, Karnataka                  | NA                                                | Researchers concluded that modification of the WHO tool is required as currently it leads to underestimation of maternal near miss. Conclusions about maternal near miss are dependent on the quality of data and challenges to this should be acknowledged. Researchers recommended adhering to the WHO criteria (adjusted to specific settings as needed) to enable meaningful comparison between similar reference populations. Determining a clear diagnosis in a woman with maternal near miss is difficult due to presence of multiple symptoms, lack of diagnostics due to fast deterioration of the woman and lack of laboratory-based markers. Researchers concluded that maternal near-miss criteria must be modified to the local context to enhance incorporation of cases (e.g. requiring lower transfusion requirements) in future studies. |
| Henklofs et al., 2019    | United Republic of Tanzania, Zanzibar | Not modified (researchers reported the tool was applicable in this setting) | Conclusions about maternal near miss are dependent on the quality of data and challenges to this should be acknowledged. Researchers recommended adhering to the WHO criteria (adjusted to specific settings as needed) to enable meaningful comparison between similar reference populations. Determining a clear diagnosis in a woman with maternal near miss is difficult due to presence of multiple symptoms, lack of diagnostics due to fast deterioration of the woman and lack of laboratory-based markers. Researchers concluded that maternal near-miss criteria must be modified to the local context to enhance incorporation of cases (e.g. requiring lower transfusion requirements) in future studies. |
| Jayaratnam et al., 2019  | Timor-Leste                        | Not modified                                       |                                                                                                                    | (continues . . .) |
### Systematic reviews

Maternal near miss in middle-income countries

| Author | Setting | Modifications applied in study | Comments and problems reported by study researchers |
|--------|---------|--------------------------------|--------------------------------------------------|
| Oppong et al., 2019<sup>47</sup> | Ghana | Addition to definition of coagulation in organ dysfunction criteria (bedside clotting time of > 7 mins) | Organ system-based criteria are regarded as the most specific means of identifying maternal near miss. However, researchers argued that these criteria require ready availability of laboratory tests and medical technologies, thus impeding their use in many low-resource local settings. |
| Owolabi et al., 2020<sup>22</sup> | Kenya | Adjustments were: lowering threshold for use of blood products to 2 units of blood (Kenyan method); addition of items (laparotomy; definition of shock; treatment with oxygen face mask) | Kenyan method yielded 1.4 times the numbers of maternal near miss than the WHO method. Researchers concluded that there is under-reporting using the WHO maternal near-miss method. |

#### Upper middle-income countries

| Author | Setting | Modifications applied in study | Comments and problems reported by study researchers |
|--------|---------|--------------------------------|--------------------------------------------------|
| Morse et al., 2011<sup>23</sup> | Brazil, Rio de Janeiro | NA | As bed availability and intensive care unit admission criteria are not the same, researchers noted that use of intensive care unit admission as a marker is questionable because it is affected by level of complexity of care in a health setting and organization of obstetric care. |
| Lotufo et al., 2012<sup>25</sup> | Brazil, São Paulo State | NA | Researchers reported no difficulties in using and identifying the WHO criteria, with the exception of certain clinical criteria (e.g. gasping, cyanosis and bedside clotting tests) which generally occurred before starting complex care in the intensive care unit. |
| Shen et al., 2013<sup>26</sup> | China | NA | The study applied 16 of the 25 WHO criteria. Researchers noted that some women in their study received blood transfusion of < 5 units or intubation related to anaesthesia and therefore did not meet the WHO criteria. Women with pre-eclampsia without jaundice and loss of consciousness for < 12 hours were not included in the WHO clinical criteria group. In the laboratory-based group, women with maternal near miss were differentiated by oxygen saturation, blood creatinine level, platelet count and total bilirubin. Researchers reported it was impossible to always obtain blood pH or lactate level, because these parameters were not routinely checked in their institute. |
| Naderi et al., 2015<sup>80</sup> | Islamic Republic of Iran | Beside the collection of data on life-threatening disease, researchers added a form based on a published method<sup>5</sup>. Four groups were added to the form (haemorrhagic; hypertensive; management; and systemic disorders) | NA |
| Oliveira & Da Costa, 2015<sup>76</sup> | Brazil, Pernambuco | NA | Mechanical ventilation was required in less than one quarter of cases of maternal near miss. Researchers noted that this finding may be attributed to local differences in accessibility of resources and interventions. It is one of the drawbacks of criteria based only on treatment because a more complex hospital and laboratory structure is required. |
| Soma-Pillay et al., 2015<sup>37</sup> | South Africa | NA | The WHO tool identified five potentially life-threatening conditions: severe postpartum haemorrhage; severe pre-eclampsia; eclampsia; sepsis or severe infection; and ruptured uterus. Researchers noted that conditions such as abruptio placenta, non-obstetric infections and medical and surgical disorders were also important causes of maternal morbidity. Researchers recommended that the WHO tool should expand the categories of potentially life-threatening conditions. |
| Ghazivakili et al., 2016<sup>81</sup> | Islamic Republic of Iran | NA | Researchers noted that a limitation of the WHO tool is that application of criteria based on organ failure requires relatively sophisticated laboratory and clinical monitoring. Underestimating occurrence of maternal near miss due to lack of equipment or unavailability of some tests is therefore possible. |
| Mohammadi et al., 2016<sup>39</sup> | Islamic Republic of Iran | Lowering threshold for use of blood products to 4 units of blood; increasing threshold for platelets to < 75 000 per mL; addition of items to laboratory criteria (rapid reduction of > 4 g/dL in haemoglobin concentration) | NA |

(continues . . .)
### Systematic reviews

#### Maternal near miss in middle-income countries

**Anke Heitkamp et al.**

| Author                | Setting                        | Modifications applied in study                                                                 | Comments and problems reported by study researchers                                                                 |
|-----------------------|--------------------------------|--------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|
| Norhayati et al., 2016 | Malaysia                       | NA                                                                                              | Researchers noted that use of the WHO criteria was limited in smaller health facilities. Laboratory-based markers (e.g., pH, PaO₂, lactate) and management-based markers (e.g., vasoactive drugs and hysterectomy) were less likely to be applicable in these health facilities. |
| Akrawi et al., 2017   | Iraq                           | Lowering threshold for use of blood products to 3 units of blood                                | NA                                                                                                                |
| Iwuh et al., 2018     | South Africa                   | Addition of items to definition of severe maternal complications (acute collapse or thromboembolism; non-pregnancy-related infections; medical or surgical disorders) | NA                                                                                                                |
| Oliveira Neto et al., 2018 | Brazil, São Paulo State       | NA                                                                                              | Researchers noted that arterial blood gas sampling was not routinely collected in all pregnant or postpartum patients admitted to the intensive care unit. PaO₂ records were missing in some cases of maternal near miss. When evaluation of the level of consciousness by the Glasgow coma scale was compromised (due to residual effects of anaesthetics in the postoperative period, or by the use of continuous sedation), the Glasgow coma score of 15 was used as a criterion. Management criteria and not laboratory criteria would be useful to identify severe maternal outcome because they are more related to organ failure. Researchers noted that arterial blood gas sampling was not routinely collected in all pregnant or postpartum patients admitted to the intensive care unit. PaO₂ records were missing in some cases of maternal near miss. When evaluation of the level of consciousness by the Glasgow coma scale was compromised (due to residual effects of anaesthetics in the postoperative period, or by the use of continuous sedation), the Glasgow coma score of 15 was used as a criterion. For the variable use of vasoactive drugs, researchers noted that WHO does not establish any other criteria for stratification of severity (e.g., blood pressure levels or whether vasodilator or vasoconstrictor drug used) which could be useful for this purpose. Researchers argue that these issues should be better addressed and possibly changed. |
| De Lima et al., 2019  | Brazil, Alagoas                | Researchers noted that intensive care unit admission was not included in the WHO criteria but was an important marker of maternal severity in their study (identified in 94.5% of pregnant women) | Researchers noted that, in contrast to laboratory and management criteria, clinical criteria are important for low-income regions, because no complex laboratory and hospital infrastructures are required. Limitations of laboratory and management criteria are that most of these criteria require high-complexity units, wards, equipment or facilities for their use. Women experiencing near miss may therefore be missed. Lowering the numbers of packed red blood cell units or including disease-based criteria was necessary in low-resource settings to classify women as near miss. Lack of high-quality medical institutions in rural areas is a problem for maternal health. In recent years, China has strengthened management of women with severe complications so that they must give birth in tertiary hospitals. The researchers argued that the lack of tertiary hospitals in rural areas will affect accessibility of pregnant women to high-quality health care. |
| Mu et al., 2019       | China                          | NA                                                                                              | Researchers noted the limited availability of laboratory tests and management options resulting in under-reporting of maternal near miss. |
| Heemelaar et al., 2020| Namibia                        | Adapted tool for middle-income countries                                                        | The researchers concluded that the WHO tool leads to underestimation of the prevalence of severe complications as the tool does not include certain disease-based conditions. |
| Veschueren et al., 2020 | Suriname                     | Evaluation of the WHO maternal near-miss tool by comparing the Suriname obstetric surveillance system with WHO maternal near miss, Namibian and sub-Saharan African tools, to identify the most useful method | (continues . . )

(continues . . )
may create an incentive for countries to upgrade their diagnostic and therapeutic capacity to improve health equity.

A limitation of our study is that small differences in methods of identification of maternal near miss between countries could result in major differences in outcomes. Moreover, we had to exclude a considerable proportion of studies that used different criteria to identify maternal near miss. This underlines the complexity of the challenge when aiming to compare maternal near miss across different countries and settings. An additional list of diagnoses would be a valuable contribution to reflect actual health problems in different settings.

This issue was also discussed in a study published by our team in 2021.98 Our search was performed without any language restriction and in large databases, but it is still possible that the search may have missed studies.

A strength of our study was the relatively large number of publications that allowed us to obtain a comprehensive overview of maternal near miss in middle-income countries and to make robust comparisons between different regions and countries. We only report data about maternal near miss from 26 of the world’s 105 middle-income countries. We excluded some studies of near miss from our review because they used different criteria from the WHO near-miss criteria or did not clearly report the criteria used. Nevertheless, the countries analysed here reported large numbers of live births as denominator populations, providing a relatively robust and comprehensive overview of maternal near-miss ratios.

We found multiple studies for Brazil and India, with India showing a particularly broad range of outcomes. These data for India reflect the large differences within this large country, indicating that smaller studies might not be representative for the entire territory.95–97

We conclude that instead of adapting the WHO maternal near-miss tool, the foremost important aim of the tool should be to improve the quality of maternity care from lessons learnt by performing audits of cases of maternal near miss.

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الاستنتاج في العديد من الدول، تم اقتراح تعديلات على أداة الاستنتاج المحلية، مما قد يعيق المقارنات الدولية، ولكنه يسهل عمليات منظمة الصحة العالمية للحالات وشيكة الوفاة لتلائم السياق المحلي، فيما قد ييجق المقارات الدولية، ولكنه يسهل عمليات التدقيق المحلية ذات الصلة للاستفادة من الدروس. دراسة في الدول من الشريحة العليا للدول ذات الدخل المتوسط أوصى ما يقرب من نصف الدراسات بإجراء تعديلات على معايير المخبر والإدارة لتجنب التقليل من شأن أية حالة وشيكة الوفاة فضلا عن إرشادات أوضح لتجنب التفسيرات المختلفة للأداة.

Résumé

Mortalité maternelle: décès évités de justesse dans les pays à moyen revenu, revue systématique

Objectif Déterminer le taux d'incidence et les principales causes à l'origine des décès maternels évités de justesse dans les pays à moyen revenu en utilisant l'outil mis au point par l'Organisation mondiale de la Santé (OMS), et évaluer son applicabilité dans ce contexte.

Méthodes Nous avons procédé à une revue systématique des études portant sur des décès maternels évités de justesse dans les pays à moyen revenu, et publiées entre 2009 et 2020. Nous avons extrait des données relatives au nombre de naissances vivantes, au nombre de décès maternels évités de justesse, aux causes majeures qui les provoquent et aux dysfonctionnements organiques les plus fréquents. Nous avons également prélevé ou calculé le taux de décès maternels évités de justesse, le taux de mortalité maternelle et l'indice de mortalité. Enfin, nous avons retenu les descriptions des chercheurs concernant leurs expériences et adaptations de l'outil OMS au contexte local.

Résultats Nous avons inclus 69 études provenant de 26 pays (12 pays à revenu moyen inférieur et 14 à revenu moyen supérieur). Ces études ont comptabilisé un total de 50 552 décès maternels évités de justesse sur 10 450 482 naissances vivantes. Le nombre médian de décès maternels évités de justesse par 1000 naissances vivantes s'élevait à 15,9 (écart interquartile, EI: 8,9–34,7) dans les pays à revenu moyen inférieur, et à 7,8 (EI: 5,0–9,6) dans les pays à revenu moyen supérieur, avec des variations considérables entre pays et au sein d'un même pays. Les causes les plus fréquentes à l'origine des décès évités de justesse étaient les hémorragies obstétricales (19 études sur 40 dans les pays à revenu moyen inférieur) et les problèmes d'hypertension (15 études sur 29 dans les pays à revenu moyen supérieur). Près de la moitié des études recommandait une adaptation aux critères de gestion et de laboratoire afin de ne pas sous-estimer le nombre de décès évités de justesse, ainsi que des orientations plus claires pour pouvoir interpréter l'outil sans équivoque.

Conclusion De nombreux pays ont suggéré d'adapter l'outil OMS au contexte local. Celui pourrait entraîner les comparaisons internationales, mais faciliterait les audits localement pertinents permettant de tirer des enseignements.

Резюме

Материнская смертность: осложнения при родах в странах со средним уровнем дохода, систематический обзор

Цель Описать частоту возникновения случаев и основные причины осложнений при родах, представляющих угрозу для жизни матери, в странах со средним уровнем дохода с помощью инструмента Всемирной организации здравоохранения (ВОЗ) для оценки такого рода осложнений, а также оценить его применимость в данных условиях.

Методы Был выполнен систематический обзор исследований, посвященных осложнениям при родах, представляющим угрозу для жизни матери, в странах со средним уровнем дохода, которые были опубликованы в 2009–2020 гг. Авторы извлекли данные о количестве жертв, количестве случаев таких осложнений, основных причинах таких осложнений и наиболее частой дисфункции органов. Авторы также извлекли или рассчитали коэффициент осложнений, коэффициент материнской смертности и индекс смертности. Авторы также обратили внимание на описание опыта исследователей и модификации инструмента ВОЗ для использования на местах.

Результаты В обзор было включено 69 исследований из 26 стран (12 стран с уровнем дохода ниже среднего и 14 стран с уровнем дохода выше среднего). Из 10 450 482 живорождений исследования сообщили в общей сложности о 50 552 случаях осложнений при родах, представляющих угрозу для жизни матери. Среднее число случаев таких осложнений на 1000 живорождений составило 15,9 (межквартильный размах, МКР: 8,9–34,7) в странах с доходом ниже среднего и 7,8 (МКР: 5,0–9,6) в странах с доходом выше среднего со значительными
Resumen

Mortalidad materna: morbilidad extrema en países de ingresos medios, una revisión sistemática

Objetivo Describir la incidencia y las principales causas de los casos de morbilidad materna extrema en los países de ingresos medios mediante la herramienta correspondiente de la Organización Mundial de la Salud (OMS) y evaluar su aplicabilidad en estos contextos.

Métodos Se realizó una revisión sistemática de los estudios sobre morbilidad materna extrema en los países de ingresos medios que fueron publicados entre 2009 y 2020. Se obtuvieron datos sobre el número de nacidos vivos, el número de los casos de morbilidad materna extrema, las principales causas de los casos de morbilidad materna extrema y las disfunciones de órganos más frecuentes. Se extrae, o se calculó, la tasa de morbilidad materna extrema, la tasa de mortalidad materna y el índice de mortalidad. Asimismo, se anotaron las descripciones de las experiencias de los investigadores y las modificaciones de la herramienta de la OMS para su uso local.

Resultados Se incluyeron 69 estudios de 26 países (12 de ingresos medios-bajos y 14 de ingresos medios-altos). Los estudios informaron de un total de 50 552 casos de morbilidad materna extrema por cada 10 450 482 nacidos vivos. La mediana del número de casos de morbilidad materna extrema por cada 1000 nacidos vivos fue de 15,9 (recorrido intercuartílico, IQR: entre 8,9 y 34,7) en los países de ingresos medios-bajos y de 7,8 (IQR: entre 5,0 y 9,6) en los países de ingresos medios-altos, con una variación considerable entre los países y dentro de ellos. Las causas más frecuentes de la morbilidad materna extrema fueron la hemorragia obstétrica en 19 de los 40 estudios de los países de ingresos medios-bajos y los trastornos hipertensivos en 15 de los 29 estudios de los países de ingresos medios-altos. Alrededor de la mitad de los estudios recomendaron adaptaciones de los criterios de laboratorio y de tratamiento para evitar la subestimación de los casos de morbilidad materna extrema, así como una orientación más clara para evitar las diferentes interpretaciones de la herramienta.

Conclusión En varios países se sugieren adaptaciones de la herramienta de la OMS sobre la morbilidad extrema a los contextos locales, lo que posiblemente dificulte las comparaciones internacionales, pero facilita la ejecución de auditorías pertinentes a nivel local para las lecciones aprendidas.

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Table 1. Characteristics of studies included in the review on maternal near miss in middle-income countries

| Author                      | Setting                  | Study period         | Study type                        | Medical care setting                                                                 | Primary objective                                                                 | Data source                  | Identification of cases of maternal near miss done by | Training of staff | Follow-up of the patient after end of pregnancy |
|-----------------------------|--------------------------|----------------------|-----------------------------------|---------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|-----------------------------|---------------------------------------------------|------------------|-----------------------------------------------|
| **Lower-middle-income countries** |                          |                      |                                   |                                                                                       |                                                                                    |                             |                                                    |                  |                                               |
| Ps et al., 2013 [53]        | India, Karnataka         | 2011–2012 Audit      | 1 tertiary referral hospital with 6 primary health centres attached               | To determine incidence of maternal near miss                                         | NR                                                                                 | NR                          | NR                                                | NR               | 42 days                                        |
| Tunçalp et al., 2013 [36]   | Ghana                    | 2010–2011 Prospective descriptive | 1 tertiary referral centre        | To assess incidence of maternal near miss and related indicators                      | Medical records                                                                    | NR                          | NR                                                | NR               | 42 days                                        |
| Kaur et al., 2014 [43]      | India, Himachal Pradesh  | 2012–2013 Prospective observational | 1 tertiary care hospital          | To assess the causes and incidence of maternal near miss                               | NR                                                                                 | NR                          | NR                                                | NR               | 42 days                                        |
| Kushwah et al., 2014 [48]   | India, Madhya Pradesh    | 2012–2013 Prospective cross-sectional | 1 government tertiary care referral centre                                      | To describe profile and outcomes of maternal near miss                               | Daily identification of women with maternal near miss in wards                      | NR                          | NR                                                | NR               | 42 days                                        |
| Luexay et al., 2014 [61]    | Lao People’s Democratic Republic | 2011 Descriptive prospective | 243 villages (community and local hospitals)                                     | To determine incidence and causes of maternal near miss and maternal death in Lao People’s Democratic Republic | Daily home visits                                                                  | Investigator                | NR                                                | NR               | 42 days                                        |
| Nacharajuh et al., 2014 [55] | India                    | 2012–2014 NR         | 1 rural medical college            | To assess number of maternal near misses and maternal near miss ratio                  | NR                                                                                 | NR                          | NR                                                | NR               | 42 days                                        |
| Pandey et al., 2014 [42]    | India                    | 2011–2012 Retrospective | 1 tertiary hospital                | To assess frequency and nature of maternal near miss                                 | Medical records                                                                    | NR                          | NR                                                | NR               | 42 days                                        |
| Bakshi et al., 2015 [51]    | India                    | NR Cross-sectional epidemiological | 2 primary, 1 community and 1 tertiary facility                                   | To determine prevalence and indicators of maternal near miss                         | Medical records                                                                    | NR                          | NR                                                | NR               | 42 days                                        |
| Mazhar et al., 2015 [56]    | Pakistan                 | 2011 Cross-sectional  | 16 government facilities           | To determine incidence and causes of severe maternal outcome                          | Medical records                                                                    | NR                          | NR                                                | NR               | 42 days                                        |
| Sangeeta et al., 2015 [27]  | India                    | 2012–2013 Prospective | 1 tertiary referral centre         | To determine frequency and analyse causes of complications of maternal near miss and deaths | Medical records                                                                    | NR                          | NR                                                | NR               | 42 days                                        |
| Abha et al., 2016 [49]      | India, Raipur            | 2013–2015 Prospective observational | 1 medical college hospital         | To audit maternal near miss and to review substandard care                            | Clinical examinations; laboratory results and criteria meeting the WHO maternal near miss criteria | NR                          | NR                                                | NR               | 42 days                                        |
| Ansari et al., 2016 [65]    | Pakistan                 | 2013 Cross-sectional descriptive | 1 tertiary referral centre         | To determine frequency and nature of maternal near miss                               | NR                                                                                 | NR                          | NR                                                | NR               | 42 days                                        |

(continues . . .)
| Author                  | Setting                       | Study period | Study type                  | Medical care setting | Primary objective                                                                 | Data source                                                                                     | Identification of cases of maternal near miss done by             | Training of staff | Follow-up of the patient after end of pregnancy |
|------------------------|-------------------------------|--------------|-----------------------------|----------------------|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|-------------------------------------------------------------------|--------------------|-----------------------------------------------|
| Kulkarni et al., 2016  | India, Maharashtra            | 2012–2014    | Prospective observational   | 2 tertiary centres   | To investigate incidence and patterns of maternal near miss and to study classification criteria | Hospital registers, patient interviews                                                             | Research officers                                                | No                 | 42 days                                       |
| Oladapo et al., 2016   | Nigeria                       | 2012–2013    | Cross-sectional             | 42 tertiary hospitals | To investigate burden and causes of life-threatening maternal complications and quality of obstetric care | Medical records collected during daily ward rounds                                                | Trained data collector                                          | Yes                | 42 days                                       |
| Parmar et al., 2016    | India                         | 2012         | Cross-sectional             | 1 tertiary referral hospital | To describe incidence of maternal near miss                                      | In-depth patient interviews                                                                      | Investigators                                                  | NR                 | 42 days                                       |
| Rathod et al., 2016    | India, Maharashtra            | 2011–2013    | Retrospective cohort        | 1 tertiary referral centre | To determine incidence of maternal near miss                                      | Medical records                                                                                 | NR                                                                 | NR                 | 42 days                                       |
| Ray et al., 2016       | India                         | 2014–2015    | Cross-sectional             | 1 tertiary referral centre | To determine prevalence of maternal near miss                                      | Medical records                                                                                 | NR                                                                 | NR                 | 42 days                                       |
| Tanimia et al., 2016   | Papua New Guinea              | 2012–2013    | Prospective observational   | 1 teaching referral hospital | To assess routinely collected data and determine rates of maternal near miss       | Identification of women with maternal near miss in daily ward rounds and discussions in unit meetings | House officers                                                  | NR                 | NR                                             |
| Bolinga et al., 2017   | Papua New Guinea              | 2014–2016    | Prospective observational   | 1 provincial hospital  | To determine maternal near-miss ratio, mortality index and associated indices      | Identification of women with maternal near miss in wards                                          | Obstetric team                                                  | NR                 | NR                                             |
| Chandak & Kedar, 2017  | India, Maharashtra            | 2013–2015    | Cross-sectional             | 1 tertiary care institute | To determine frequency and nature of maternal near miss                            | Medical records by daily rounds                                                                 | NR                                                                 | NR                 | 42 days                                       |
| Mbachu et al., 2017    | Nigeria                       | 2014–2015    | Cross-sectional             | 1 tertiary centre      | To evaluate maternal near miss and maternal deaths                                | Medical records                                                                                  | Medical officer and interns                                    | NR                 | 42 days                                       |
| Tallapureddy et al., 2017 | India                     | 2014         | Retrospective cohort        | 1 tertiary care hospital | To study severe maternal outcome and use WHO maternal near-miss tool              | Medical records                                                                                  | NR                                                                 | NR                 | 42 days                                       |
| Panda et al., 2018     | India, Odisha                 | 2017         | Cross-sectional             | 1 tertiary care hospital | To estimate burden of maternal near miss                                           | Medical records                                                                                 | NR                                                                 | NR                 | 42 days                                       |
| Reena & Radha, 2018    | India, Kerala                 | 2011–2012    | Cross-sectional             | 1 government medical college | To determine frequency, nature and timing of delays in cases of maternal near miss | Medical records; patient interviews                                                              | Obstetrician                                                   | NR                 | NR                                             |

(continues...)
| Author                        | Setting         | Study period          | Study type                | Medical care setting | Primary objective                                                                 | Data source                      | Study type | Setting          | Study period | Study type | Medical care setting | Primary objective                                                                 | Data source                      |
|------------------------------|-----------------|-----------------------|---------------------------|----------------------|-----------------------------------------------------------------------------------|----------------------------------|------------|------------------|--------------|-------------|----------------------|-----------------------------------------------------------------------------------|----------------------------------|
| Chaudhuri & Nuth, 2019       | India, Kolkata  | 2013–2014             | Prospective observational | 1 tertiary care hospital | To test application of clinical definitions of life-threatening complications and to determine the level of near-miss complications, maternal morbidity, maternal mortality, and to explore predictive factors of near-miss complications, maternal morbidity, and mortality | Medical records                   | 1 tertiary level | Training of staff | No           | 42 days     | Yes                  | To study incidence of severe maternal morbidity and mortality associated with life-threatening obstetric complications and to determine the level of near-miss complications | Daily ward visits, medical records |
| Chhabra et al., 2019         | India, Delhi    | 2013–2014             | Case–control              | 1 tertiary level      | To study incidence of severe maternal morbidity and mortality associated with life-threatening obstetric complications and to determine the level of near-miss complications | Medical records                   | 42 days     | Follow-up of the patient after end of pregnancy | No           | 42 days     | Yes                  | To study incidence of severe maternal morbidity and mortality associated with life-threatening obstetric complications and to determine the level of near-miss complications | Daily ward visits, medical records |
| El Agwany, 2019              | Egypt, Alexandria | 2015–2016             | Retrospective cohort      | 1 tertiary level      | To study incidence of severe maternal morbidity and mortality associated with life-threatening obstetric complications and to determine the level of near-miss complications | Medical records                   | 42 days     | Follow-up of the patient after end of pregnancy | No           | 42 days     | Yes                  | To study incidence of severe maternal morbidity and mortality associated with life-threatening obstetric complications and to determine the level of near-miss complications | Daily ward visits, medical records |
| Gabbur et al., 2019          | India, Karnataka | 2015–2017             | Case series               | 1 tertiary level      | To determine the level of near-miss complications, maternal morbidity, and mortality associated with life-threatening obstetric complications and to explore predictive factors of near-miss complications, maternal morbidity, and mortality | Medical records                   | 42 days     | Follow-up of the patient after end of pregnancy | No           | 42 days     | Yes                  | To study incidence of severe maternal morbidity and mortality associated with life-threatening obstetric complications and to determine the level of near-miss complications | Daily ward visits, medical records |
| Heikots et al., 2019         | United Republic of Tanzania, Zanzibar | 2017–2018             | Prospective cohort       | 1 main referral hospital | To explore incidence and factors associated with maternal near miss along with maternal mortality and morbidity in the region | Medical records                   | 42 days     | Follow-up of the patient after end of pregnancy | No           | 42 days     | Yes                  | To study incidence of severe maternal morbidity and mortality associated with life-threatening obstetric complications and to determine the level of near-miss complications | Daily ward visits, medical records |
| Jayawardane et al., 2019     | Timor-Leste      | 2015–2016             | Retrospective cohort      | 1 main referral hospital | To explore incidence and factors associated with maternal near miss along with maternal mortality and morbidity in the region | Medical records                   | 42 days     | Follow-up of the patient after end of pregnancy | No           | 42 days     | Yes                  | To study incidence of severe maternal morbidity and mortality associated with life-threatening obstetric complications and to determine the level of near-miss complications | Daily ward visits, medical records |
| Karim et al., 2020           | Pakistan         | 2016–2017             | Descriptive              | Tertiary hospital     | To explore incidence and factors associated with maternal near miss along with maternal mortality and morbidity in the region | Medical records                   | 42 days     | Follow-up of the patient after end of pregnancy | No           | 42 days     | Yes                  | To study incidence of severe maternal morbidity and mortality associated with life-threatening obstetric complications and to determine the level of near-miss complications | Daily ward visits, medical records |
| Lilungulu et al., 2020       | United Republic of Tanzania, Dodoma | 2015–2016             | Retrospective cohort      | 1 regional referral hospital | To explore incidence and factors associated with maternal near miss along with maternal mortality and morbidity in the region | Medical records                   | 42 days     | Follow-up of the patient after end of pregnancy | No           | 42 days     | Yes                  | To study incidence of severe maternal morbidity and mortality associated with life-threatening obstetric complications and to determine the level of near-miss complications | Daily ward visits, medical records |
| Author | Setting | Study period | Study type | Medical care setting | Primary objective | Data source | Identification of cases of maternal near miss done by | Training of staff | Follow-up of the patient after end of pregnancy |
|--------|---------|--------------|------------|----------------------|------------------|-------------|-----------------------------------------------|----------------|-----------------------------------------------|
| Owolabi et al., 2020<sup>22</sup> | Kenya | 2018 | Cross-sectional | 16 county hospitals, 2 national level hospitals and 46 subcounty hospitals | To determine incidence and causes of maternal near miss | Identification of cases in wards; medical records; patient interviews in case of missing data | Identified “study clinician” such as Medical officers and nurses | Yes | 42 days |
| Samuels & Ocheke, 2020<sup>64</sup> | Nigeria | 2012–2013 | Cross-sectional | 1 university hospital | To determine frequency of maternal near miss and maternal deaths to identify common causes | Identification of cases during admission and in the wards; medical records | | NR | NR | 42 days |
| Ugwu et al., 2020<sup>63</sup> | Nigeria | 2013–2016 | Prospective | 1 hospital | To determine frequency of maternal near miss and maternal deaths, to document primary causative factor and to compare maternal near miss and maternal deaths | Medical records | Research assistants (residents in internal medicine) | Yes | 42 days |
| Cecatti et al., 2011<sup>24</sup> | Brazil, São Paulo State | 2002–2007 | Retrospective | Intensive care unit of 1 tertiary referral centre | To evaluate WHO maternal near-miss criteria | Medical records | Investigators and research assistants | NR | 42 days |
| Morse et al., 2011<sup>23</sup> | Brazil, Rio de Janeiro | 2009 | Cross-sectional prospective | 1 regional public referral hospital | To investigate severe maternal morbidity and maternal near miss using different identification criteria | Medical records; identification of cases during daily ward rounds | Principal investigator and trained students | Yes | 42 days |
| Lotufo et al., 2012<sup>25</sup> | Brazil, São Paulo State | 2004–2007 | Cross-sectional retrospective | Intensive care unit of 1 university referral hospital | To study maternal morbidity and mortality among women in intensive care | Medical records | Investigator | No | 42 days |
| Jabir et al., 2013<sup>82</sup> | Iraq | 2010 | Cross-sectional | 6 public hospitals | To use WHO maternal near-miss tool to assess characteristics and quality of care in women with severe complications | Medical records; daily staff interviews | Coordinators | Yes | 7 days |
| Shen et al., 2013<sup>26</sup> | China | 2008–2012 | Retrospective | 1 private tertiary hospital | To investigate factors associated with maternal near miss and mortality | Medical records | Audit committee of obstetricians and specialist registrars | Yes | 42 days |
| Dias et al., 2014<sup>72</sup> | Brazil, nationwide | 2011–2012 | National, hospital-based study of women who have recently given birth and their newborns | 1043 hospitals | To estimate incidence of maternal near miss in hospitals | Medical records; patient interviews | Students and health-care workers, coordinators from different health facilities and specialists | Yes | 42 days |

(continues . . .)
| Author                        | Setting                              | Study period       | Study type                  | Medical care setting                  | Primary objective                                                                 | Data source                           | Identification of cases of maternal near miss done by | Training of staff | Follow-up of the patient after end of pregnancy |
|------------------------------|--------------------------------------|--------------------|-----------------------------|---------------------------------------|-----------------------------------------------------------------------------------|---------------------------------------|-----------------------------------------------------|------------------|---------------------------------------------|
| Galvão et al., 2014          | Brazil, Sergipe                       | 2011–2012          | Cross-sectional and case–control | 2 reference maternity hospitals       | To determine prevalence of severe acute maternal morbidity and maternal near miss and to identify risk factors | Identification of cases in wards; medical records; patient interviews | Obstetrician and trained staff | Yes              | 42 days                                    |
| Madeio et al., 2015          | Brazil, Piaui                         | 2012–2013          | Prospective                 | 1 public tertiary referral hospital   | To investigate incidence and determinants of severe maternal morbidity and maternal near miss | Medical records                       | Trained investigators | Yes              | 42 days                                    |
| Naderi et al., 2015          | Islamic Republic of Iran              | 2013               | Prospective                 | 8 hospitals                          | To estimate incidence and identify underlying factors of severe maternal morbidity | Identification of cases during admission and in the wards | Midwife and gynaecologist | NR               | 42 days                                    |
| Oliveira & Da Costa, 2015    | Brazil, Pernambuco                    | 2007–2010          | Descriptive cross-sectional  | Obstetric intensive care unit of 1 tertiary hospital | To analyse epidemiological and clinical profile of maternal near miss | Medical records                       | Investigator and research assistants | Yes              | 42 days                                    |
| Soma-Pillay et al., 2015     | South Africa                         | 2013–2014          | Descriptive population-based| 9 delivery facilities                | To determine spectrum of maternal morbidity and mortality                         | Medical records; daily audit meetings | NR                     | No               | 42 days                                    |
| Cecatti et al., 2016         | Brazil, nationwide                   | 2009–2010          | Cross-sectional             | 27 referral maternity hospitals       | To identify severe maternal morbidity cases, study their characteristics and test WHO criteria | Medical records                       | Medical coordinators | Yes              | 42 days                                    |
| Ghazivakili et al., 2016     | Islamic Republic of Iran              | 2012               | Cross-sectional             | 13 public and private hospitals       | To assess incidence of maternal near miss and audit quality of care               | Medical records                       | Midwives with data collection form | Yes              | 7 days                                     |
| Mohammad et al., 2016        | Islamic Republic of Iran              | 2012–2014          | Incident case–control       | 3 university hospitals; 1 secondary, 2 tertiary hospitals | To determine frequency, causes, risk factors and perinatal outcomes of maternal near miss | Medical records                       | Investigators | NR               | 42 days                                    |
| Norhayati et al., 2016       | Malaysia                              | 2014               | Cross-sectional             | 2 referral and tertiary hospitals     | To study severe maternal morbidity and maternal near miss and related indicators | Hospital and home-based medical records | Research assistant trained in nursing | No               | 42 days                                    |
| Akrawi et al., 2017          | Iraq                                 | 2013               | Cross-sectional             | 1 maternity teaching hospital         | To determine major determinants of maternal near miss and maternal death          | Medical records; interviews of women who experienced maternal near miss | NR                     | NR               | 42 days                                    |
| Iwuh et al., 2018            | South Africa                         | 2014               | Retrospective observational | 3 hospitals (secondary and tertiary)  | To measure maternal near-miss ratio, maternal mortality ratio and mortality index | Medical records                       | Investigator and health-care providers, with identification confirmed by senior obstetric specialists | No               | 42 days                                    |

(continues . . )
| Author               | Setting                          | Study period   | Study type                  | Medical care setting                                                                 | Primary objective                                                                 | Data source                          | Identification of cases of maternal near miss done by | Training of staff | Follow-up of the patient after end of pregnancy |
|---------------------|----------------------------------|----------------|-----------------------------|---------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|--------------------------------------|-----------------------------------------------------|------------------|-----------------------------------------------|
| Oliveira Neto et al., 2018 & 77 | Brazil, São Paulo State          | 2013 – 2015    | Retrospective cross-sectional | Obstetric intensive care unit of 1 public teaching hospital 1 tertiary                  | To explore indicators of WHO maternal near-miss criteria                         | Medical records                      | NR                                                  | NR               | 42 days                                      |
| De Lima et al., 2019 & 34 | Brazil, Alagoas                  | 2015 – 2016    | Prospective cohort observational | Obstetric intensive care unit of 1 public teaching hospital 1 tertiary                  | To collect data on maternal near miss                                              | Patient interviews; medical records at admission and at day 42 | Principle investigator and research assistants | NR               | 42 days                                      |
| Miu et al., 2019 & 79 | China                            | 2012 – 2017    | Population-based surveillance system | Medical records, web-based online reporting system                                   | To introduce maternal near miss into a national surveillance system and to report maternal near miss | Medical records, web-based online reporting system | Obstetrician and nurses responsible for patient care | Yes              | 42 days                                      |
| Heemelaar et al., 2020 & 38 | Namibia                          | 2018 – 2019    | Nationwide surveillance     | All public hospitals (1 tertiary, 4 regional, 30 district)                            | To obtain data on pregnancy outcomes and assess benefits of such surveillance in comparison with surveillance of maternal deaths only | Medical records                      | Nominated staff                                      | Yes              | 42 days                                      |
| Ma et al., 2020 & 78 | China                            | 2012 – 2018    | Cross-sectional             | Medical records, electronic medical record system                                   | To explore prevalence of maternal near miss, risk factors for maternal near miss and relationship between maternal near miss and perinatal outcomes | Electronic medical record system        | Nurses and doctors                                   | Yes              | 42 days                                      |
| Verschueren et al., 2020 & 45 | Suriname                        | 2017 – 2018    | Prospective nationwide population-based cohort | Identification of cases during daily ward rounds; medical records | To find reason for high maternal mortality ratio and stillbirths and compare findings with other countries to improve quality of care | Identification of cases during daily ward rounds; medical records | Research coordinator (doctor) and investigator | Yes              | 42 days                                      |
| Multiple countries |                                  |                |                             |                                                                                       |                                                                                   |                                      |                                                      |                  |                                               |
| Bashour et al., 2015 & 83 | Egypt, Lebanon                   | 2011           | Cross-sectional             | Medical records, investigators                                                        | To report on prevalence of maternal near miss                                      | Medical records                      | Investigators                                         | Yes              | 7 days                                       |
| De Mucio et al., 2016 & 30 | Colombia, Dominican Republic, Ecuador, Honduras, Nicaragua, Paraguay, Peru | 2013           | Cross-sectional             | Medical records, health-care professionals                                           | To evaluate performance of a systematized form to detect severe maternal outcomes | Medical records                      | Health-care professionals                           | Yes              | 42 days                                      |

NR: data not reported; WHO: World Health Organization.