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The contribution of suicide and injuries to pregnancy-related mortality in low and middle-income countries: A systematic review and meta-analysis

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Summary

Background—Although suicide is one of the leading causes of deaths among young women in low and middle-income countries (LMIC), the contribution of suicide and injuries to pregnancy-related mortality remains unknown.

Methods—We conducted a systematic review to identify studies reporting the proportion of pregnancy-related deaths attributable to suicide and/or injuries in LMIC. Random-effects meta-analysis was used to calculate the pooled prevalence of pregnancy-related deaths attributable to suicide, stratified by WHO region. To account for the possible misclassification of suicide deaths as injuries, we calculated the pooled prevalence of deaths attributable to injuries, and undertook a sensitivity analysis reclassifying the leading methods of suicides among women in LMIC (burns, poisoning, falling or drowning) as suicide.

Findings—36 studies from 21 countries were identified. The pooled total prevalence across the regions was 1·00% for suicide (95% confidence interval (CI): 0·54–1·57) and 5·06% for injuries (95% CI: 3·72–6·58). Reclassifying the leading suicide methods from injuries to suicide increased the pooled prevalence of pregnancy-related deaths attributed to suicide to 1·68% (95% CI: 1·09–2·37). Americas (3·03%, 95% CI: 1·20–5·49),the Eastern-Mediterranean region (3·55%, 95% CI: 0·37–9·37), and the South-East Asia region (2·19%, 95% CI: 1·04–3·68) had the highest

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Contributors

DF wrote the first draft of the paper, conducted the systematic review of the literature and was responsible for data extraction and quality assessment. CC assisted with the systematic review of the literature, data extraction and conducted the meta-analyses. CC, CR, PC, SS, MDS and VP contributed to the interpretation of data, critically revised the paper, and approved the final version.

Conflict of interests

All authors declare no conflict of interest.

prevalence for suicide, with the Western-Pacific region (1·16%, 95% CI: 0·00–4·67) and the Africa region (0·65%, 95% CI: 0·45–0·88) having the lowest.

Interpretation—The available data suggest a modest contribution of injuries and suicide to pregnancy-related mortality in LMIC with wide regional variations. However, this study may have underestimated suicide deaths due to lack of recognition and inclusion of these causes in eligible studies. We recommend that injury-related and other co-incidental causes of death are included in the WHO definition of maternal mortality to promote measurement and effective intervention for reduction of maternal mortality in LMIC.

Introduction

According to the Global Burden of Disease study, suicide is the fourth leading cause of death for women aged 15–49 years worldwide[1], and has been identified as one of the major killers of young women in low and middle-income countries (LMIC).[2–6] Despite the importance of suicide as a cause of death in women of reproductive age, the proportion of pregnancy-related deaths attributable to suicide in LMIC is unknown. This is principally because suicide deaths along with other coincidental causes of death have conventionally not been considered in the WHO definition of maternal mortality, and included direct and indirect obstetric causes of death only.[7] This is in contrast to the definition of pregnancy-related mortality, which considers all maternal mortality causes in addition to coincidental causes of deaths such as injuries. However, some maternal mortality studies recognize suicide as a cause of maternal mortality, arguing that it can be a fatal outcome of perinatal or postpartum mental illness and have advocated that it should therefore be considered as an indirect cause of maternal death.[8–11] The WHO, in its revision of the causes of maternal mortality for the new ICD-XI, have recently discussed that point and proposed that all antepartum and postpartum suicide deaths should from now on be included as direct obstetric deaths.[12]

Depression during pregnancy and postpartum, a major risk factor for suicide[13], is highly prevalent in LMIC, and it is in these settings where the highest rates of postpartum depression have been observed affecting up to 20% of all mothers.[2,14] Unfortunately, in many of these regions, the coverage of vital registration is poor and cause of death data is often collected via verbal autopsies (VA) requesting relatives to provide information on the circumstances surrounding the death. The validity of such VA methods is questionable with regards to suicide deaths as suicide is criminalized in some societies, and is associated with stigma.[3] Misclassification of suicide deaths as accidental causes of death may therefore be common.[3,15–18]

We conducted a systematic review and meta-analysis on the contribution of suicide to pregnancy-related mortality in LMIC. Due to the possible misclassification of suicide deaths as unintentional injuries, we also estimated pregnancy-related mortality attributable to injuries, providing an upper uncertainty limit of suicide deaths.

Methods

Search strategy and selection criteria

The following databases were searched to identify population-based studies reporting the proportion of maternal or pregnancy-related deaths attributable to injuries and/or suicides: Medline, EMBASE, Global Health, Popline, Latin American and Caribbean Health Science Information, African Index Medicus, Index Medicus for the Eastern Mediterranean Region and Index Medicus for the South-East Asian Region. Databases were searched from January 1, 1994, when the current International Classification of Disease (ICD-10) was introduced,[7] until September 1, 2013. The search strategy was not restricted by language and was developed with an information scientist. Search terms for maternal/pregnancy were combined with search terms for cause of death, injury-specific causes of deaths (e.g. drowning) and suicide, as well as a list of LMIC based on the world bank list of economies, July 2012[19] (see appendix I for the full search strategy). To identify grey literature such as confidential enquiries into maternal deaths or other global or country-specific reports on maternal mortality and causes of death, web-based searches were conducted. In addition, the websites of international organizations (WHO, UNICEF, UNFPA, UN Women, the World Bank) and the biographies of eligible papers were searched for additional studies. Finally, authors of eligible papers were contacted to identify additional studies.

The first author (DF) carried out the literature search. All titles and abstracts from the selected databases were screened independently by two reviewers (DF, CC) who selected papers for full text screening. Full texts were independently assessed by the same reviewers; in case of disagreement a third author was consulted (CR) and a decision agreed by consensus. The paper had to meet the following inclusion criteria: (1) be a population-based study reporting maternal or pregnancy-related deaths by cause and designed to capture all deaths in the respective area; (2) report the proportion of pregnancy-related/maternal deaths attributable to suicide or injuries; (3) be conducted in a LMIC; (4) include any data from 1994 onwards. Studies were excluded if one or more of the above mentioned criteria were not met. The full list of inclusion and exclusion criteria are included in appendix II.

Data extraction and quality assessment

Data from eligible papers were double extracted by two authors (DF, CC) on the study setting (country, region), study design (study population and age, type of study design, data sources, years of data collection), outcome measures (denominator: number of maternal deaths, number of pregnancy-related deaths; numerator: number of cases for discrete categories of injuries including suicide and specific causes of intentional and unintentional injuries); and definition of the denominator (maternal or pregnancy-related mortality) and numerator (injuries). We followed the criteria of Khan et al[20] and Grollman and Ronsmans[21] to investigate the study's internal validity. Two authors (DF, CC) then independently assessed the study's internal validity and overall level of risk of bias firstly, concerning the quality of methods which have been used for death ascertainment and 5 secondly, concerning the completeness of cause of death assignation. Low, medium and high level of risk was assigned according to table 1 (table adapted from Grollman and Ronsmans, 2013).[21]

Statistical analysis

Two separate meta-analyses, one of the prevalence of suicide deaths and one of the prevalence of injury-related deaths (including suicide) were undertaken. To take account of possible misclassification of suicide as injury, we also conducted a sensitivity analysis by adding all common methods of suicide (i.e. falls, drowning, poisoning and burns)[3,15–18] among women in LMIC which were reported as injuries to suicide. All these meta-analyses were repeated excluding studies with a small sample size (<50 pregnancy-related deaths).

Forest plots were generated to present the study-specific and pooled prevalence of deaths from suicide and injury among all maternal/pregnancy-related deaths with 95% confidence intervals. Prevalence estimates were also stratified by WHO region: the Americas (AMRO), Africa (AFRO), Eastern-Mediterranean region (EMRO), Europe (EURO), South-East Asia (SEARO), and the Western Pacific region (WPRO). Statistical analyses were conducted using R Studio (version 3.0.2).[22] Proportions were transformed prior to meta-analysis using the Freeman-Tukey double arcsine transformation for variance stabilization.[23] Meta-analyses were conducted using the DerSimonian-Laird random-effects model,[24] and the pooled proportions were back-transformed to the original scale. Use of the random-effects model means the summary proportions should be interpreted as an average of the study proportions which are genuinely different from one another. Between-study heterogeneity was assessed by using the I^2 statistic, which is expressed as a percentage with 25%, 50%, and 75% being generally considered as representing low, moderate or high heterogeneity, respectively.[25] The p-value from Cochrane's test of heterogeneity is also reported.

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Results

We identified 6411 unique records from database searching (figure 1). 360 full texts were screened and 36 studies (24 research papers, 12 grey literature studies) met our eligibility criteria. Out of the 324 studies which did not meet the inclusion criteria, 140 studies did not report causes of death while 50 studies did report causes but excluded suicide and injury deaths.

Table 2 describes the 36 studies included in the review. Studies were from 21 countries and 6 WHO regions (8 from AMRO, 9 from AFRO, 4 from EMRO, 1 from EURO, 7 from SEARO, and 3 from WPRO). Thirteen studies reported national data[26–37] and 23 studies

reported sub-national data.[38–60]The majority of studies (n=32) reported pregnancy-related deaths while three studies reported maternal deaths.[27,46,51] Studies were published in English, Spanish and Portuguese.

Multiple methods were used to collect information on the number of maternal or pregnancy-related deaths. Six studies used reproductive-age mortality surveys (RAMOS)[26,27,38,45,53,59] and eleven studies used routine data from multiple sources such as local registries, hospital-based records, data of management information systems and/or by conducting interviews with health attendants.[29,30,44,46,49,51,52,54,55,58,60] Eight confidential enquiries into maternal deaths enumerated deaths from facility-based records.[31–36,56,57] Three studies used data from a national maternal mortality surveillance system.[37,50] Two studies conducted key-informant surveys in the community[39,48] while three studies used data from household censuses.[28,40,61] Three studies followed up a cohort of women[41,42,47] one of which obtained cohort data from a community-based trial.[42]

Seventeen studies conducted VA to assign causes of deaths.[28–30,39–43,45,47–50,53,54,59,60] Nine of these used a consensus panel consisting of medical staff or health researchers to agree on the cause of death[28–30,39,42,45,48,49,60], while six did not specify whether a consensus panel was used or not.[41,47,50,53,54,59] Two VA studies interpreted data using Inter VA-models.[40,43] All other studies (n=19) used reviews of physicians and/or other health professionals to establish the cause of the pregnancy-related deaths by using RAMOS (n=3)[27,38,44], routine data (n=6)[30,46,51,52,55,58], surveillance[37] or confidential enquiries (n=8)[31–36,56,57], while one study asked relatives what the cause of death was.[26]

Twelve studies were assessed to be at high risk of bias as selective information on the number of deaths has been sought by using single data sources or confidential enquiries using facility-based data only. Fifteen studies were at low risk of bias because they used RAMOS, censuses, cohort studies or comprehensive sources of household ascertainment to identify pregnancy-related deaths. Completeness of cause of death assignation was generally high. There were only six studies where more than 10% of deaths were of unknown cause,[40,42,47,49,56,57] while for three studies no information on the completeness of cause of death assignation could be obtained.[43,46,52]

Pregnancy-related deaths/maternal deaths attributable to injuries

Appendix III summarizes the number of pregnancy-related deaths, maternal deaths, intentional and unintentional injuries reported by each study while figure 2 presents the prevalence of pregnancy-related deaths/maternal deaths attributable to injuries, overall and stratified by region.

All studies reported deaths from injuries. Across all studies, 24021 pregnancy-related deaths/maternal deaths were reported out of which 868 deaths were attributed to intentional (suicide, violence, homicide, other injuries such as stab wound) or unintentional injuries (road traffic accident, fall, drowning, poisoning, burn, other injuries such as snake bite or trauma). The pooled prevalence was 5·06% (95% CI: 3·72–6·58; I^2=94·9%, tau^2 p-value: p<0.0001). Individual estimates of the prevalence of injury ranged from 0% in Vietnam[59] to 23·08% in Argentina.[53] Across the regions, the highest prevalence was found in AMRO in

which 10·14% of pregnancy-related deaths were attributable to injuries (95% CI: 6·29–14·72; I^2= 85·7%, tau^2 p-value: p<0.0001). The second highest pooled prevalence was found in EMRO (6·31%; 95% CI: 0·96–15·51; I^2= 96·2%, tau^2 p-value: p=0.0001), followed by EURO/Russia (5·03%; 95% CI: 2·24–8·78, estimate based on one study only). SEARO had a pooled prevalence of 4·50% (95% CI: 2·90–6·40; I^2= 72·2%, tau^2 p-value: p<0.0001). WPRO's pooled prevalence was 3·94% (95% CI: 0·00–14·70; I^2= 96·5%, tau^2 p-value: p<0.0001) and AFRO's was 2·70% (95% CI: 1·52–4·19; I^2= 95·3%, tau^2 p-value: p<0.0001). All estimates were associated with high between-study heterogeneity.

The pooled prevalence dropped slightly when restricting to studies which included at least 50 deaths (4.62%, 95% CI: 3.33–6.08; I^2=95.2%, tau^2 p-value: p<0.0001)(Appendix IV.I).

Pregnancy-related/maternal deaths attributable to suicide

25 studies reported deaths from suicide including 21317 pregnancy-related/maternal deaths and 155 suicide-related deaths. Figure 3 presents the prevalence of pregnancy-related/maternal deaths attributable to suicide, overall and stratified by region. The prevalence of pregnancy-related deaths assigned to suicide ranged from 0% in South Africa[36] and Vietnam[59] to 23·08% in Argentina (all injury deaths reported in the Argentina study are suicide deaths).[53] The pooled prevalence for suicide-related deaths was 1·00% (95% CI: 0·54–1·57). There was strong evidence for between-study heterogeneity (I^2=87·2%, tau^2 p-value: p<0.0001).

AMRO had the highest pooled prevalence of suicide-related deaths across the regions with 3·03% (95% CI: 1·20–5·49; I^2=73·9%, tau^2 p-value: p<0.0008). The single based estimate for EURO/Russia was 5·03% (95% CI: 2·24–8·78). SEARO had a pooled suicide prevalence of 1·91% (95% CI: 1·04–3·00; I^2=26·5%, tau^2 p-value: p=0.2264). The pooled prevalence for suicide was lowest in EMRO (0·44%, 95% CI: 0·10–0·95; I^2=0%, tau^2 p-value: p<0.436), AFRO (0·31%, 95% CI: 0·14–0·55; I^2=71·5%, tau^2 p-value: p<0.0036), and WPRO (0·24%, 95% CI: 0·00–1·12; I^2=60·5%, tau^2 p-value: p=0.1115).

When only studies with at least 50 deaths were included in the meta-analysis, 0.92% of deaths were attributed to suicide (95% CI: 0·53–1·40; I^2=86·0%, tau^2 p-value: p<0.0001) (Appendix IV.II.

Figure 4 presents the prevalence of pregnancy-related/maternal deaths attributable to suicide, pooling suicide, falls, drowning, poisoning and burns. The overall prevalence of deaths attributable to suicide increased to 1·68% (95% CI: 1·09–2·37; I^2=86·8%, tau^2 p-value: p<0.0001). The highest increase in prevalence was seen in EMRO (3·55%, 95% CI: 0·37–9·37; I^2=93· 4%, tau^2 p-value: p<0.0001), followed by WPRO (1·16%, 95% CI: 0·00–4·67; I^2=87·6%, tau^2 p-value: p=0.0003), AFRO (0·65%, 95% CI: 0·45–0·88; I^2=49·0%, tau^2 p-value: p=0.0672) and SEARO (2·19%, 95% CI: 1·04–3·66; I^2=48·1%, tau^2 p-value: p=0.061). The prevalence in AMRO and EURO/Russia did not change.

The pooled prevalence of deaths attributed to suicide, falls, drowning, poisoning and burns was estimated to be 1.52% (95% CI: 1·01–2·12; I^2=86·2%, tau^2 p-value: p<0.0001) after restricting to studies with more than 50 deaths (Appendix IV.III).

Discussion

Our systematic review of the proportion of maternal and pregnancy-related deaths in LMIC that are attributable to injury or suicide found that about 1 in 20 pregnancy-related deaths are due to injuries and 1 in 100 are due to suicide. There was large variation between regions, with those regions which have overall low rates of pregnancy-related mortality such as AMRO and EMRO showing the highest prevalence of pregnancy-related deaths due to injuries. The prevalence of deaths due to injuries was lowest in WPRO and AFRO. For suicide, the highest prevalence of pregnancy-related deaths was found in AMRO, with AFRO, EMRO and WPRO being low in prevalence. Counting certain unintentional injuries as suicide deaths to adjust for possible misclassification increased the overall proportion of deaths attributable to suicide from 1·0% to 1·7%. This figure represents the upper uncertainty limit for the estimate of suicide deaths.

This is the first systematic review investigating the contribution of suicide and injuries to pregnancy-related mortality in LMIC, and thus we are unable to compare our findings to estimates reported in previous studies. The most recent systematic review of the causes of maternal deaths, for example, excluded suicide as a cause of death.[20] Comparing the results for suicide with the WHO estimates of the prevalence of deaths due to intentional self-harm among all deaths in women of reproductive age for 2011[62] shows that our results are considerably lower than the GBD estimates, especially for SEARO and WPRO. In SEARO and WPRO, the GBD study reports that 9·1% and 7·8% of deaths in women of reproductive age are due to suicide, compared to 2·2% and 1·2% of pregnancy-related deaths in our sensitivity analysis. For the other regions our estimates among pregnant and postpartum women are similar to those among women of reproductive age as reported in the GBD (data not shown).

A lower rate of suicide mortality among pregnant women and women in the postpartum is a finding which is not surprising. Women in pregnancy and in the postpartum may have a high prevalence of depression and are at risk of suicide, however, the risk to die from injuries and suicide is still reported to be higher among women who are not pregnant and not in the postpartum period.[13,63] This finding is even found in settings with very good cause of death ascertainment, such as in the UK confidential enquiries, and has been attributed in part to the fact that women who become pregnant are healthier than the general population of non-pregnant women.[64] Similarly, in a demographic surveillance site in Bangladesh, violent deaths were not more common in pregnant women compared to women who were not pregnant, except for pregnant adolescents in which a higher rate to die from suicide and injuries has been observed(the higher number of injuries among pregnant adolescents has largely been explained by the high number of unwanted pregnancies in unmarried young girls).[65] Studies on injuries comparing pregnant and postpartum women with women of childbearing age are however limited and more research on this topic would be needed to ascertain and confirm injury rates between these two groups.

Our study has some limitations, and our estimates may not represent the true proportion of deaths attributable to suicide or injuries among pregnant/postpartum women in LMIC. This is supported by recent evidence from Sri Lanka which indicated that suicide may account for

a significant proportion of pregnancy-related mortality (18% of pregnancy-related mortality) if suicide deaths are properly classified and reported.[18] Although we conducted a sensitivity analysis and considered, for example, deaths from poisonings to provoke an abortion[47] as suicide deaths (abortion-related suicides are common in countries in which abortion is illegal[38,47,53]), it is likely that we still have underestimated rather than overestimated the proportion of pregnancy-related deaths due to suicide and injuries for several reasons: First, 50 maternal mortality studies with good cause of death data had to be excluded from our review because no data on injuries were reported. This deliberate exclusion of injuries as a cause of death limited our ability to accurately assess the magnitude of the problem. Second, some regional estimates were based on very few countries, thereby affecting the generalizability of the estimates. There is a need to conduct additional studies within regions to arrive at representative regional estimates. Third, although we only included population-based studies, some studies relied on selective and largely facility-based data sources to enumerate pregnancy-related deaths, and suicide deaths which may have occurred in the community may have been missed in these studies. Fourth, deaths from suicide or homicide are difficult to ascertain. Medical records may not be available, or if available may not mention the cause of death. Cause of death assignation may also be hampered by misreporting of suicide deaths from families and relatives. Suicide is a crime in many LMIC and associated with great stigma.[3,15] Due to the fear of legal consequences, families tend to conceal suicide deaths, especially among unmarried women, resulting in misclassification of suicide into unintentional injuries or other causes of death.[3,38,47,51] Fifth, verbal autopsy is an imprecise instrument and deaths which were assigned as having an unknown cause of death were included in our estimates. It is therefore possible that missing causes of death have disproportionally included injuries which may have biased our results towards a lower bound estimate. Finally, there was extensive between-study heterogeneity in some of our estimates, and so the summary proportions should be interpreted with caution. It is likely that some of this heterogeneity is driven by methodological differences between studies in, for example, length of postpartum follow-up or study quality.

This review has important implications for the measurement of maternal mortality. The exclusion of injuries from the ICD-10 definition of maternal death has clearly been met with unease since a number of studies in this review considered suicide as an indirect maternal death[27,46,51] although no study classified suicide as direct obstetric as recommended in the latest WHO revision of causes of maternal death for ICD-11.[12] One study went even further by only considering postpartum suicide as directly attributable to pregnancy, while antenatal suicide was thought to be coincidental to pregnancy.[29] Although a substantial number of LMIC will not meet the target for reducing maternal mortality by 2015 as outlined in the Millennium Development Goals[66], many LMIC are undergoing an epidemiological transition with the number of direct obstetric causes decreasing.[66,67] It is plausible that injury and co-incidental deaths might therefore become more prominent in the future. In high-income countries like the UK, and more developed regions of LMIC, suicide and injuries are already one of the major causes of maternal deaths.[9–11,18] Pregnancy-related mortality including all deaths in pregnancy regardless of attribution might therefore be a more suitable indicator for monitoring progress on improving maternal health outcomes than using the orthodox definition of maternal mortality. To improve recognition and

measurement of suicide and injury deaths among pregnant women and women in the postpartum, there needs to be increased awareness in health departments and among researchers conducting VA on mental illness, suicide and injuries in increasing the risk of pregnancy-related mortality. High quality data, incorporating facility and community-based data is urgently needed to understand the magnitude of coincidental causes of deaths in pregnancy-related mortality in LMIC.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Panel: Research in context

Systematic review

We conducted a systematic review of the literature, and reviewed maternal mortality studies of LMIC of the last 20 years. This included a review of grey literature such as confidential enquiries into maternal deaths and maternal mortality reports from international organizations. Study quality was evaluated by assessing the quality of methods of death ascertainment and completeness of cause of death assignation, according to criteria of Grollman and Ronsmans.[21]

Interpretation

To the best of our knowledge, this is the first systematic review on the contribution of suicide and injuries to pregnancy-related mortality in LMIC. Our findings show that suicide and injuries contribute to pregnancy-related mortality with 1 in 20 pregnancy-related deaths resulting from these causes.. Coincidental causes of deaths should be included in the ICD-10 coding of maternal deaths to promote recognition, awareness and effective interventions for reduction of maternal mortality in LMIC.

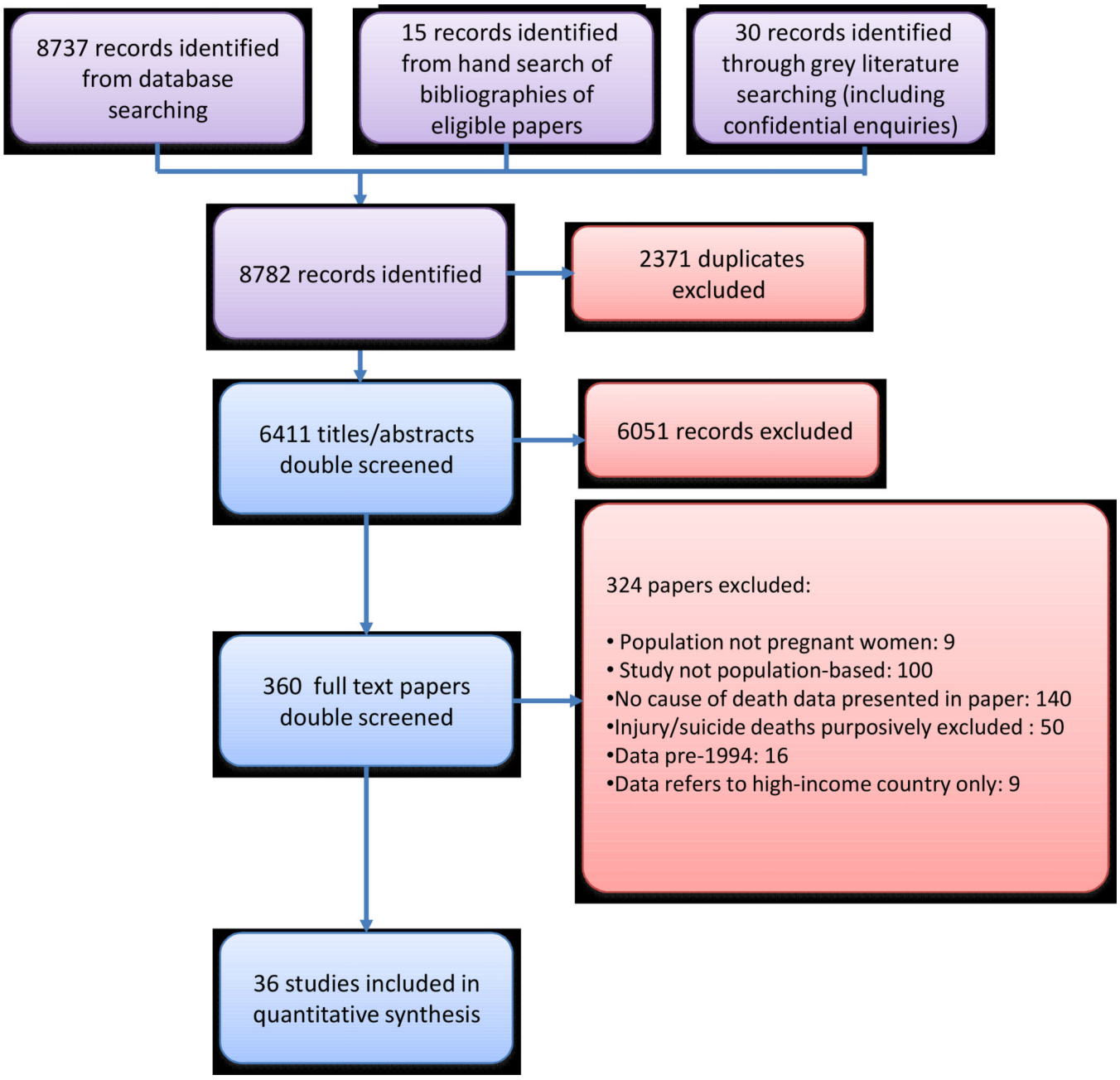

Figure 1.
Selection of studies

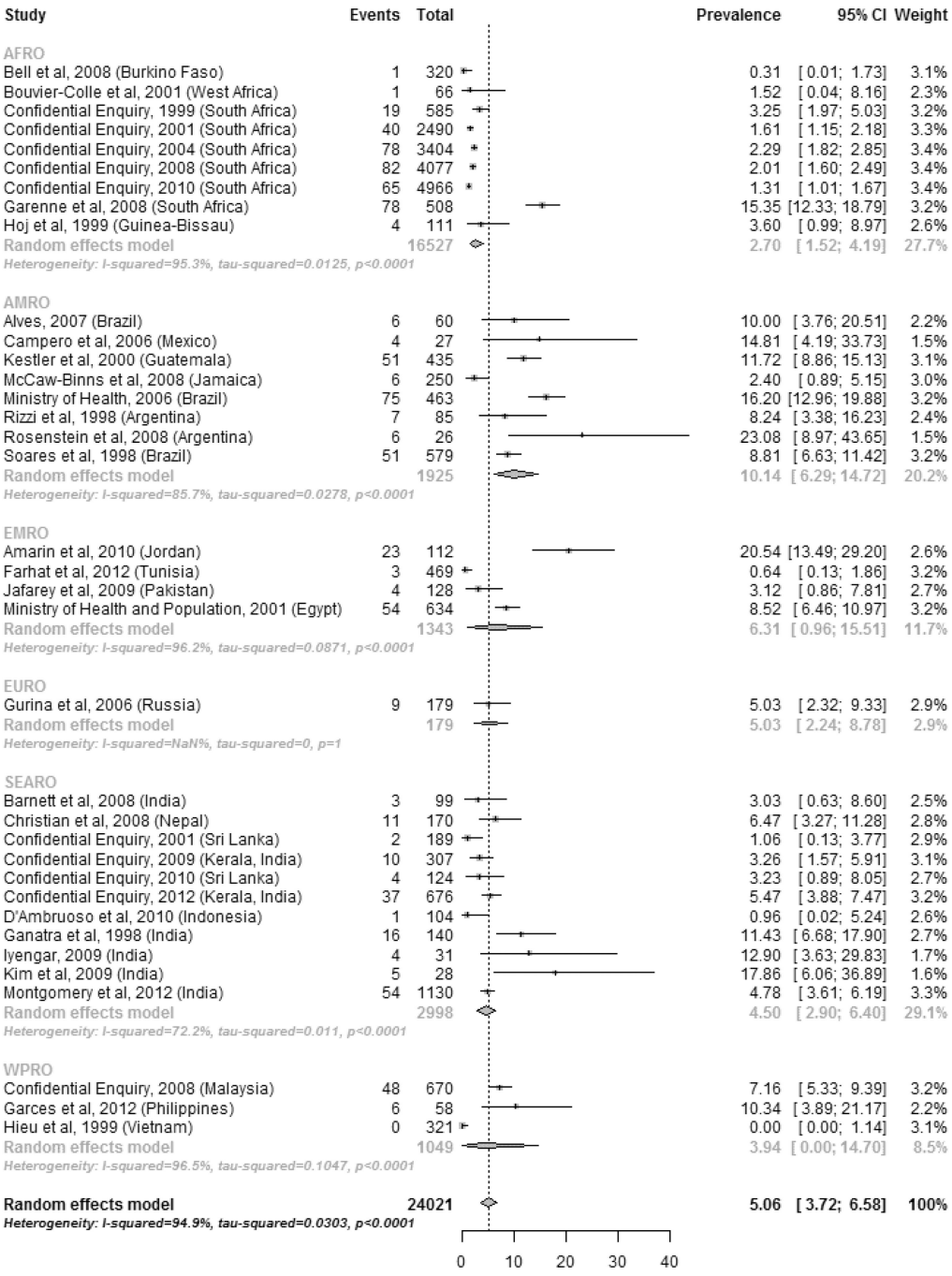

Figure 2.

Proportion of pregnancy-related deaths/maternal deaths attributable to injuries

Footnote: The discrepancy in the pooled and individual estimate for the single study in the EURO region arises as the exact binomial confidence interval for single studies is shown, while the normal approximation is used to calculate the confidence interval in the random effects meta-analysis.

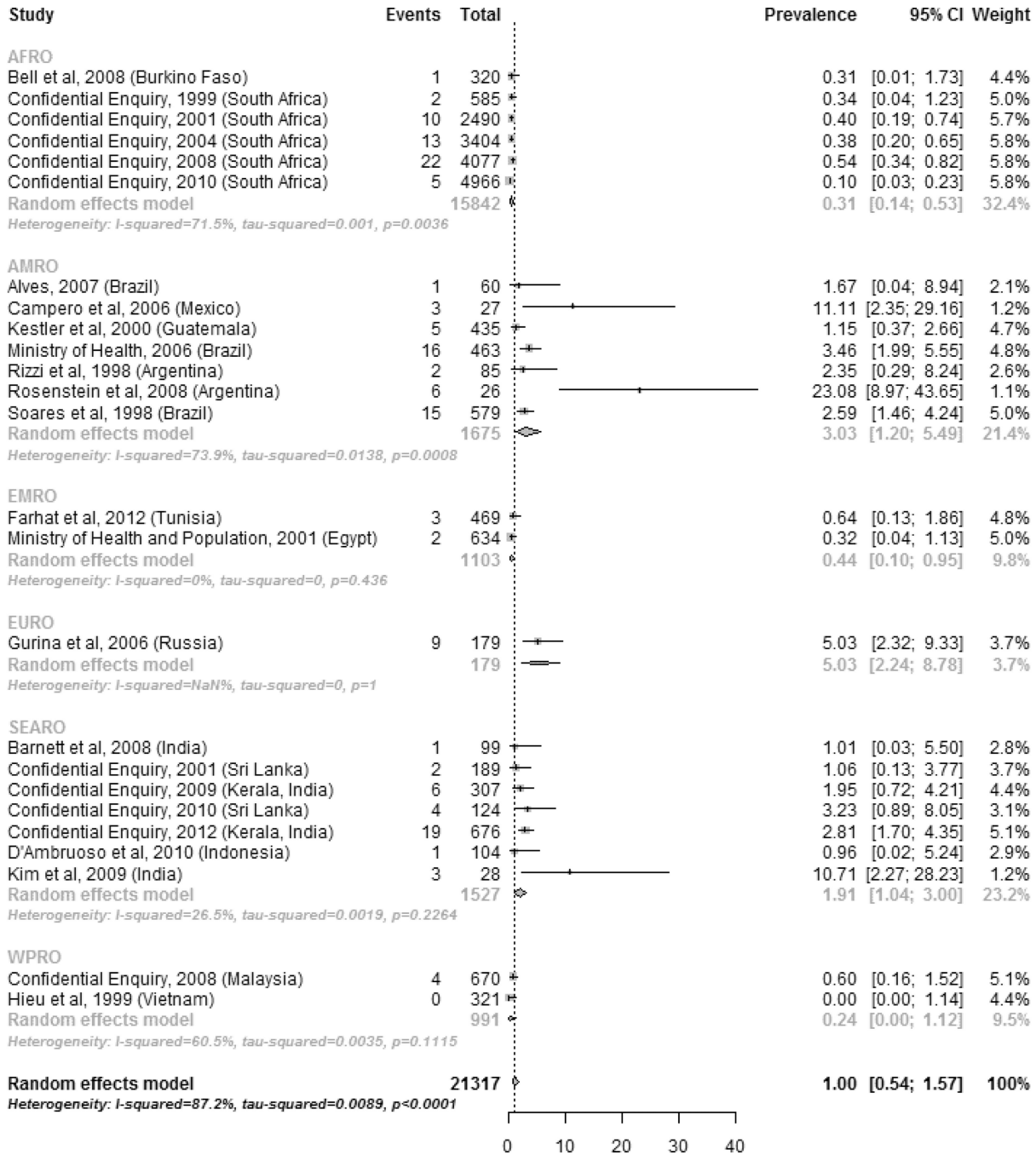

Figure 3.

Proportion of pregnancy-related deaths/maternal deaths attributable to suicide

Footnote: The discrepancy in the pooled and individual estimate for the single study in the EURO region arises as the exact binomial confidence interval for single studies is shown, while the normal approximation is used to calculate the confidence interval in the random effects meta-analysis.

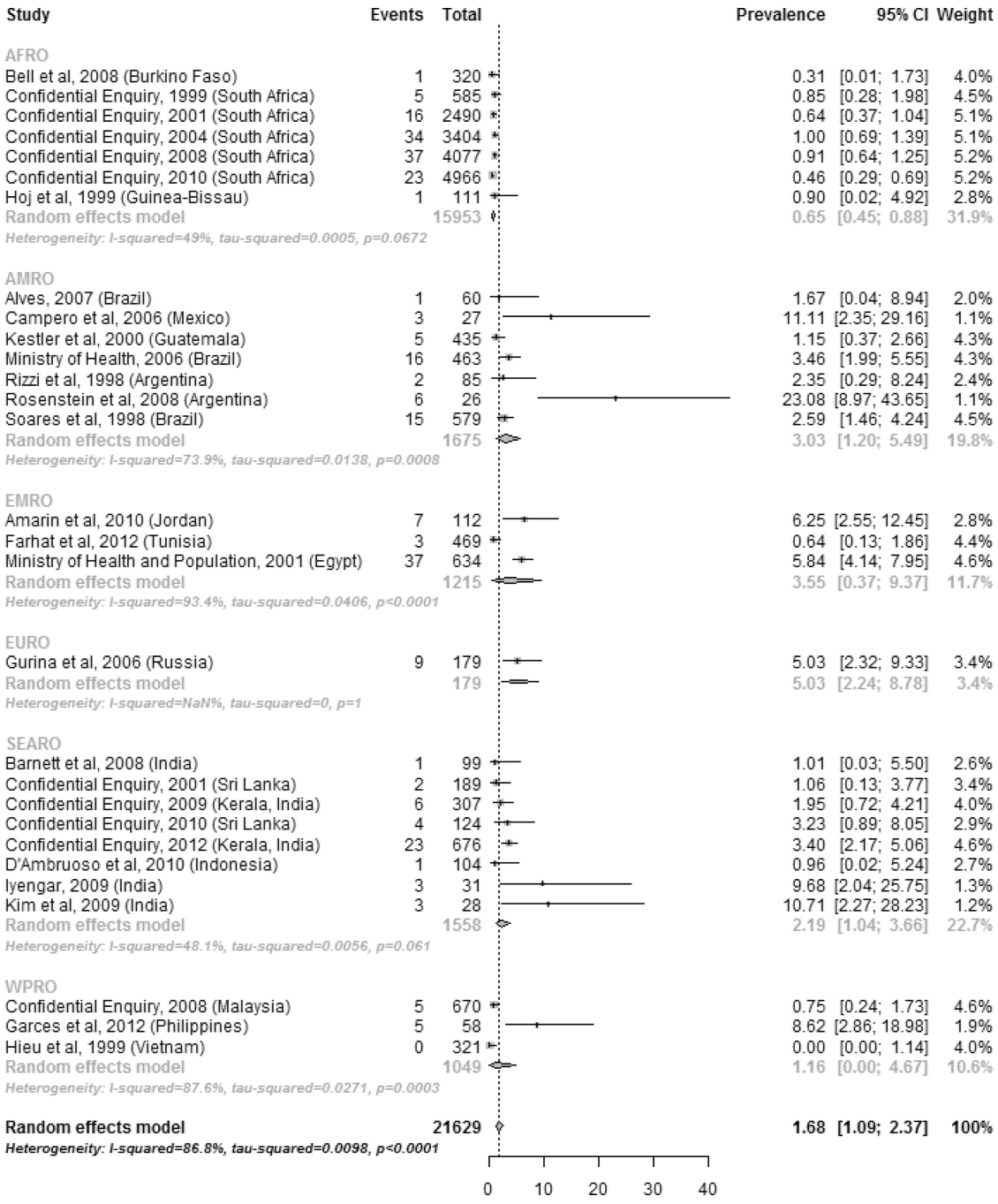

Figure 4.

Proportion of pregnancy-related deaths/maternal deaths attributable to suicide, falls, drowning, poisoning and burns

Footnote: The discrepancy in the pooled and individual estimate for the single study in the EURO region arises as the exact binomial confidence interval for single studies is shown, while the normal approximation is used to calculate the confidence interval in the random effects meta-analysis.

Table 1

Quality assessment criteria

Level of risk	Quality of method of death ascertainment	Completeness of cause-of-death assignation
Low	Cohort/prospective surveillance; RAMOS*/survey using multiple data sources of household ascertainment; census	Causes assigned to ≥90% of deaths
Medium	RAMOS*/survey using limited data sources (e.g. facility records, key informants);	Causes assigned to 75–90% of deaths
High	Selective routine reporting using single data sources such as hospital records/deaths certificates with no assessment of completeness possible	Causes assigned to <75% of deaths

Grollman and Ronsmans, 2013, adapted table[21];

*RAMOS (Reproductive Age Mortality Study)

Table 2

Description of studies reporting the proportion of pregnancy-related/maternal deaths attributable to suicide and injuries

Author, year	Setting (period of data collection)	Study population	Ascertainment of deaths		Ascertainment of cause of death assignation	Completeness of data (cause of death assignation)	
			Method	Risk of Bias	Method	% unknown	Risk of bias
AFRO							
Bell et al, 2008 [39]	Burkina Faso (Diapaga and Ouargaye), 2002–2006	Pregnancy-related deaths (42 days postpartum), 15–49 years	Household census and sisterhood method were used to record all adult female deaths in households, followed up with a verbal autopsy to identify pregnancy-related deaths	Low	Verbal autopsy (InterVA-M model)	16·6%	Medium
Bouvier-Colle et al, 2001 [40]	Seven sites in West Africa: Abidjan in Ivory Coast, Bamako in Mali, Niamey in Niger, Nouakchott in Mauritania, Ouagadougou in Burkina Faso, and Saint-Louis and Kaolack in Senegal, 1994–1996	Pregnancy-related deaths (one year postpartum), 15–49 years	Door to door enquiry to recruit pregnant women which were followed up through the postpartum period (cohort); trained investigators (physicians) identified deaths	Low	Verbal autopsy (reviewed and analysed by three gynaecologists-obstetricians and two public health researchers)	7·5%	Low
Garenne et al, 2008 [26]	South Africa, (entire country), 2001	Pregnancy-related deaths (42 days postpartum), 15–49 years	South Africa population census (random sub-sample of 10% of census was analysed)	Medium	Verbal autopsies (reviewed independently by two physicians, adjudicated by a third in case of discrepancy), consensus panel	0%	Low
Hoj et al, 1999 [46]	Guinea Bissau (five northern regions), 1989–1996	Pregnancy-related death (42 days postpartum), no information on age provided	Followed up a randomly selected cohort of women of fertile age at 6 monthly intervals	Low	Verbal autopsy (death assigned and reviewed by author of the paper using a series of pre-defined diagnostic algorithms)	29·7%	High
South African Confidential Enquiries, 1999 [31]	South Africa (entire country), 1998	Pregnancy-related deaths (42 days postpartum), 15–49 years	Facility-based records	High	Maternal death notification form sent from facility to provincial assessor (doctor and midwife) who reviewed the form and the case notes, and provided information on the causes of death. The provincial Maternal Child and Women's Health coordinator took a sample of assessed cases and submitted them to a provincial facilitator who reassessed the cases for quality control. Discrepancies were discussed at the local assessors meeting, consensus panel.	3·1%	Low
South African Confidential Enquiries, 2001 [32]	South Africa (entire country), 1999–2001	Pregnancy-related deaths (42 days	Facility-based records	High	Maternal death notification form sent from facility to provincial assessor (doctor and midwife) who	1·8%	Low

Author, year	Setting (period of data collection)	Study population	Ascertainment of deaths		Ascertainment of cause of death assignation	Completeness of data (cause of death assignation)	
			Method	Risk of Bias	Method	% unknown	Risk of bias
		postpartum), 15–49 years postpartum), 15–49 years			reviewed the form and the case notes, and provided information on the causes of death. The provincial Maternal Child and Women's Health coordinator took a sample of assessed cases and submitted them to a provincial facilitator who reassessed the cases for quality control. Discrepancies were discussed at the local assessors meeting, consensus panel.		
South African Confidential Enquiries, 2004 [33]	South Africa (entire country), 2002–2004	Pregnancy-related deaths (42 days postpartum), 15–49 years	Facility-based records	High	Maternal death notification form sent from facility to provincial assessor (doctor and midwife) who reviewed the form and the case notes, and provided information on the causes of death. The provincial Maternal Child and Women's Health coordinator took a sample of assessed cases and submitted them to a provincial facilitator who reassessed the cases for quality control. Discrepancies were discussed at the local assessors meeting, consensus panel.	3·0%	Low
South African Confidential Enquiries, 2007 [34]	South Africa (entire country), 2005–2007	Pregnancy-related deaths (42 days postpartum), 15–49 years	Facility-based records	High	Maternal death notification form sent from facility to provincial assessor (doctor and midwife) who reviewed the form and the case notes, and provided information on the causes of death. The provincial Maternal Child and Women's Health coordinator took a sample of assessed cases and submitted them to a provincial facilitator who reassessed the cases for quality control. Discrepancies were discussed at the local assessors meeting, consensus panel.	4·1%	Low
South African Confidential Enquiries, 2010 [35]	South Africa (entire country), 2008–2010	Pregnancy-related deaths (42 days postpartum), 15–49 years	Facility-based records	High	Maternal death notification form sent from facility to provincial assessor (doctor and midwife) who reviewed the form and the case notes, and provided information on the causes of death. The provincial Maternal Child and Women's Health coordinator took a sample of assessed cases and submitted	4·4%	Low

Author, year	Setting (period of data collection)	Study population	Ascertainment of deaths		Ascertainment of cause of death assignation	Completeness of data (cause of death assignation)	
			Method	Risk of Bias	Method	% unknown	Risk of bias
					them to a provincial facilitator who reassessed the cases for quality control. Discrepan		
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					them to a provincial facilitator who reassessed the cases for quality control. Discrepan		
AMRO							
Alves, 2007 [37]	Brazil (Five subregions of	Pregnancy-related deaths (one year	RAMOS* (hospital records, postmortem autopsy reports, home	Low	Consensus panel (composed of physicians, nurses, epidemiologists	3·7%	Low
Campero et al, 2006 [57]	Mexico (region not specified),	Pregnancy-related deaths (42 days	Death certificates and hospital records	High	Review of death certificates and hospital records independently by	0%	Low
Kestler et al, 2000 [49]	Guatemala (17 districts, not	Pregnancy-related deaths (42 days	Prospective surveillance system to identify deaths to women of	Low	Verbal autopsy (reviewed by a group of researchers)	6·2%	Low
Rizzi et al, 1998 [51]	Argentina (Corboda), 1992–1996	Pregnancy-related deaths (42 days postpartum), 12–44 years	Reports from autopsies obtained from the forensic department of the province of Corboda were used to identify deaths	High	Reports and causes of deaths reviewed by forensic physicians	_†	-
Rosenstein et al, 2008 [52]	Argentina (Chaco, Formosa, Mendoza, San Luis, Tucuman), 2002	Pregnancy-related deaths (42 days postpartum), 10–49 years	RAMOS* (data of national and provincial registries) were used to identify deaths; women who died in hospitals were excluded	Low	Verbal autopsy (reviewed independently by study investigators)	0%	Low
Soares et al, 1998 [53]	Brazil (Parana), 1994–1996	Pregnancy-related deaths (42 days postpartum), 10–49 years	Interviews with health workers and death certificates from hospitals to identify deaths	Medium	Verbal autopsy (no further information provided)	4·3%	Low
McCaw-Binns et al, 2008 [59]	Jamaica (four regions), 1998–2003	Pregnancy-related deaths (one year postpartum), 15–49 years	Monthly surveillance reviewing admission registers of all hospitals, holding discussions with health care providers and local registrars, funeral homes, police headquarters and traditional birth attendants to identify deaths (reported cause of death data refers to deaths in hospitals only)	High	Case reports were reviewed by a regional team, consensus panel. Case review process was complemented by information from a visit with relatives of the deceased and included a verbal autopsy	0%	Low
Ministry of Health, Brazil, 2006 [54]	Brazil (25 towns and districts), 2002	Pregnancy-related deaths (42 days postpartum), 10–49 years	Key informant questionnaires, hospital-based records and primary health care records were used to identify deaths	Medium	Cause of death data reviewed by physicians, consensus panel	0%	Low
EMRO							

Author, year	Setting (period of data collection)	Study population	Ascertainment of deaths		Ascertainment of cause of death assignation	Completeness of data (cause of death assignation)	
			Method	Risk of Bias	Method	% unknown	Risk of bias
Amarin et al, 2010 [25]	Jordon, (entire country), 2007–2008	Pregnancy-related deaths (42 days postpartum), 15–49 years	RAMOS* (data from the Ministry of Health, civil registry, police units, forensic departments, records from the United Nations Relief and Works Agency,	Low	Relatives of women who died were contacted by phone to obtain information on the cause of death	0%	Low
Farhat et al, 2012 [26]	Tunisia, entire country, 1999–2007	Maternal deaths (42 days postpartum), 15–49 years	Modified RAMOS* (private and public hospital data only) to identify deaths. Private hospital data refers to the year 2006 only.	High	Review of hospital records and CEMD** questionnaires by regional advisory board (composed of specialists in obstetrics and a national committee on maternal	0%	Low
Jafarey et al, 2009 [48]	Pakistan (Sindh), 2005–2007	Pregnancy-related deaths (retrospective) and pregnant women prospective, 42 days postpartum), 15–49 (prospective, 42 days postpartum), 15–49 years	Deaths were identified through monthly reports of lady health workers, health management information systems, records of hospitals, graveyards, and union information systems, records of hospitals, graveyards, and union councils in addition to a survey with complete population coverage	Low	Verbal autopsy (reviewed by three physicians and the principal investigator of study in case of disagreement), consensus panel disagreement), consensus panel	10·1%	Medium
Ministry of Health and Population, Egypt 2001 [29]	Egypt (all governorates), 2000	Pregnancy-related deaths (42 days postpartum), 15–49 years	Vital routine registration data from a selection of 149 health bureaus in all governorates. Deaths were identified by using data from a screening questionnaire at the health bureaus, medical records, drug prescriptions, records from hospitals and private clinics.	Medium	Verbal autopsy (cause of death data reviewed by a local advisory group), consensus panel	3·3%	Low
EURO							
Gurina et al, 2006 [45]	Russia Petersburg), 1992–2003	(St. Maternal death (42 days postpartum), 15–49 years	Retrospective data collection using data from the Department of Mother and Child at the St. Petersburg Public Health Committee, the Medical Information Analytical Centre and the St. Petersburg Statistic Committee to identify deaths	Medium	Group of researchers and medical doctors collectively re-classified all deaths according to definitions / recommendations in the UK CEMD**, consensus panel	-†	-
SEARO							
Barnett et al,	India (West	Pregnancy-related	Prospective key informant	Medium	Verbal autopsy (reviewed	0%	Low
Christian et al,	Nepal (Sarlahi),	Pregnancy-related	Identification of pregnant women	Medium	Verbal autopsy (reviewed	10·0%	Medium

Author, year	Setting (period of data collection)	Study population	Ascertainment of deaths		Ascertainment of cause of death assignation	Completeness of data (cause of death assignation)	
			Method	Risk of Bias	Method	% unknown	Risk of bias
D'Ambruoso et	Indonesia (Serang	Pregnancy-related	Village-based informant survey based sample to identify deaths)	High	Verbal autopsy (InterVA-M model)	_†	-
Ganatra et al, 1998 [43]	India (Pune, Aurangabad and Ahmednagar in Maharashtra), 1993–1995	Pregnancy-related deaths (42 days postpartum), 15–45 years	Deaths of women were identified by collating information from vital registration records, primary health centre registers, municipal corporation records, surveillance of public service and private medical facilities and an informal village information system comprised of community health volunteers, women's groups, school teachers, interviews with the woman's own family and healthcare providers	Low	Panel of public health specialists and obstetricians determined cause of death, consensus panel	2·1%	Low
Iyengar, 2009 [47]	India (Rajasthan), 2002–2003	Pregnancy-related deaths (42 days postpartum), 15–49 years	Retrospective key informant survey with midwifes, child nutrition workers, local government members, elderly women and shopkeepers in main villages to identify deaths	Medium	Verbal autopsy (physician assigned cause of death which was reconfirmed by an external blinded reviewer), consensus panel	0%	Low
Kim et al, 2009 [50]	India (Vellore), 1999–2004	Maternal deaths (42 days postpartum), 12–50 years	In-depth interviews, semistructured interviews with key informants and structured questionnaires were used to identify deaths known to health care providers and community leaders. In addition, data from a management information system recording deliveries and deaths was being used.	Medium	Deaths reports reviewed by staff at the government, the primary care hospital and the medical college hospital	0%	Low
Montgomery et al, 2012 [28]	India (28 states and 7 union territories), 2001–2003	Pregnancy-related deaths (42 days postpartum), 15–49 years	Data from an Indian sample registration system was used: 150 households were drawn from 28 states and 7 union territories. Deaths were recorded during monthly visits by trained nonmedical enumerators and every six months by registrar general surveyors.	Medium	Verbal autopsy (deaths coded independently by two physicians); review of deaths by consensus panel (two physicians and a midwife)	8·0%	Low

Author, year	Setting (period of data collection)	Study population	Ascertainment of deaths		Ascertainment of cause of death assignation	Completeness of data (cause of death assignation)	
			Method	Risk of Bias	Method	% unknown	Risk of bias
Kerala Confidential Enquiries, 2009 [55]	India (Kerala), 2004–2005	Pregnancy-related deaths (42 days postpartum), 15–49 years	Facility-based records in addition to community-based data from the Director of Health Services (DHS) were used to identify deaths	Medium	Maternal death notification sent to zonal coordinators and senior professors at a state medical college who agreed on cause of death with general assessors, consensus panel.	10·1%	Medium
Kerala Confidential Enquiries, 2012 [56]	India (Kerala), 2006–2009	Pregnancy-related deaths (42 days postpartum), 15–49 years	Facility-based records in addition to community-based data from the Director of Health Services (DHS) were used to identify deaths	Medium	Maternal death notification sent to zonal coordinators and senior professors at state medical college who agreed on cause of death with general assessors, consensus panel.	15·6%	Medium
Sri Lankan Maternal Mortality Surveillance System, 2001 [36]	Sri Lanka (entire country), 2000	Pregnancy-related deaths (42 days postpartum), 15–49 years	Surveillance of maternal deaths compiling data of field investigations, facility-based records, vital registration, health returns and the media were used to identify deaths	Low	Cause of death assigned by health personnel based on post-mortem report. Review of case reports by a group of experts at the national level (maternal mortality review meeting), consensus panel.	_†	-
Sri Lankan Maternal Mortality Surveillance System, 2010 [36]	Sri Lanka (entire country), 2010	Pregnancy-related deaths (42 days postpartum),15–49 years	Surveillance of maternal deaths compiling data of field investigations, facility-based records, vital registration, health returns and the media were used to identify deaths	Low	Cause of death assigned by health personnel based on post-mortem report. Review of case reports by a group of experts at the national level (maternal mortality review meeting), consensus panel.	_†	-
WPRO							
Garces et al, 2012 [44]	Philippines (Bukidnon), 2008	Pregnancy-related deaths (42 days postpartum), 15–49 years	RAMOS* (data from rural health units, municipal health offices, local civil registries, municipal police stations, hospitals, clinics, parishes, community sources, and by interviewing relatives) were used to identify deaths	Low	Verbal autopsy (reviewed independently by three obstetricians/physicians), consensus panel	0%	Low
Hieu et al, 1999 [58]	Vietnam (Three provinces: Vinh Phu, Quang Ngai and Song Be), 1994–1995	Pregnancy-related deaths (42 days postpartum), 15–49 years	RAMOS* (communal population registers, hospitals registers, meetings with the National Committee for the Population and Family Planning and the Ministry of Health, meetings with the commune, village officials, the woman's union and by interviewing relatives) were used to identify deaths	Low	Verbal autopsy with additional information provided by the principal healthcare provider	0%	Low

Author, year	Setting (period of data collection)	Study population	Ascertainment of deaths		Ascertainment of cause of death assignation	Completeness of data (cause of death assignation)	
			Method	Risk of Bias	Method	% unknown	Risk of bias
Malaysia Confidential Enquiries, 2008 [30]	Malaysia (all provinces), 2006–2008	Pregnancy-related deaths (42 days postpartum), 15–49 years	Facility-based records	High	Maternal death notification sent to national secretariat of the CEMD** within 48 hours. Standardized review of deaths at the individual hospitals. Interviews conducted with family members to assist in cause of death ascertainment. Review by national technical committee, consensus panel.	0%	Low

† unknown – no data provided in paper;

* RAMOS (Reproductive Age Mortality Study);

** CEMD (Confidential Enquiries into Maternal Deaths)