The lifetime risk of maternal near miss morbidity in Asia, Africa, the Middle East, and Latin America: a cross-country systematic analysis

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Summary

Background Life-threatening maternal near miss (MNM) morbidity can have long-term consequences for the physical, psychological, sexual, social, and economic wellbeing of female individuals. The lifetime risk of MNM (LTR-MNM) quantifies the probability that a female individual aged 15 years will have an MNM before age 50 years, given current mortality and fertility rates. We compare the LTR-MNM globally to reveal inequities in the cumulative burden of severe maternal morbidity across the reproductive life course.

Methods We estimated the LTR-MNM for 40 countries with multifacility, regional, or national data on the prevalence of MNM morbidity measured using WHO or modified WHO criteria of organ dysfunction from 2010 onwards (Central and Southern Asia=6, Eastern and Southeastern Asia=9, Latin America and the Caribbean=10, Northern Africa and Western Asia=2, sub-Saharan Africa=13). We also calculated the lifetime risk of severe maternal outcome (LTR-SMO) as the lifetime risk of maternal death or MNM.

Findings The LTR-MNM ranges from a 1 in 269 risk in Viet Nam (2010) to 1 in 6 in Guatemala (2016), whereas the LTR-SMO ranges from a 1 in 201 risk in Malaysia (2014) to 1 in 5 in Guatemala (2016). The LTR-MNM is a 1 in 20 risk or higher in nine countries, seven of which are in sub-Saharan Africa. The LTR-SMO is a 1 in 20 risk or higher in 11 countries, eight of which are in sub-Saharan Africa. The relative contribution of the LTR-MNM to the LTR-SMO ranges from 42% in Angola to 99% in Japan.

Interpretation There exist substantial global and regional disparities in the cumulative burden of severe maternal morbidity across the reproductive life course. The LTR-MNM is an important indicator to highlight the magnitude of inequalities in MNM morbidity, once accounting for obstetric risk, fertility rates, and mortality rates. The LTR-SMO can be used to highlight variation in the relative importance of morbidity to the overall burden of maternal ill-health across the female reproductive life course, given countries' stage in the obstetric transition. Both the LTR-MNM and LTR-SMO can serve as important indicators to advocate for further global commitment to end preventable maternal morbidity and mortality.

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Introduction

A maternal near miss (MNM) case is defined as "a woman who nearly died but survived a complication that occurred during pregnancy, childbirth or within 42 days of termination of pregnancy".[1] WHO identifies MNM cases based on clinical-based, laboratory-based, and management-based indicators of organ dysfunction.[1] However, these criteria are not used universally, and some countries use complication-based or management-based criteria instead.[2] Sharing many characteristics with the review of female individuals who die from maternal causes, clinical audits of those who survive life-threatening complications are an effective tool to improve the quality of maternal health care.[3,4] MNM events reflect the ability of a health system to save a life when life-threatening complications arise, and are testament to the importance of expanding access to and the quality of emergency obstetric care.[3,4] However, surviving a complication of this severity can also lead to long-term physical, psychosocial, sexual, and economic sequelae.[5,6] As countries progress through the obstetric transition,[7,8] from high to low maternal mortality and direct obstetric to indirect (infectious and non-communicable) causes of maternal death, a greater proportion of severe maternal outcomes are cases of near miss morbidity than maternal deaths.

Existing measures of MNM morbidity typically estimate the level of obstetric risk associated with an individual pregnancy only—for example, the MNM ratio (MNM cases per 1000 livebirths)[1] or MNM rate (MNM cases per 1000 female individuals of reproductive age). Few standard measures of non-life-threatening

Research in context

Evidence before this study

We searched Embase, MEDLINE, and Global Health for English language studies reporting national, regional, or multifacility estimates of the prevalence of life-threatening maternal morbidity (ie, maternal near miss events), published from Jan 1, 2010 to July 15, 2024 (date of search). Search terms included "maternal near miss"/"severe (acute) maternal morbidity"/"life-threatening condition/complications" and "prevalence"/"incidence"/"ratio"/"surveillance". Our search revealed a dearth of population-level estimates: most existing prevalence data derive from (single) facility-based studies without accounting for births that occur outside of the facility. This bias might be substantial when institutional delivery rates are low. Second, existing global comparisons of the maternal near miss ratio indicate differences in the level of obstetric risk associated with an individual pregnancy only. However, since women are at risk of having a life-threatening complication with each pregnancy, existing data fail to account for differences in cumulative risk from repeat pregnancy.

The lifetime risk of maternal near miss is a new indicator oriented to address these deficits in the existing evidence and aiming to better understand global inequities in the burden of maternal near miss morbidity across women's reproductive lives.

Added value of this study

We provide the first cross-country estimates of the lifetime risk of maternal near miss for 40 countries with multifacility, regional, or national data on the prevalence of maternal near miss. We also calculate how the lifetime risk of maternal near miss compares with the lifetime risk of maternal death for a given country–year, and the relative contribution of morbidity to the lifetime risk of severe maternal outcome (the risk of death or near miss morbidity). This is the first study to do so.

Implications of all the available evidence

First, there are substantial global inequalities in the risk of severe maternal morbidity across women's reproductive lifetimes. By accounting for the cumulative risk from repeat pregnancy and reproductive age survival, the lifetime risk of maternal near miss presents a clearer picture of cross-country disparities in the burden of near miss morbidity than prevalence data alone might suggest. Second, the composite risk that a girl will either die from a maternal cause or experience near miss morbidity during her lifetime is extremely high in many countries, particularly in sub-Saharan Africa. These findings provide a new lens through which to understand reproductive injustice, and a new opportunity to advocate for increased global commitment to end preventable maternal morbidity and mortality.

maternal morbidity exist at all.[9] In response to global calls for comparable, population-level estimates of maternal morbidity,[9,10] Gazeley and colleagues[11] proposed a new summary measure called the lifetime risk of maternal near miss (LTR-MNM) to estimate the risk (1 in N chance) that a female individual aged 15 years will have an MNM complication before age 50 years. The LTR-MNM extends metrics of maternal morbidity to a cumulative risk framework. This conceptual shift recognises that female individuals face repeated exposure to the risk of maternal morbidity with each recurrent pregnancy, and that this risk accumulates over their reproductive lives.

Measurement of the LTR-MNM is analogous to the lifetime risk of maternal death (LTR-MD), a widely-used metric to compare maternal mortality across countries and changes over time.[12] As a composite measure, its computation requires three components: the MNM ratio (the level of obstetric risk), fertility rates (a proxy for the number of times female individuals are exposed), and all-cause mortality (to have an MNM, the individual must not die from a maternal cause or something else).[11] When two lifetime risks—of death or MNM—are combined, the lifetime risk of severe maternal outcome (LTR-SMO) denotes the risk that a female individual aged 15 years will either die from a maternal cause or have an MNM during her reproductive lifetime. The LTR-MNM and LTR-SMO are important tools that could help to strengthen global advocacy to reduce preventable maternal mortality and morbidity.[11]

To our knowledge, no global estimates of the LTR-MNM or LTR-SMO currently exist. Our objective is to produce the first, population-level estimates of the LTR-MNM and LTR-SMO for countries with available data, to better understand global inequalities in reproductive outcomes.

Methods

Overview

Our methodological approach to produce cross-country estimates of the LTR-MNM and LTR-SMO involved several key steps. First, we conducted a systematic review of the literature to identify eligible MNM prevalence studies. When necessary, these MNM data were adjusted to generate population-level estimates of the MNM ratio. For countries with more than one MNM ratio estimate, we then conducted a meta-analysis to derive a single pooled MNM ratio per country. Finally, we calculated the country-related LTR-MNM and LTR-SMO estimates using our adjusted MNM ratio estimates and additional input data on fertility and mortality rates. We used the GATHER statement to guide the reporting of our methods.[13]

Procedures

All procedures were conducted using R version 4.4.1[14] and are reproducible from open data.

For more on the **procedures** see https://doi.org/10.17605/osf.io/jygvk

Since age-specific data on the MNM ratio were not available, we calculated the LTR-MNM using the MNM ratio for all reproductive ages (15–49 years) combined, following the procedure described by Gazeley and colleagues.[11] The LTR-MNM is a composite measurement that depends on the level of obstetric risk, fertility, and mortality.

$$LTR_{MNM}={}_{35}MNMRatio_{15}\cdot NRR\cdot\left(\frac{SRB}{100}+1\right)\cdot\frac{l_0}{l_{15}} \quad (1)$$

The first input is the MNM ratio for ages 15–49 years, ${}_{35}MNMRatio_{15}$. The second input is expected fertility, as a function of the net reproduction rate (NRR; the number of daughters that would be born to a female individual if she had current fertility and mortality rates over her lifetime), and the sex ratio at birth (SRB; the number of male births per one hundred female births). Jointly, the two terms incorporate a female individual's repeat exposure to the risk of MNM (fertility rates) and survival across the reproductive ages of 15–49 years (mortality rates). Finally, the third input conditions the LTR-MNM on survival to age 15 years, using the radix of the life table (100 000), l_0, divided by the number of female survivors to age 15 years, l_{15}.

We also calculated the LTR-MD analogously. Along with the LTR-MNM, the LTR-MD was used to calculate the LTR-SMO. Since SMOs are the summation of maternal deaths and MNM cases,[1] the LTR-SMO is the summation of the two lifetime risks—death or morbidity.

$$LTR_{MD}={}_{35}MMRatio_{15}\cdot NRR\cdot\left(\frac{SRB}{100}+1\right)\cdot\frac{l_0}{l_{15}} \quad (2)$$

$$LTR_{SMO}=LTR_{MD}+LTR_{MNM} \quad (3)$$

MNM data inputs

Our objective was to derive population-level estimates of the LTR-MNM for each country with available MNM data (ie, country-related estimates, which might not represent the national lifetime risk). To do so required data on the frequency of MNM. However, as the fertility and mortality data used to calculate the LTR-MNM are national, we included only multifacility, regional, or nationally representative data on the MNM ratio, excluding estimates deriving from a single facility only.

Search strategy and selection criteria

To identify eligible MNM prevalence studies, we implemented two search strategies. First, we searched Embase, MEDLINE, and Global Health for studies reporting the prevalence of MNM from Jan 1, 2010 to July 15, 2024 (appendix p 2). This search yielded 1285 results, of which 787 remained once duplicates were removed, and 130 were eligible for full-text review. Second, we searched recent systematic reviews for multifacility, regional, or national studies of MNM prevalence.[2,15–18] In total, from these two search strategies we identified 43 studies (with 80 separate estimates from 40 countries) eligible for inclusion. The appendix (pp 3–8, 9–10) shows which countries' MNM data were national only (n=18), subnational only (n=12), or both (n=10). Only two studies involved a national audit of all facilities; other national studies aimed to improve representation by randomly sampling multiple regions and facilities within regions; data were considered subnational if facilities were selected from one region only or from more than one region but without random sampling.

There is little consistency in the criteria used to identify severe maternal morbidity cases.[2,19] In 2009, WHO developed a set of 25 clinical-based, laboratory-based, and management-based criteria of organ dysfunction to standardise the measurement of MNM.[1] However, in health systems where laboratory or management capacity is inadequate, the full WHO criteria can be hard to implement, and might miss true positive MNM cases (ie, high specificity but low sensitivity).[2,19–21] Many studies therefore apply adaptations to the WHO organ dysfunction criteria to improve sensitivity in LMICs, such as lowering the units of blood transfused, including admission to intensive care, and specific severe conditions.[20–22]

Very HICs use the WHO or modified organ-dysfunction criteria, and instead often apply disease-based or management-based criteria that are more readily available from routine administrative records.[2,23] With higher sensitivity but lower specificity, disease-based and management-based criteria typically result in higher estimates of the MNM ratio than the WHO criteria.[2,19,24]

These differences in the measurement criteria can introduce substantial heterogeneity in the MNM ratio estimates; to mitigate this, we only included studies that applied either the WHO criteria of organ dysfunction or modified versions adapted for low resource settings (appendix pp 11–12). With this approach, we aimed to ensure estimates of the same severity of morbidity were included in the calculation of the lifetime risk. However, this restriction also resulted in more conservative estimates of the MNM ratio and led to the exclusion of numerous studies from HICs. In instances where multiple organ dysfunction-based criteria were applied in the same study, we included each separate MNM estimate.

Denominator adjustment

The denominator of the MNM ratio, as specified in WHO guidelines, is livebirths.[1] For studies that used deliveries (n=4), pregnant individuals (n=1), or obstetric admissions (n=1) as the denominator, we approximated livebirths using global data on the twin birth rate per 1000 deliveries during 2010–15 to partially account for multiple births,[25] and open access data on the stillbirth rate from UNICEF.[26]

See Online for appendix

Most MNM ratio estimates are derived from facility-based data. Since MNM cases require emergency intervention in a facility, facility-level estimates might approximate the true number of MNM cases in a given geographical area. The accuracy of this approximation depends on the proportion of facilities included and how referrals are accounted for. However, in countries with low institutional delivery rates, facility-based estimates of livebirths in the MNM ratio denominator might underestimate livebirths in a population. This potential bias is even greater if the MNM ratio derives only from tertiary referral facilities. To avoid overestimating the MNM ratio and the LTR-MNM, we adjusted facility-based estimates of livebirths using open access data from WHO on the institutional delivery rate from the closest available year to studies' reference period to derive a population-level estimate of total livebirths (facility livebirths multiplied by the inverse of the institutional delivery rate).[11] To test the sensitivity of our results, we also calculated the MNM ratio and the corresponding LTR-MNM without applying the denominator adjustment to the facility-based studies.

Meta-analysis

To derive estimates of the LTR-MNM for each country with available data, we first required a single, population-level estimate of the MNM ratio for each country (eg, MNM ratio for each country). For 26 of 40 countries, only a single MNM ratio estimate was available, and hence this was used as the input to the LTR-MNM. For the remaining 14 countries with multiple studies, we used a random effects meta-analysis model to derive a pooled MNM ratio estimate (R package metafor).[27] Studies were weighted by their sample size. A random-effects only model was used to partly account for the heterogeneity in study designs, study populations, and MNM criteria.[18] Our population-level MNM estimates for each country are available in the appendix (pp 13–15).

	Year*	MNM data type†	Number of MNM estimates‡	Total fertility rate§	MNM ratio¶	Maternal mortality ratio‖	LTR-MNM (1 in N)	LTR-maternal death (1 in N)**	LTR-SMO (1 in N)	Contribution of LTR-MNM to LTR-SMO††
Central and Southern Asia										
Afghanistan	2010	National only	1	6·1	7·1	898·7	24	19	11	44·3%
India	2014	Both	7	2·3	8·5	134·9	52	326	45	86·3%
Iran	2014	Subnational only	4	2·0	8·2	20·9	61	2372	59	97·5%
Nepal	2012	Both	2	2·4	2·1	287·7	206	148	86	41·7%
Pakistan	2013	Both	2	4·1	14·8	206·1	17	120	15	87·8%
Sri Lanka	2010	National only	1	2·2	4·0	37·3	114	1234	104	91·6%
Eastern and Southeastern Asia										
Cambodia	2010	National only	1	2·8	10·6	276·4	35	134	28	79·3%
China	2015	Both	6	1·7	4·1	26·0	148	2321	140	94·0%
Japan	2010	National only	1	1·4	5·9	5·7	122	12788	121	99·1%
Laos	2020	Subnational only	1	2·5	9·8	126·1	41	316	36	88·6%
Malaysia	2014	Subnational only	1	2·1	2·2	22·5	222	2146	201	90·6%
Mongolia	2010	National only	1	2·5	8·2	65·5	49	616	45	92·6%
Philippines	2010	National only	1	3·3	1·7	105·0	186	295	114	61·4%
Thailand	2010	National only	1	1·6	5·7	35·3	112	1811	106	94·2%
Viet Nam	2010	National only	1	1·9	2·0	87·6	269	608	186	69·3%
Latin America and the Caribbean										
Argentina	2012	Both	2	2·3	5·0	45·0	87	958	80	91·7%
Brazil	2011	Both	3	1·8	10·0	61·9	56	904	53	94·2%
Ecuador	2010	National only	1	2·6	2·6	76·2	150	507	116	77·2%
Guatemala	2016	Subnational only	1	3·0	61·9	103·1	6	330	5	98·4%
Honduras	2014	Subnational only	1	2·6	11·8	68·3	33	561	31	94·5%
Mexico	2010	National only	1	2·3	11·1	51·2	39	841	37	95·6%
Nicaragua	2010	National only	1	2·6	13·2	97·8	30	397	28	93·1%
Paraguay	2010	National only	1	2·7	2·1	100·5	174	369	118	67·9%
Peru	2010	National only	1	2·6	10·0	76·4	40	515	37	92·9%
Suriname	2018	National only	3	2·4	12·9	97·6	32	428	30	93·0%
Northern Africa and Western Asia										
Iraq	2010	Subnational only	1	4·4	3·9	114·9	59	200	46	77·2%
Lebanon	2010	National only	1	2·1	4·3	18·0	109	2630	105	96·0%

(Table continues on next page)

	Year*	MNM data type†	Number of MNM estimates‡	Total fertility rate§	MNM ratio¶	Maternal mortality ratio‖	LTR-MNM (1 in N)	LTR-maternal death (1 in N)**	LTR-SMO (1 in N)	Contribution of LTR-MNM to LTR-SMO††
(Continued from previous page)										
Sub-Saharan Africa										
Angola	2010	National only	1	6·2	2·6	367·3	65	46	27	41·5%
Democratic Republic of the Congo	2013	Both	2	6·5	19·7	584·6	8	28	6	77·2%
Ethiopia	2018	Subnational only	10	4·3	12·8	311·9	19	76	15	80·4%
Ghana	2016	Subnational only	1	3·9	26·9	258·1	10	103	9	91·2%
Kenya	2015	Both	3	3·8	4·5	483·0	62	57	30	48·0%
Namibia	2018	Both	3	3·5	9·6	218·0	31	138	25	81·5%
Niger	2010	National only	1	7·5	5·5	593·9	26	24	12	47·9%
Nigeria	2014	National only	3	5·7	11·3	1135·3	17	17	8	49·9%
South Africa	2014	Subnational only	3	2·4	6·2	141·2	69	303	56	81·4%
Tanzania	2012	Subnational only	1	5·1	22·3	393·7	9	52	8	85·0%
Uganda	2012	Both	2	5·8	13·6	334·4	13	54	11	80·2%
Zambia	2016	Subnational only	1	4·7	13·0	155·4	17	142	15	89·3%
Zimbabwe	2016	Subnational only	1	3·8	9·3	399·8	30	69	21	69·9%

MNM=maternal near miss. LTR-MNM=lifetime risk of maternal near miss. LTR-SMO=lifetime risk of severe maternal outcome. TFR=total fertility rate. *Year is the average of the reference period midpoints across the studies for that country. †Data type is classified as national if the input data aimed towards national representation of the MNM ratio by using multistage, random sampling to select facilities from multiple regions, provinces, or states in the country, and subnational if facilities were selected from one region or from regions without random sampling. ‡The number of MNM estimates corresponds to the number of separate studies and separate estimates within a single study (eg, if two different MNM criteria were applied, both estimates were extracted). Full details of all MNM input data are available in the appendix (pp 3–8). §Total fertility rate is expressed as births per woman and is the total number of children that would be born to a woman if she were to live to the end of her childbearing years based on observed age-specific fertility rates. We use estimates of the TFR from World Population Prospects. ¶MNM ratio is the number of MNM per 1000 livebirths; this is the denominator adjusted MNM ratio where facility-based estimates have been adjusted using the institutional delivery rate. For countries with multiple studies, this is the pooled (adjusted) MNM ratio from the random effects meta-analysis. Full meta-analysis results can be found in the appendix (pp 13–15). ‖Maternal mortality ratio is the number of maternal deaths per 100 000 livebirths. We used the WHO and UN Joint Agency estimates of the MMR, matched according to closest year. **Authors' calculation of LTR-maternal death using WHO and UN Joint Agency MMR estimate for the given country-year and equation 2 for summary estimates of the MMR. These estimates might differ from WHO and UN Joint Agency LTR-maternal death estimates. ††The LTR-MNM as a proportion of the LTR-SMO, expressed as a percentage (ie, LTR-MNM/[LTR-MNM + LTR-maternal death]).

Table: **Global estimates of the lifetime risk of MNM, maternal death, and SMO**

For the 14 countries where meta-analyses were used, sensitivity to the weighting procedure is available in the appendix (p 16); heterogeneity by country is also available (appendix pp 17–19). Univariable and multivariable meta-regression suggests the type of MNM criteria was a significant source of heterogeneity in estimates of the MNM ratio (appendix pp 19–22).

Additional data inputs

We used open-access estimates of the NRR, SRB, and l_{15} from the UN World Population Prospects (WPP) 2022 estimates[31] to calculate the LTR-MNM for each country with eligible MNM ratio data. To estimate the LTR-MD (and consequently the LTR-SMO), we used the latest WHO and Joint UN estimates of the maternal mortality ratio (MMR),[12] alongside survival and fertility data from the WPP for consistency with the LTR-MNM. Countries' stage in the obstetric transition[7,8] was categorised according to their MMR from the WHO and UN Joint Agency estimates. We calculated the relative contribution of the LTR-MNM to the overall LTR-SMO according to a country's stage in the transition: stage 1: MMR ≥500, stage 2: MMR 300–499; stage 3: MMR 100–299; stage 4a: MMR 20–99; stage 4b: MMR <20.[8]

Uncertainty analysis

We estimated uncertainty in the LTR-MNM deriving from variation in the pooled country-related MNM ratio estimate, excluding other sources of uncertainty (ie, from WPP fertility and mortality estimates). We computed the 95% CIs of the MNM ratio and the corresponding upper and lower bounds of the LTR-MNM.

Role of the funding source

The funders of the study had no role in study design, data collection, data analysis, interpretation, or writing of the report.

Results

We estimated population-level estimates of the LTR-MNM, LTR-MD, and LTR-SMO for 40 countries with multifacility, regional, or national data on the MNM ratio (table).

In central and southern Asia, the LTR-MNM ranges from 1 in 206 (Nepal in 2012) to 1 in 17 (Pakistan in 2016);

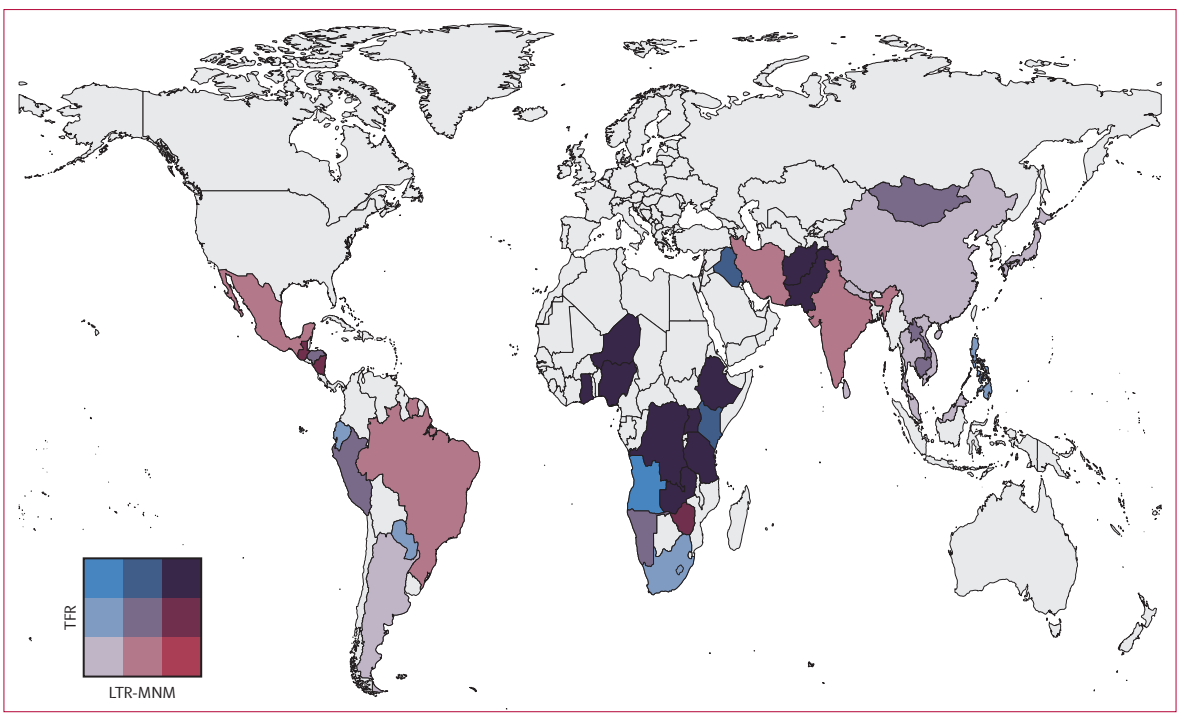

Figure 1: **Global variation in the LTR-MNM by the TFR**
LTR-MNM=lifetime risk of maternal near miss. TFR=total fertility rate.

in eastern and southeastern Asia from 1 in 269 (Viet Nam in 2010) to 1 in 35 (Cambodia in 2010); in Latin America, from 1 in 174 (Paraguay in 2010) to 1 in 6 (Guatemala in 2016); in northern Africa and west Asia, from 1 in 109 (Lebanon in 2010) to 1 in 59 (Iraq in 2010); in sub-Saharan Africa, from 1 in 69 (South Africa in 2014) to 1 in 8 (Democratic Republic of the Congo in 2016). The LTR-MNM is almost 45 times higher in Guatemala (the highest risk) than in Viet Nam (the lowest risk).

Global variation in the LTR-MD is substantially greater than for the LTR-MNM, and ranges from 1 in 12 778 (Japan in 2010) to 1 in 17 (Nigeria in 2012), representing over a 750-fold higher risk. Variation in the LTR-SMO (of having either an MNM event of dying from a maternal cause) is still substantial, but less than for either the LTR-MNM or the LTR-MD. However, 11 countries had an LTR-SMO of at least 1 in 20 risk or higher; eight of these countries are in sub-Saharan Africa. Figure 1 shows the LTR-MNM and total fertility rate (TFR, from WPP) according to three quantile classes for each indicator—ie, high (>1 in 32 lifetime risk), medium (1 in 32–65), and low (<1 in 65) LTR-MNM, and high ((>3·77 births per female individual), medium (2·42–3·77), and low (<2·42) TFR. Although most countries with a high LTR-MNM have a high TFR (eg, Democratic Republic of the Congo) and vice versa (eg, Japan), there are some countries with a high LTR-MNM despite low fertility (eg, Nicaragua).

Global inequalities in the LTR-SMO of death or MNM morbidity is substantial. Figure 2 shows that the cumulative burden of these two adverse maternal outcomes across reproductive lifetimes is the highest among countries in sub-Saharan Africa, and some parts of central and southern Asia (eg, Afghanistan and Pakistan).

The contribution of the LTR-MNM to the LTR-SMO varies according to countries' positions in the obstetric transition. Figure 3 shows that for most countries in sub-Saharan Africa in stage 1 (MMR ≥500 per 100 000 livebirths) or stage 2 (MMR 300–499 per 100 000 livebirths) of the obstetric transition, the contribution of near miss morbidity to the LTR-SMO is relatively low. However, as countries progress through the obstetric transition and mortality declines, the relative contribution of morbidity to the LTR-SMO increases. There are some exceptions: the proportion of lifetime risk from near miss morbidity is greater than expected in Tanzania and Guatemala given their mortality rates, and lower than expected in Viet Nam and Ecuador.

The relationship between countries' LTR-MNM and their LTR-MD is available in the appendix (pp 25–26). On a log–log scale, there is a positive association between a countries' LTR-MNM and their LTR-MD: countries with a high burden of MNM morbidity are likely to also have a high burden of maternal mortality across the female reproductive life course.

We calculated the LTR-MNM for estimates of the MNM without applying the denominator adjustment for facility-based studies. This adjustment makes a much greater difference in low resource contexts where the institutional delivery rate is low (appendix pp 27–28).

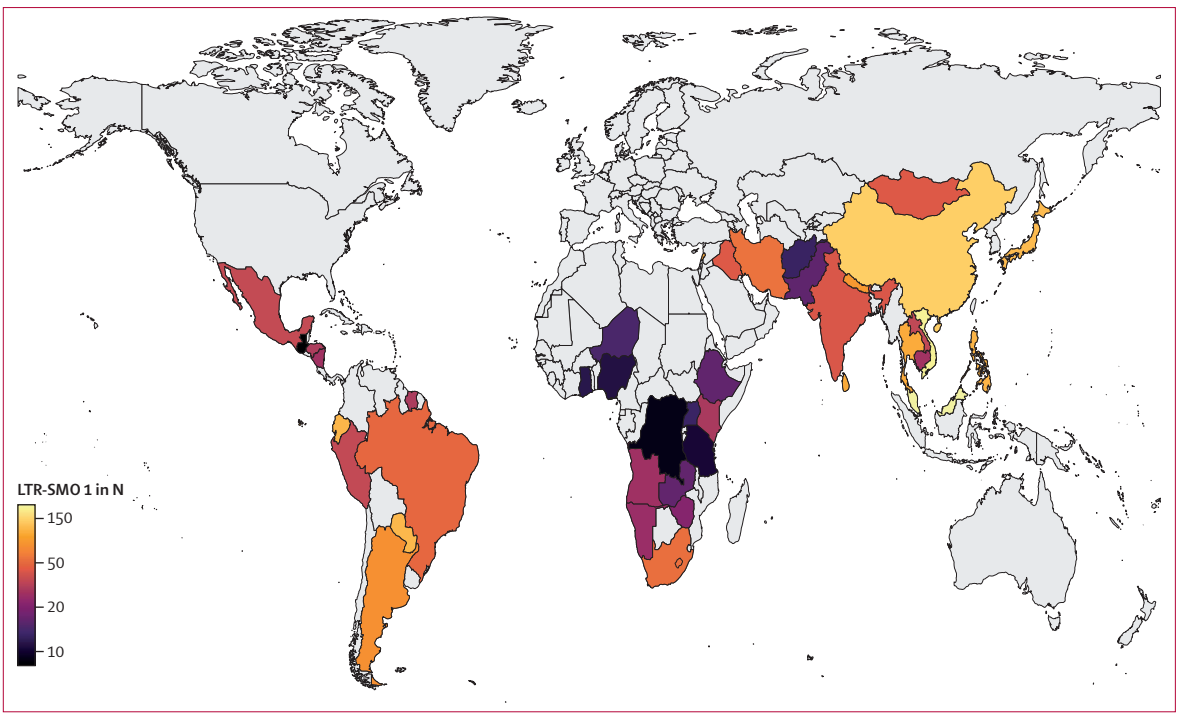

***Figure 2*: Global variation in the LTR-SMO**
LTR-SMO=lifetime risk of severe maternal outcome.

This downward adjustment of the level of obstetric risk therefore results in a lower estimate of the LTR-MNM than if this adjustment was not applied (appendix p 29).

Uncertainty in the LTR-MNM is substantial when there is a large degree of variability in the MNM ratio across studies (appendix pp 23–24).

Discussion

To our knowledge, we present the first cross-country estimates of the LTR-MNM—a new indicator that calculates the cumulative burden of severe maternal morbidity across the female reproductive life course. This measure addresses the call for more comparable measures of maternal morbidity. Unlike existing global comparisons of MNM prevalence, the LTR-MNM accounts for repeated exposure to the risk of severe maternal morbidity with each pregnancy, and survival throughout the reproductive age of 15–49 years. Capturing changes in the level of obstetric risk and accounting for prevailing fertility and mortality rates means that LTR-MNM can be a better indicator of the burden of maternal morbidity in a population than the MNM ratio.

Our results indicate that in Guatemala, female individuals aged 15 years have a 1 in 6 chance of having an MNM during their reproductive lifetime, and this is largely driven by a high (adjusted) MNM ratio estimate. In the Democratic Republic of the Congo, there is a 1 in 8 chance, due to a moderately high MNM ratio and high fertility rates. Finally, with a very low (adjusted) MNM ratio, and low fertility, we estimate that in Viet Nam, female individuals aged 15 years have a 1 in 269 chance of having a near miss in their reproductive lifetime. This substantial inter-regional and intra-regional heterogeneity in the LTR-MNM highlights persistent inequalities in maternal health outcomes. Global variation in the level of obstetric risk associated with an individual pregnancy (ie, the MNM ratio) might reflect both low access to (and poor quality of) antepartum, intrapartum, and postpartum care, and signify a health system's capacity to identify and treat complications before they progress to become life threatening.[2,3] However, the LTR-MNM also reveals how these inequalities in obstetric risk are cumulative across the female reproductive life course. High fertility rates in many sub-Saharan African countries,[28] and repeated exposure to near miss with each subsequent pregnancy, contribute to the high and extremely high LTR-MNM. These results emphasise the need to ensure access to contraception and safe abortion for all individuals who wish to use them. The LTR-MNM therefore presents a more accurate picture of the scale of global inequalities in near miss morbidity than would be implied by differences in the MNM ratio alone.[11]

We also provide the first cross-country estimates of the LTR-SMO—the risk that female individuals aged 15 years would either have an MNM complication or die from maternal cause during their reproductive lifetime. LTR-SMO is an important tool for advocacy because most MNM complications and almost all maternal

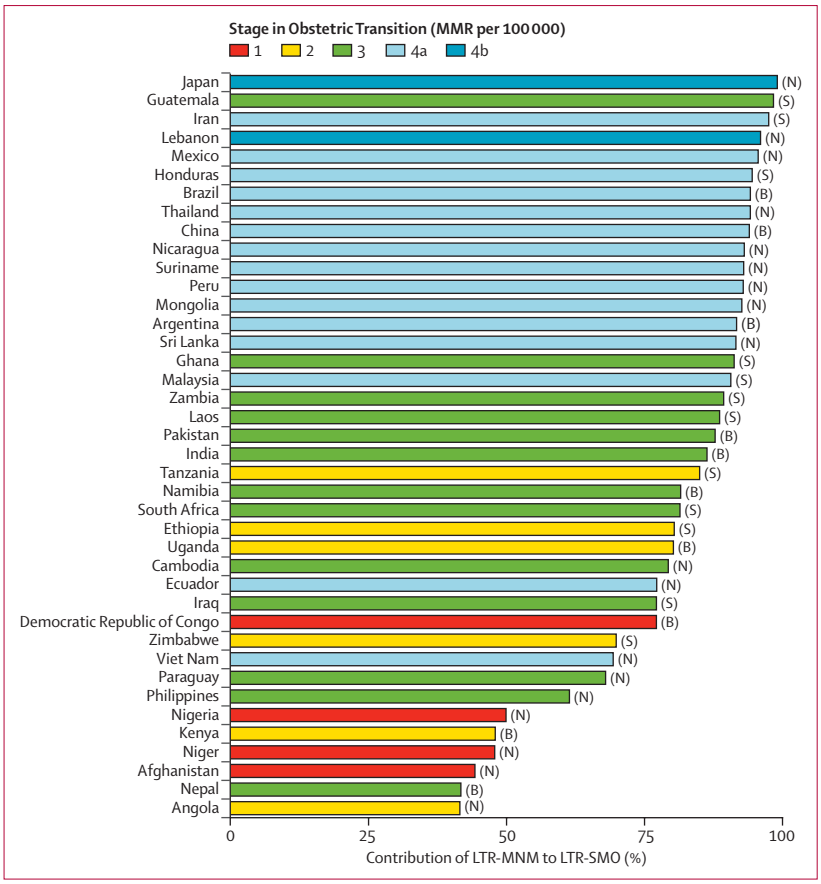

***Figure 3*: Contribution of the LTR-MNM to the LTR-SMO by stage in the obstetric transition**
LTR=MNM=lifetime risk of maternal near miss. LTR-SMO=lifetime risk of severe maternal outcome. MMR=maternal mortality ratio.

deaths are preventable. The LTR-SMO provides a more comprehensive depiction of the cross-country inequalities in reproductive outcomes and the work required to end preventable forms of maternal morbidity and mortality.[11,29]

The relative contribution of LTR-MNM to the LTR-SMO might be indicative of a country's position in the obstetric transition—the secular shift from high to low maternal mortality, and direct to indirect causes of maternal death.[7,8] As a country progresses through the obstetric transition, the capacity of the health-care system to manage severe complications and save lives should improve with expansions in access to and the quality of emergency obstetric care. Therefore, it might be expected that the contribution of LTR-MNM to the LTR-SMO would be higher for countries that are further progressed through the obstetric transition—our results largely support this. Exceptions (eg, Guatemala and Tanzania) indicate that the relative contribution of LTR-MNM to the LTR-SMO is higher than might be expected given their stage in the obstetric transition.

An unavoidable conclusion of our efforts to generate comparable estimates of the LTR-MNM is the urgent need for improved standardisation in the measurement of MNM globally.[2,4,19] To measure the same severity of maternal morbidity, we restricted estimation of the LTR-MNM to countries with national, regional, or multifacility data on the MNM ratio measured using WHO or modified WHO criteria of organ dysfunction. Many disease-based or management-based criteria of severe maternal morbidity capture part of the morbidity spectrum closer to so-called potentially life-threatening conditions, that may or may not develop into life-threatening MNM events. Studies using these broader criteria—predominantly from HICs—were excluded to avoid substantial heterogeneity in MNM measurement that may bias our LTR-MNM results. The exclusion of most HICs from our estimates reaffirms the need for increased global compliance to the WHO criteria to improve comparability of MNM data.[4]

As the standard WHO MNM criteria are not currently being implemented across all income settings, this means that we are left with an incomplete picture of global overview of global inequalities in the LTR-MNM. These SDG regions excluded from our estimates contain the countries in which almost all severe maternal outcomes are near miss events, and not maternal deaths, and hence where estimation of the LTR-MNM is imperative. Unlike most existing criteria used in HICs, the WHO near miss criteria do not use ICD codes, although ICD codes are routinely used in public health surveillance in most HICs.[19] The lack of ICD integration probably contributes to the low uptake of the WHO criteria across high-income settings.[19] The application of ICD codes to the WHO criteria might facilitate measurement in countries' routine administrative records or health management information systems. In turn, improved administrative integration might help to incentivise compliance with the WHO criteria and improve the consistency of MNM measurement across income settings.

Finally, our systematic search for MNM data highlights a lack of nationally representative MNM data in many countries. Ultimately, the development of surveillance systems to institutionalise routine collection of MNM are essential to improve the availability of national-level MNM data and their global comparability.[4,30] Continuous monitoring frameworks developed in Latin America and the Caribbean recommend prospective and retrospective identification of MNM cases in health facilities based on WHO criteria, before aggregation and review at local, regional, and national Maternal and Perinatal Morbidity and Mortality Surveillance and Response committees.[4,30] However, as electronic health records are a prerequisite for the successful implementation of these initiatives, there is a need for health system digitisation to improve national MNM surveillance in many LMICs, especially in sub-Saharan Africa.

Although this study has multiple strengths—including its novelty, advancement of population-level indicators of

maternal morbidity, and our attempts to standardise heterogeneous MNM measurement—it also has limitations.

First, the LTR-MNM is a population-average measure that does not account for heterogeneity of risk within a population (eg, by parity, age, or previous morbidity). Second, the use of WHO or modified WHO criteria might miss true MNM cases, meaning our LTR-MNM estimates could be conservative. Third, our estimates might not be nationally representative, especially for countries where the adjusted MNM ratio estimate is based only on regional or multifacility data. This limitation reiterates the need for more nationally representative MNM data. Fourth, differences in study design and MNM measurement are substantial, and for countries with multiple studies, the random-effects model might not solve all heterogeneity problems. Our approach to standardise study design differences (facility *vs* population-level MNM ratio estimates) also has a considerable effect on the estimated level of obstetric risk in some African populations. This effect emphasises the need for more standardised, population-level data on severe maternal morbidity, especially in LMICs. Finally, some input data might have included MNM cases among female individuals outside of the age range used to calculate the LTR-MNM (ie, younger than 15 years or older than 49 years), although the overall effect on the LTR-MNM is likely to be small.

Our findings expose substantial global and regional disparities in the cumulative burden of MNM morbidity across the female reproductive lifespan. The LTR-MNM and LTR-SMO are valuable indicators to emphasise the magnitude of maternal morbidity and mortality, and the need for the global community to redouble its efforts to improve maternal outcomes.

Contributors

UG conceived the idea of the study, developed the search strategy, ran the database searches, extracted the maternal near miss data, performed the computations, developed the code, and drafted the initial manuscript. JRP, JMA, AP, GR, and VF supported the refinement of the study design and the interpretation of results. AP developed the code and built the code repository. JRP, JMA, AP, GR, and VF revised the article. UG and AP accessed and verified the data. All authors had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Declaration of interests

We declare no competing interests.

Data sharing

The full list of included MNM estimates are available in the appendix. Data on the twin birth rate are available from Monden and colleagues (2021) supplementary table 2. WHO data on the institutional delivery rates are available at: https://www.who.int/data/gho/data/indicators/indicator-details/GHO/institutional-births-(-). WHO and UN Joint Agency estimates of the maternal mortality ratio are available at: https://www.who.int/publications/i/item/9789240068759. UNICEF data on the stillbirth rate are available at: https://data.unicef.org/topic/child-survival/stillbirths/#data. All fertility and mortality data used in this Article are available for download from the UN World Population Prospects Download Centre: https://population.un.org/wpp/Download/Standard/CSV/. All code is available at: https://doi.org/10.17605/osf.io/jygvk.

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