

## Maternal Health 1



# Diversity and divergence: the dynamic burden of poor maternal health

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Maternal health is a big issue and is central to sustainable development. Each year, about 210 million women become pregnant and about 140 million newborn babies are delivered—the sheer scale of maternal health alone makes maternal well being and survival vital concerns. In this Series paper, we adopt primarily a numerical lens to illuminate patterns and trends in outcomes, but recognise that understanding of poor maternal health also warrants other perspectives, such as human rights. Our use of the best available evidence highlights the dynamic burden of maternal health problems. Increased diversity in the magnitude and causes of maternal mortality and morbidity between and within populations presents a major challenge to policies and programmes aiming to match varying needs with diverse types of care across different settings. This diversity, in turn, contributes to a widening gap or differences in levels of maternal mortality, seen most acutely in vulnerable populations, predominantly in sub-Saharan Africa. Strong political and technical commitment to improve equity-sensitive information systems is required to monitor the gap in maternal mortality, and robust research is needed to elucidate major interactions between the broad range of health problems. Diversity and divergence are defining characteristics of poor maternal health in the 21st century. Progress on this issue will be an ultimate judge of sustainable development.

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### Introduction

Around 210 million women become pregnant annually, meaning that maternal health is not a marginal issue.<sup>1,2</sup> Maternal health is key to sustainable development and to future generations. Poor maternal health as measured by mortality and morbidity, however, remains an issue for marginalised women—those women who are vulnerable by virtue of where they live or who they are. As the world moves from Millennium Development Goals (MDGs) to Sustainable Development Goals (SDGs), patchy progress across regions and countries has been achieved in the reduction of maternal mortality. High mortality continues in some populations, presenting a major challenge to one of the strategic cornerstones of the SDG agenda—reducing inequities—“leaving no one behind”.<sup>3</sup> In 1876, William Farr commented on maternal death as “A deep, dark continuous stream of mortality” and asked “how long is this sacrifice to continue?”.<sup>4</sup> Drastic reductions in maternal mortality—ending the sacrifice to which William Farr refers—are realistic, and have already been achieved in some countries and for some women. The challenge to replicate this success for all populations by 2030 is complex but not insurmountable. In this Series paper, we examine two important contributors to the challenge: first, the increasing diversity in the magnitude and causes of maternal mortality and morbidity and, second, the widening inequities or divergence in these key indicators, between countries and within populations. This diversity and divergence emphasises the dynamic nature of the burden of maternal mortality and morbidity and hence the key need for dynamic health systems. We aim to use the best available evidence to

further illuminate the changing burden and so provide insights for the new strategic frameworks for action in the SDG era.<sup>5,6</sup>

### Key messages

- Pregnancy and childbirth affects the lives of millions of women and families worldwide each year. At this scale, sustainable development goal (SDG) 3 will not be achieved without reducing the burden of poor maternal health in all populations.
- Progress has been made in reducing maternal mortality globally, but this is patchy at regional and national levels—the hard-won gains over the last 25 years in some countries are susceptible to slow down.
- The causes of maternal mortality and morbidity are increasingly diverse, including a shift in the contribution of non-communicable diseases, reflecting large-scale demographic, epidemiological, socioeconomic, and environmental transitions.
- This diversity of burden has major implications for the crucial policy and programmatic goal of matching needs with care. Diverse maternal health needs require diverse maternity services, within the framework of universal health coverage.
- At the dawn of the SDG era, the distribution of poor maternal health is highly inequitable between and within populations; the gap between the group of countries with the lowest and highest maternal mortality increased from around 100 times to 200 times difference between 1990 and 2013.
- The highest burden of maternal mortality and severe morbidity clusters where health systems are weakest and where the broader context is challenging, such as in fragile states.
- In all countries, the burden falls disproportionately on the most vulnerable groups of women. This reality presents a challenge both to the rapid catch-up required to achieve grand convergence and to the underlying aim of the SDGs—“to leave no one behind”.
- Reliable population-based data on poor maternal health, disaggregated by key indicators of vulnerability, are essential to monitor widening inequities, and to inform innovative policies and programmes to halt this divergence and to manage the increasing diversity of burden..

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This paper is the first in the 2016 *Lancet* Series on maternal health. It focuses on creating the overall picture and thus relies heavily on aggregate evidence, which enables large-scale regional and international comparisons. Both the United Nations' Maternal Mortality Estimation Inter-agency Group (MMEIG)<sup>7</sup> and the Global Burden of Disease (GBD)<sup>8</sup> study estimated maternal health parameters at global, regional, and national levels, and used different but overlapping data inputs, data adjustments, and modelling methods. In this Series paper, we did not aim to compare and cross-validate different estimates, something that other papers have undertaken.<sup>9–11</sup> Instead, we pluralistically use both UN and GBD sources, drawing on each depending on the degree of temporal or regional specificity the sources provide, along with other data to produce the most appropriately disaggregated statement of the burden of poor maternal health. We acknowledge that useful insights can also be obtained from large-scale studies and datasets from individual countries. Our focus, however, is on lessons across major world regions, and specifically for low-income and middle-income countries (LMICs) where levels of fertility (the primary exposure) and maternal death (the most adverse outcome of pregnancy-related health problems) are highest. This macro-level focus is inevitably limited by the availability of relevant data. We used three main approaches to creatively fill the gaps: our own review of systematic reviews<sup>12,13</sup> on a broad range of the morbidities identified by WHO;<sup>14,15</sup> a structured review of papers with international comparative analyses and grey literature published since 2005; and secondary analyses of large-scale international data series available in the public domain.

### Acknowledgment of diversity in the burden of poor maternal health

As the MDG era ended, almost half of the world's estimated population of 7.3 billion were female, about 52% of whom were aged 15–49 years, and a further 5% were girls aged 12–14 years.<sup>1</sup> With an estimated 210 million pregnancies and 140 million livebirths annually, the sheer scale of these numbers cannot be ignored.<sup>1,2</sup> Ensuring the good health of women and newborns during and after pregnancy, as well as prevention of unintended pregnancies, has enormous implications for health systems. Thus while elimination of preventable maternal mortality<sup>16</sup> should remain a priority, it is also timely to recognise death as the tip of the iceberg beneath which lies the true diversity of the burden or consequences of pregnancy-related health problems—ie, poor maternal health. Now is the moment to revisit this burden and so refine priorities and bases for judging progress.

### The new agenda for action

The SDG agenda reflects a new chapter in which the future needs of human beings are conceptualised. The

SDGs include just one explicitly framed health goal out of 17: “Ensure healthy lives and promote well-being for all at all ages”.<sup>17</sup> This goal acknowledges a social determinants framework built on the two-way relationship between health and development.<sup>18</sup> The way SDG3 is framed has significance for all health conditions, with promotion of a broader perspective and acknowledgment of diversity. SDG3 goes beyond mortality to consider morbidity, disability, and functionality; it goes beyond physical health to include social and mental well being and also goes beyond individual episodes to a life-course perspective and intergenerational or intra-household effects. Crucially, SDG3 emphasises the universal human right of every individual to health. This emphasis provides renewed impetus and urgency to address the inequitable burden of poor maternal health. In this paper we follow the conceptualisation used in the GBD study<sup>8</sup> and refer to burden as the effect of pregnancy-related health problems as measured by mortality and morbidity. Key questions need to be revisited on where and whom this burden falls and on the evidence for divergence and increasing inequities.

Reconceptualisation of burden has already occurred for the broader domains of women's sexual and reproductive health and rights.<sup>19</sup> Life-course approaches have emerged as unifying frameworks,<sup>20</sup> bringing together important temporal dimensions for women and for their offspring. Thus the fetal origins of adult disease link with maternal conditions in pregnancy, such as diabetes; life long advantages emerge from appropriate maternal nutrition,<sup>21</sup> and the long-term sequelae of childbirth, such as prolapse, become visible. Examples of programmatic responses include attention to the first 1000 days,<sup>22</sup> emphasising preconception and adolescent health.<sup>19,23</sup>

### Maternal mortality and beyond

The current strategic frameworks<sup>5,6</sup> for the post-MDG period appropriately emphasise the unfinished agenda of the estimated 98% of maternal deaths that are preventable.<sup>24,25</sup> This emphasis should not, however, preclude acknowledgment of a broader range of pregnancy outcomes for women and newborn babies, and their implications for interventions.<sup>19,26,27</sup> The shift from normality to pathology and back within one pregnancy and between pregnancies is often unpredictable, mediated by a range of risk factors and broader determinants that influence uptake of care as well as the availability of secondary or tertiary prevention. This complexity requires special attention because of the implications for interventions, programmes, and policies, in terms of how to match needs with care, at both individual and population levels. Similarly for measurement and research, routine information systems need to be woman and family based, and to link health states across time and between a woman and her children.

### What have been major drivers of change in the burden of poor maternal health?

In this section, we highlight four transitions that define and influence diversity and divergence in the burden as measured by maternal mortality and morbidity: the demographic, epidemiological, socioeconomic, and environmental transitions.

The demographic transition towards reduced fertility and mortality provides a framework for understanding and prediction of population growth, change, and redistribution.<sup>28</sup> Global fertility patterns are closely linked to maternal health because pregnancy is the prerequisite. Although fertility has declined in almost all world regions,<sup>1</sup> the young age structure of the population and the continuing high unmet need for contraception—estimated at 225 million women in 2014<sup>2</sup>—continue to drive high rates of population growth. Population growth has obvious repercussions for sustainable development, particularly in LMICs with fragile health systems.<sup>22</sup> Projected numbers of pregnancies and deliveries have major consequences for achievement of equitable coverage and adequate quality of maternity services. Increased life expectancy associated with the demographic transition and changing roles of women are two important factors linked to older age at first birth, and so to increased prevalence and impact of obstetric complications and non-communicable diseases, such as diabetes. This increase in complications shows the interaction between demographic change and the epidemiological transition, in which patterns of disease shift from acute communicable episodes towards chronic and non-communicable conditions.<sup>29</sup> A variant specific to maternal health is called the obstetric transition, comprising a phased shift from high to low fertility and maternal mortality, and from a high to a low proportion of deaths due to direct obstetric causes.<sup>30</sup> Several analyses

indicate this obstetric transition is underway in middle-income populations, and is apparent in historical patterns from high-income countries.<sup>31</sup>

Demographic and epidemiological transitions need to be interpreted in the light of the socioeconomic transition and political drivers of change.<sup>32</sup> As noted in *The Lancet's* Women and Health Commission,<sup>19</sup> these transformations disproportionately affect women's health, rights, and roles, because of biological and gender-specific drivers. Similarly, the environmental transition of climate change, environmental degradation, and natural disasters, brings changes that are not gender neutral.<sup>19</sup> These environmental changes broadly affect human health and well being, but particularly women in relation to, for example, opportunity costs of increased time spent collecting fuel and water.<sup>33</sup>

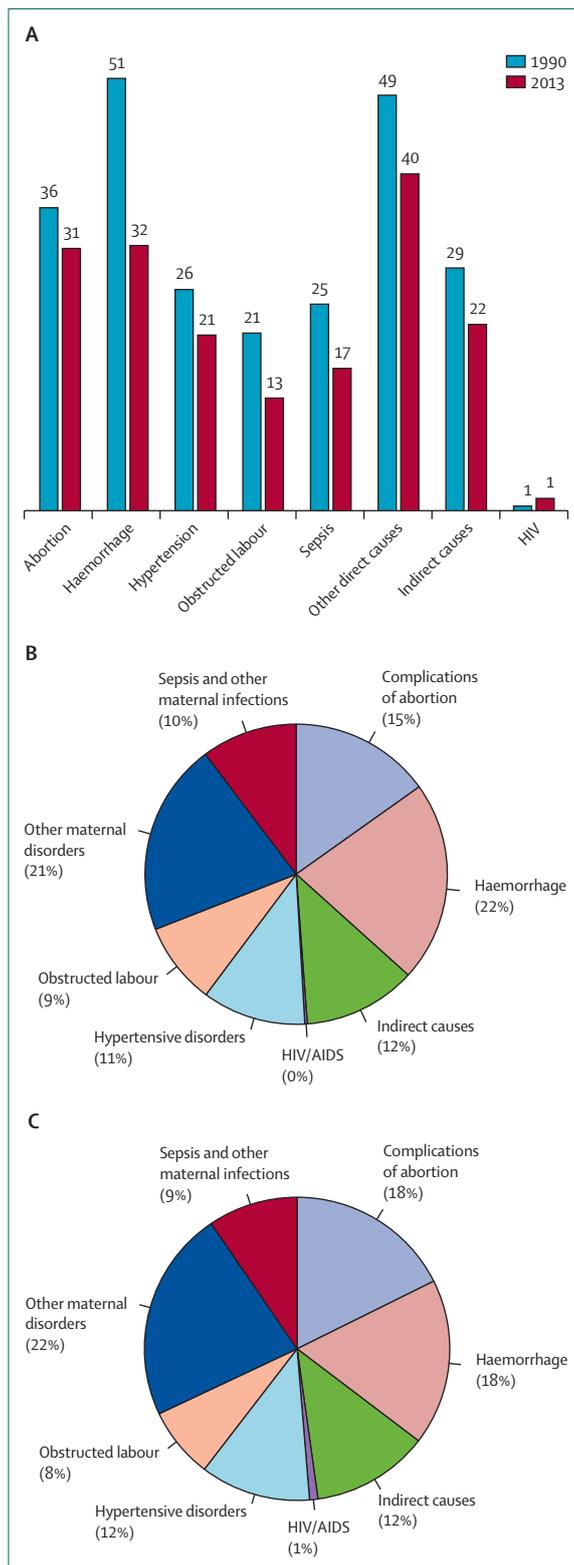
### How do we know about the burden of poor maternal health?

The range of data sources at national and international levels has changed little over the past half century, including routine health information systems, vital registration, and population-based censuses and surveys.<sup>34</sup> Many limitations in these data sources persist, such as incompleteness and poor reliability<sup>35</sup>—as does the stark reality that the poorest information exists in the poorest contexts alongside the poorest maternal health.<sup>36</sup> Almost two-thirds of births and a greater proportion of maternal deaths are unregistered or misclassified,<sup>34</sup> and population-based data on maternal morbidity, stillbirths, and newborn outcomes are particularly sparse. Improved methods in data capture, processing capacity, and analytical techniques, are encouraging but lack widespread implementation. Initiatives in LMICs to strengthen the availability of actionable data on maternal deaths—referred to as Maternal Death Surveillance and

	Maternal mortality ratio				Number of maternal deaths		Lifetime risk of maternal death*			
	1990 ratio (80% UI)	2015 ratio (80% UI)	% change 1990–2015	Average annual % change	1990	2015	1990	2015	Absolute change	Relative change
World	385 (359–427)	216 (207–249)	44%	2.3 (1.7–2.7)	532 000	303 000	73	180	107	2.47
HICs	23 (22–25)	12 (11–14)	48%	2.6 (2.1–3.0)	3500	1700	2400	4900	2500	2.04
LMICs†	430	239	44%	2.4	..	302 000	..	150	..	..
Sub-Saharan Africa	987 (898–1120)	546 (511–652)	45%	2.4 (1.6–2.8)	223 000	201 000	16	36	20	2.25
Northern Africa	171 (145–204)	70 (56–92)	59%	3.6 (2.4–4.5)	6400	3100	130	450	320	3.46
East Asia	95 (79–114)	27 (23–33)	72%	5.0 (4.0–6.0)	26 000	4800	370	2300	1930	6.22
East Asia excluding China†	51	43	16%	0.7	..	..	..	..	..	..
Southern Asia	538 (457–641)	176 (153–216)	67%	4.5 (3.5–5.2)	210 000	66 000	40	210	170	5.25
Southeastern Asia	320 (277–376)	110 (95–142)	66%	4.3 (3.1–5.0)	39 000	13 000	87	380	93	2.07
Western Asia	160 (132–199)	91 (73–125)	43%	2.2 (0.8–3.4)	6700	4700	130	360	230	2.77
Caucasus and central Asia	69 (65–73)	33 (27–45)	52%	3 (1.7–3.8)	1300	610	360	1100	740	3.06
Latin America and the Caribbean†	135	60	50%	2.8	14 000	6000	220	760	540	3.45
Oceania	391 (242–673)	187 (95–381)	52%	3.0 (1.1–4.9)	780	500	54	150	96	2.78

United Nations data from Alkema and colleagues.<sup>7</sup> HICs=high-income countries. LMICs=low-income and middle-income countries. UI=uncertainty interval. \*Expressed as 1 in N. †Uncertainty intervals not available.

**Table 1: Global and regional estimates of maternal mortality by Millennium Development Goal region.**



**Figure 1: Causes of maternal death in 1990 and 2013<sup>30</sup>**  
 (A) Cause-specific maternal mortality ratios, 1990 and 2013 (maternal deaths from cause per 100 000 livebirths). (B) Percentage distribution of causes of maternal mortality, 1990. (C) Percentage distribution of causes of maternal mortality, 2013.

Response—is an important development but requires long-term investment and commitment.<sup>37</sup> The *Lancet* Series on counting births and deaths emphasised the importance of strengthening vital registration,<sup>38</sup> and such routine cause-of-death assignment is essential for monitoring of maternal deaths.<sup>39</sup> Although challenges remain, the volume of data for global comparisons has increased over the past decade, strengthened by links to accountability mechanisms such as the Commission on Information and Accountability and Independent Expert Review Group.<sup>40</sup>

Classifications of causes of maternal mortality and morbidity have varied over time. Changes such as the introduction of late maternal deaths into International Statistical Classification of Diseases and Related Health Problems 10th Revision, and revisions in categorisation of pregnancy-related deaths in women with HIV/AIDS, present challenges to the tracking of causes over time.<sup>36,41</sup> Some conditions, such as the complications of unsafe abortion, continue to be under-reported in routine and ad-hoc sources,<sup>42</sup> while others remain poorly captured by health services, such as post-partum genital tract infection.<sup>39</sup> However, some advances in maternal classification have occurred. The GBD study<sup>43</sup> brought new insights on risk factors, co-morbidities, and sequelae, and their association with national socio-demographic scores. Similarly, work by WHO defined maternal morbidity as “any health condition attributed to and/or aggravated by pregnancy and childbirth that has a negative impact on the woman’s wellbeing”, and has identified 121 diagnostic categories, so illustrating the diversity of the morbidity burden.<sup>14,15</sup> This definition of maternal morbidity builds on earlier WHO work to develop standardised definitions of near miss cases.<sup>44</sup>

Acknowledgment of the potential for biases in morbidity data is crucial.<sup>45</sup> Information about maternal morbidity is frequently collected in hospital studies and thus only representative of women who seek care. Maternal morbidity gathered through community-based studies is rare in LMICs, and estimates of prevalence from self-reporting generally mismatch with those derived from medical assessment.<sup>46</sup> Studies reveal very high proportions of women who report pregnancy-related complications,<sup>47</sup> suggesting self-perceived ill health is not simply a result of biological change but also of social support and influences.<sup>48,49</sup> The few community-based studies that exist have focused on direct obstetric complications, and little is known about the nature and incidence of many indirect complications aggravated by pregnancy, such as asthma.

### Diversity in the burden of poor maternal health Maternal mortality

The number of maternal deaths globally has fallen continuously since 1990. The UN<sup>7</sup> estimates 303 000 maternal deaths occurred worldwide in 2015. This estimate corresponds to a fall in the maternal mortality ratio of

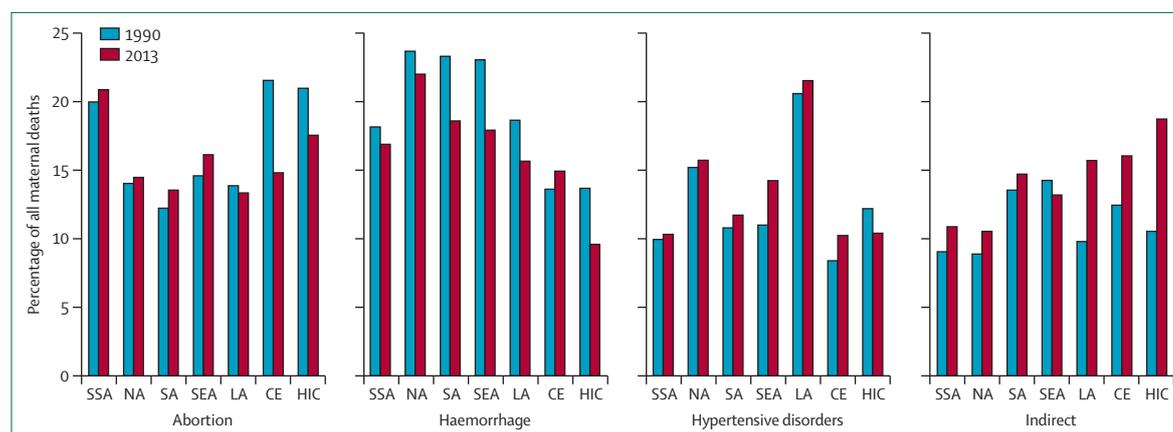
44% over 25 years (table 1). Such a decline is substantial in view of the number of women entering the reproductive period and the number of pregnancies and livebirths over the same time frame has steadily increased. The decrease in the death numerator and the increase in the livebirths denominator means the maternal mortality ratio (MMR) has fallen from 385 (uncertainty interval 359–427) per 100 000 in 1990, to 216 (207–249) per 100 000 in 2015.<sup>7</sup> Based on these midpoint estimates and uncertainty intervals, there can be reasonable confidence that a reduction in the global scale of maternal deaths has occurred. These reductions should be qualified by two messages: first, progress has been extremely patchy geographically, and second, the MDG5a target of a 75% decline in the global maternal mortality ratio from 1990 to 2015 was not achieved.

Maternal mortality varies widely across countries and world regions.<sup>7</sup> The overall maternal mortality ratio for high-income countries (12 per 100 000 livebirths) is 46 times lower than the highest figure in sub-Saharan Africa (546 per 100 000). Various indicators show wide differentials—lifetime risk reflects the widest gap because it is influenced by both levels of fertility and risk of maternal death per livebirth. The highest estimated lifetime risk in 2015 was one in 36 for sub-Saharan Africa versus one in 4900 for high-income countries—more than a 100 times difference. The sub-Saharan African region alone accounted for an estimated 66% (201 000) of global maternal deaths, followed by southern Asia at 22% (66 000 deaths). At national level, two countries account for one-third of the global total: Nigeria at 19% (58 000 deaths) and India at 15% (45 000 deaths); together with eight other countries, the proportion of global maternal deaths reaches 59%. Thus, 5% of the world's countries account for over half of maternal deaths.

Present levels of maternal mortality reflect diverse rates of change since 1990. Table 1 summarises these diverse changes for world regions, with annual average

declines from 1990 to 2015 varying from 5·0% in east Asia (China included) to 2·2% in western Asia. Declines in maternal mortality accelerated for most world regions in 2005–15 compared with 1990–2004.<sup>7</sup> National diversity was extensive, with the highest annual decline in MMR among all LMICs occurring in the Maldives at 9·2%, and the joint second highest declines occurring in Cambodia and Bhutan at 7·4%. In terms of achievement of the MDG5a target, of 95 countries with an MMR over 100 in 1990, nine achieved a 75% decline by the end of 2015. Conversely, 26 countries appeared to have had no reduction, and three countries showed increases in MMR over the period (Guyana, South Africa, and Suriname). The wide uncertainty boundaries for most national estimates emphasise the need for caution in interpretation of national trends. Nevertheless, the overall diversity in rates of change is striking.

Figure 1 shows the global picture of cause-specific mortality, using the GBD data, comparing 1990 with 2013.<sup>50</sup> All cause-specific MMRs appear to have declined over time, with the exception of HIV; the largest absolute decline occurred for haemorrhage, which had the highest MMR in 1990. The cause showing the smallest decline was abortion, as confirmed by other analyses,<sup>2</sup> closely followed by modest declines for hypertensive disorders and indirect causes. The diverse category of other direct maternal disorders, including life-threatening conditions such as embolism and complications of anaesthesia, had the second highest cause-specific MMR in 1990, but became the highest by 2013. However, the influence of improved differential diagnosis on these trends is hard to assess and an increasing number of conditions are now included in the other disorders category. Distribution of causes is shown in the pie charts in figure 1; the increased proportion owing to abortion and decrease in haemorrhage are the most notable shifts. This finding differs, however, from the results of an earlier systematic analysis and a systematic review by WHO.<sup>36,51</sup> Say and colleagues<sup>36</sup> estimated that



**Figure 2: Trends in the percentage distribution of four main causes of maternal death for world regions, 1990 and 2013**

Data are from GBD 2013 Mortality and Causes of Death Collaborators.<sup>50</sup> SSA=sub-Saharan Africa. NA=north Africa and Middle East. SA=southern Asia.

SEA=south eastern Asia, east Asia, and Oceania. LA=Latin America and Caribbean. CE=central Europe, eastern Europe, and central Asia. HIC=high-income countries.

	SSA	NA	SA	SEA	LA	CE	HIC
<b>Abortion</b>							
1990	128.0	21.9	46.9	15.1	9.7	4.4	1.3
2013	92.0	11.4	16.9	4.5	3.7	1.0	0.6
<b>Haemorrhage</b>							
1990	117.1	36.1	89.7	22.8	13.0	2.8	0.8
2013	75.1	16.6	23.3	4.9	4.5	0.9	0.3
<b>Hypertensive disorders</b>							
1990	61.1	22.4	40.0	11.0	13.7	1.7	0.6
2013	44.0	11.6	14.2	4.2	6.2	0.7	0.4
<b>Indirect</b>							
1990	56.0	13.1	51.5	13.9	6.5	2.5	0.5
2013	46.6	7.9	17.9	3.6	4.5	1.0	0.8

SSA=sub-Saharan Africa. NA=north Africa and Middle East. SA=southern Asia. SEA=southeastern Asia, east Asia, and Oceania. LA=Latin America and Caribbean. CE=central Europe, eastern Europe, and central Asia. HIC=high-income countries. \*Rates are calculated using maternal deaths from specific cause per 100 000 women of reproductive age, using GBD data.<sup>30</sup>

**Table 2: Maternal mortality rates\* for four main causes of maternal death for world regions in 1990 and 2013**

7.9% of all maternal deaths were due to abortive outcomes (95% CI 4.7–13.2%), including spontaneous or induced abortions and ectopic pregnancies; lower than the 13% reported in the earlier review<sup>51</sup> of unsafe abortion. The proportion of maternal deaths attributed to indirect causes in the GBD study (12%)<sup>30</sup> is low compared with other sources. The figure was 27% in the WHO systematic analysis,<sup>36</sup> and a similar proportion was reported from INDEPTH demographic sites.<sup>52</sup>

Figure 2 and table 2 show patterns for four main causes of maternal death across seven world regions based on the proportional distribution and mortality rates in 1990 and 2013.<sup>30</sup> Similar proportions of deaths from haemorrhage are seen across all LMIC regions and these decrease over time. Sub-Saharan Africa shows the highest death rates with the smallest declines. For two other direct causes—abortion and hypertensive disorders—more regional variation exists in proportions, rates, and trends. Sub-Saharan Africa has a higher proportion and death rates owing to abortion than to hypertension, but the reverse is true in Latin America. The pattern of indirect deaths warrants further comment. For six of seven regions, the proportional contribution of indirect causes increased between 1990 and 2013, almost doubling in the case of high-income countries, but with more modest changes elsewhere. Thus the cause-specific patterns based on percentages look different in 2013 compared with 1990, supporting our proposition of increasing diversity. However, mortality rates due to indirect causes have declined almost everywhere, but to a lesser extent than other causes, explaining the increasing proportion of indirect causes of all maternal deaths.

The WHO systematic analysis provides useful additional information to breakdown the indirect causes

fraction: 20% of deaths are linked to pre-existing medical conditions in high-income countries, compared with 12% in sub-Saharan Africa.<sup>36</sup> An important differentiating cause here is HIV: 6.4% of maternal deaths in sub-Saharan Africa and 2.7% in high-income countries are HIV related. Estimates of the probable contribution of HIV/AIDS to maternal mortality vary considerably, with most estimates higher for sub-Saharan Africa than the 6.4% as reported by WHO.<sup>36</sup> Zaba and colleagues,<sup>41</sup> for example, estimated HIV-related maternal mortality to be 24%.

### Maternal morbidity and other outcomes

In this section, we draw on multiple sources to construct a picture of morbidity related to pregnancy. The WHO Multi-Country survey<sup>30</sup> provides insights across 28 LMICs, covering almost a third of a million women who attended 357 district or tertiary hospitals. The proportion of all deliveries and complications captured by these participating facilities is unknown, but selection biases can be expected, as confirmed by a study in South Africa<sup>53</sup> Table 3 summarises the key findings from the WHO survey. Overall, for every maternal death there were just over five near misses. Of all women admitted to facilities, 0.8% experienced a near-miss episode (defined on the basis of organ dysfunction).<sup>54</sup> The pattern varied between direct obstetric causes, with rates for severe morbidity, near-miss and maternal deaths being highest for haemorrhage, although eclampsia had the worst near-miss to death ratio. Souza and colleagues<sup>30</sup> also noted the high ratio for all infections, and significant death rates from this group of causes have also been noted in the surveillance sites in the INDEPTH network.<sup>52</sup>

We reviewed published systematic reviews to provide further evidence on morbidity; the appendix contains further details on the methods used and on the findings. The burden of direct maternal morbidity was appreciable, with an estimated 27 million morbid episodes in 2015 from the five main direct obstetric causes. This estimation includes data from systematic reviews on post-partum haemorrhage (prevalence 6.2–10.8%), eclampsia (0.5%), pre-eclampsia (2.3%), and severe abortion complications (0.6%), together with the only global estimate for puerperal sepsis (4.4%). Substantial direct maternal morbidity occurs in the antepartum and post-partum period, with four systematic reviews on gestational diabetes showing prevalence estimates of 5.1% in Africa<sup>59</sup> and 17.4% across LMICs.<sup>60</sup> Extremely common mild morbidities—such as nausea and vomiting—affected an estimated 69.4% of pregnant women.<sup>61</sup> The burden of indirect maternal morbidity was also notable from our review, including from infectious diseases and mental health conditions. Mental health is commonly neglected by maternity services and is substantially associated with other forms of morbidity.<sup>62</sup> Norhayati and colleagues,<sup>63</sup> for example, found that

See Online for appendix

	All	Post-partum haemorrhage	Pre-eclampsia	Eclampsia	Puerperal endometritis	Indirect*	Abortion
Women	314 623	4716 (1.5%)	7001 (2.2%)	1008 (0.3%)	321 (0.1%)	11 163 (3.5%)	..
Livebirths	306 771	..	..	..	..	..	..
Severe maternal outcome (per 10 000 women)	3024 (96)	808 (25.7)	493 (15.7)	158 (5.0)	49 (12.4)	589 (19.0)	322 (10.2)
Maternal near miss (per 10 000 women)	2538 (81)	484 (17.6)†	262 (8.4)‡	126 (4.0)‡	..	467 (14.8)	295 (9.4)
Maternal deaths (per 10 000 women)	486 (15)	105 (3.8)†	29 (0.9)‡	32 (1.0)‡	..	122 (3.9)	27 (0.8)
Maternal near-miss mortality ratio§	5.2	4.6	9.0	3.9	..	3.8	10.9
Prevalence from systematic review in this Series paper	..	6.0–10.8%	2–3%	0.5%	..	..	0.6%
Association with early neonatal mortality; adjusted odds ratio (95% CI)	..	..	1.7 (1.4–2.2)	4.8 (3.2–6.2)	..	1.6 (1.1–2.2)¶	..

\*Denominator 314 574; conditions include infections (pyelonephritis, influenza-like illness, sepsis, and other systemic infections), chronic hypertension, severe anaemia, cancer, heart disease, lung disease, renal disease, and hepatic disease. †Denominator 274 985; excludes Japan, those with caesarean section before labour, mode of delivery unknown, induced termination of pregnancy and laparotomy for ectopic; 95.3% received prophylactic uterotonic. ‡Denominator 313 030. §Maternal near miss: one maternal death. ¶Embolic disease, cancer, heart disease, lung disease, renal disease, or hepatic disease. Data are from Souza and colleagues<sup>30</sup>, Vogel and colleagues<sup>54</sup>, Sheldon and colleagues<sup>35</sup>, Abalos and colleagues<sup>36</sup>, Lumbiganon and colleagues<sup>37</sup>, and Dragoman and colleagues.<sup>38</sup>

**Table 3: Association between maternal mortality and severe morbidity from the WHO Survey on Maternal and Newborn Health**

between 1.0% and 26.3% of post-partum women in LMICs experienced depressive disorders.

Increases in programmatic attention to newborn babies<sup>26</sup> and stillbirths<sup>64</sup> during the past decade have also brought greater consideration to maternal conditions. The link between sexually transmitted infections in pregnancy and increased risks of pre-term delivery, for example, has been understood for many years, and improved detection and treatment through antenatal care would bring many benefits.<sup>2</sup> Findings from the WHO Multi-Country survey<sup>54</sup> show 20–30% of maternal complications coincide with stillbirths and early neonatal deaths, and data from country-specific studies suggest this estimate is conservative.<sup>65</sup> A re-examination of approaches for prediction of risks in pregnancy is needed given the relevance to both maternal and newborn outcomes.<sup>26</sup> For mortality risks, the period around childbirth is crucial whereas, for morbidity outcomes, the window of opportunity for detection and management extends before, during, and after pregnancy (appendix).

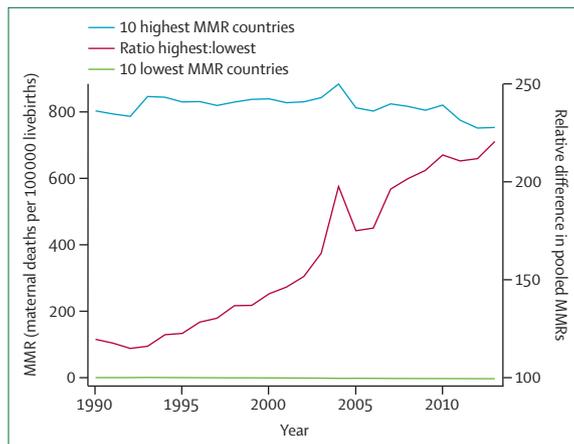
A further area of renewed attention is nutrition. Rising levels of undernutrition and overnutrition in women of reproductive age and in adolescence have major implications for maternal, newborn, and child health.<sup>21</sup> Overall, obesity (body-mass index  $\geq 30$  kg/m<sup>2</sup>) has increased in LMICs in the past 15 years. However obesity levels vary by region: wealthier women are most affected in the poorest regions, women in middle-income quintiles are most affected in South America, and women from all socioeconomic backgrounds are affected equally in the wealthiest regions. Obesity is associated with increased rates of miscarriage,<sup>66</sup> diabetes,<sup>67</sup> caesarean section,<sup>68</sup> antenatal and postnatal depression,<sup>69</sup> and adverse newborn outcomes.<sup>70–74</sup>

Long-term consequences for women's health can arise from a life-threatening episode in the most recent

pregnancy or from the incremental effects of repeated pregnancies. Many individual studies on the consequences of one pregnancy affecting maternal health in subsequent pregnancies exist, but no large-scale comparisons have been done. Consequences of previous pregnancy can be physical (eg, fistulae), mental (eg, anxiety and depression), and socioeconomic (eg, health-related debt, loss of productivity, and stigma of repeated pregnancy loss or perinatal death), and borne by the woman, her offspring, household, or community.<sup>48</sup>

The spatial diversity in maternal mortality reported earlier in this paper can be expected to be broadly similar for life-threatening morbidity. The triple impact of high fertility, poor maternal health, and low perinatal survival in sub-Saharan Africa is clear. Southern Asia shows similarly high levels of perinatal mortality as does sub-Saharan Africa, but much lower rates for maternal disability-adjusted life-years and deaths to women of reproductive age—emphasising the varying patterns between maternal and newborn outcomes. Although population projections show a fall in total fertility rates in all world regions, demographic momentum will ensure high levels of growth through to 2050 in sub-Saharan Africa. Of the 21 high-fertility countries, 19 are in this region.<sup>1</sup>

Differential access to and thus uptake of interventions also contributes to the wide variation in the prevalence of life-threatening complications. Some differences in prevalence reflect variations in biological, genetic, or lifestyle disposing factors, such as for eclampsia or diabetes. However, access to and quality of care affect both primary prevention, as in the case of puerperal infections,<sup>75</sup> and secondary prevention through prompt care for potentially life-threatening conditions, such as post-partum haemorrhage. Provision of transport to health facilities in Ethiopia, for example, has been



**Figure 3: Relative difference in pooled maternal mortality ratios in ten countries with highest level\* to ten countries with lowest level†, by year, 1990–2013**

Data are from GBD 2013 Mortality and Causes of Death Collaborators.<sup>50</sup> MMR=maternal mortality ratio. \*10 highest MMR countries (in one or more years): Afghanistan, Botswana, Burma (Myanmar), Burundi, Cameroon, Central African Republic, Chad, Côte d'Ivoire, Equatorial Guinea, Eritrea, Ethiopia, Guinea, Guinea-Bissau, Liberia, Malawi, Mauritania, Papua New Guinea, Rwanda, Sierra Leone, South Sudan, and Zimbabwe. †10 lowest MMR countries (in one or more years): Australia, Austria, Canada, Denmark, Estonia, Finland, Greece, Ireland, Israel, Italy, Montenegro, Norway, Singapore, Slovenia, Spain, Sweden, and Switzerland.

associated with substantially decreased maternal mortality.<sup>76</sup> Differences in effective coverage of care thus play a major part in the explanation of health and mortality inequities between and within populations.

### Divergence in the burden of poor maternal health

Acknowledgment that poor maternal health is unevenly distributed is important so that programmatic efforts can be prioritised and progress can be judged. The way burden clusters is a reminder of the social determinants of health,<sup>18</sup> reflecting inequities in wealth, rights, and access to care. Improvements in average levels of maternal health problems can mask increases in relative and absolute inequities between and within populations. This disparity is acknowledged in the strategic frameworks to accelerate progress in women's and children's health post-2015,<sup>5,6</sup> and in the broader case to achieve equity in health or grand convergence.<sup>77</sup>

The concept of grand convergence was proposed in *The Lancet's* Commission on Investing in Health 2035,<sup>73</sup> postulating that the next two decades provide a unique opportunity for investment to bring a substantial shift in global health equity. Health-disadvantaged countries would need to rapidly improve in the areas of child mortality, HIV, and tuberculosis. Since publication in late 2013, discussion has occurred on whether global health data<sup>78</sup> and projected trends show signs of convergence or divergence for particular world regions<sup>79</sup> and for specific conditions such as HIV/AIDS.<sup>80</sup> The results of the latest GBD report<sup>81</sup> show divergence has increased in age-specific mortality between countries for men and women aged

15–44 years, and the diversity of causes between populations has also increased—consistent with our observations. Earlier GBD analyses explored national patterns in the burden of disease in relation to Gini coefficients, observing the link between key risk factors and poverty, and noted that many countries in sub-Saharan Africa are being left behind.<sup>82</sup>

### What is the evidence for divergence between countries?

Maternal deaths are strongly clustered in LMICs, with the highest levels of maternal mortality found in the sub-Saharan African region but large numbers of deaths also occur in south Asia. Furthermore, the global distribution (table 1) shows an upward trend in the proportion of deaths occurring in sub-Saharan Africa, from 42% in 1990 to 66% in 2015—a notable increase given that this is not the most populous LMIC region. Fertility momentum is a relevant driver here, which has implications for maternity services,<sup>22</sup> and for coverage of other key interventions along the continuum of care.<sup>83</sup> From 2015 to 2050, half the world's population growth is projected to occur in nine countries,<sup>1</sup> highlighting the acute challenges facing countries in the central and west African regions with high fertility, high maternal mortality, and weak health systems.<sup>8</sup>

Figure 3 shows a steady increase over time in the relative difference of pooled MMRs for the ten countries with the highest levels to the ten countries with the lowest, using annual estimates provided by the GBD study.<sup>50</sup> Notwithstanding some fluctuations as specific countries dropped in and out of the 10 highest and 10 lowest groups, the relative difference increased steadily over the period, confirming divergence. The relative difference increased from over a 100 times difference in 1990, to over 200 times in 2013. Continued divergence would not only compromise the target for 2030 of an MMR of 70, but would also imply the lack of a rapid catch-up by the most health-disadvantaged countries which is essential for grand convergence.

Goli and Arokiasamy<sup>84</sup> explored differential progress in maternal and child mortality in 187 countries. An overall divergent trend was shown since 1990 but with some deceleration since 2000, a pattern attributed to reduced variance and skewness in rates of progress between countries. Goli and Arokiasamy<sup>84</sup> also noted that some countries are converging into clusters, defined by similar levels of mortality, with the largest cluster comprised of countries with MMRs less than 300. In other words, divergence and convergence of the burden can co-exist—some clusters of countries converge to lower mortality, while others show little or no progress, and thus diverge. Strategies to prevent maternal and child mortality therefore need to focus not just on tracking of overall change, but also to specifically target countries that lag behind.<sup>5</sup> Other analyses<sup>6,7</sup> suggest this parallel track prevailed during the MDG5 reporting period, and that countries in sub-Saharan Africa might drive divergence during the SDG era.

However, alongside increasing gaps between countries, the potential for growing inequities within countries also exists, spatially in terms of rural and urban areas or remote districts,<sup>19,85</sup> and between population subgroups.

### Is there evidence for increasing inequities in the burden of poor maternal health among women?

Burdens should be monitored at the individual level and within geopolitical areas to achieve health equity goals for all conditions. The availability of reliable data disaggregated by important covariates or determinants, such as educational status and access to care, has improved in LMICs over the past three decades, in part due to large-scale, population-based surveys such as the Demographic and Health Surveys (DHS) and Multiple Indicator Cluster Surveys.<sup>86</sup> However, in the case of maternal health, these sources have limited capacity to link individual characteristics with mortality or morbidity, but a few research studies<sup>87,88</sup> do enable this. The association between determinants and health outcomes has been a crucial lever for national and international advocacy and action for infant and child health, and this lesson should be heeded for maternal health.<sup>22,89</sup>

One proxy approach for assessment of differentials in mortality or morbidity for individual women would be to assume similar inequities to those seen for the uptake or coverage of maternity services.<sup>90</sup> Comprehensive population-based evidence from Countdown to 2015<sup>87</sup> relates women's socioeconomic and demographic characteristics to coverage for 75 LMICs. Rich–poor gaps in women's uptake of maternity services persist across rural and urban areas within countries, and across very different national levels of maternal mortality.<sup>22</sup> A study<sup>91</sup> compared intersurvey trends for 47 LMICs on wealth quintiles for a composite coverage index, including antenatal care and skilled attendant at childbirth. The rich–poor gap declined from 28% in 2000, to 19% in 2014, while subgroups of women experienced increasingly similar access to maternity services over time. However, the extent to which this progress also reduces the burden of maternal mortality and morbidity, depends on the key mediating factor of the quality of care received—timely, appropriate, effective, and respectful care is required.<sup>6</sup> Exploration of inequities in both coverage and quality is not possible from existing population-based surveys, such as the DHS.<sup>92</sup> Data captured in facilities, conversely, often has selection biases, and routine sources frequently lack information on relevant socioeconomic characteristics. The WHO Multi-Country hospital-based survey<sup>30</sup> does, however, provide some important insights. Women with the least education were found to be twice as likely to have a severe maternal outcome and nearly six times as likely to die compared with those with the highest education. The greatest difference was seen in countries with the poorest overall level of socioeconomic development.<sup>93</sup> Moreover, the poorest women often receive the poorest quality of services, including disrespectful and abusive care during labour,<sup>94,95</sup>

highlighting the crucial importance of women's agency to their health and wellbeing.<sup>19</sup>

### Grand divergence: the case of vulnerable populations

Finally, we will examine populations that show extreme divergence in the burden of poor maternal health. We refer to this as grand divergence because of the large scale and substantial implications of such inequity. The major transitions—demographic, epidemiological or obstetric, socioeconomic, and environmental—imply population-wide progression between stages over time. However, evidence on maternal mortality suggests that geographically defined populations can contain subgroups who experience little change over time and often with limited options for future progress. These subgroups can be likened to the clusters of countries defined by similar levels of mortality, mentioned earlier in the paper.<sup>84</sup> We will focus on populations who are at greatest risk of being left behind—who will not experience the rapid catch-up necessary for grand convergence.<sup>77</sup> We describe these as vulnerable populations with some—but not all—residing in countries fulfilling usual definitions of fragility.

Fragility is conventionally applied to two main population groups: those afflicted by humanitarian crises and those vulnerable because of social class, wealth, religion, or ethnicity. The specific term fragile state is applied to countries based on a broader set of factors. The Fragile State Index,<sup>96</sup> for example, ranks countries by their stability based on 12 indicators, including deterioration of public services, security threats, and sharp economic decline. In view of the gendered nature of many risks in these settings, such as sexual violence and a lack of routine and emergency services, these populations of women are indeed vulnerable. A substantial proportion of this vulnerability is found in fragile states in sub-Saharan Africa (appendix). For women, there is a stacking-up of poor maternal health, with high fertility and the natural risks faced during every pregnancy compounded by an absence of services, economic functionality, and human rights.

Vulnerability is not, however, peculiar to fragile states. Goli and Ariokasamy<sup>84</sup> highlight the pockets of disadvantage that reside within countries showing positive signs of progress at a national level. Groups of vulnerable women at increased risk of death clearly persist across the world despite global reductions in maternal mortality. The key issue is whether the well-emphasised SDG goal of greater equity—to leave no one behind—will reach these vulnerable groups who experience a disproportionate fraction of the burden of poor maternal health.

Many equity targets primarily focus on geography;<sup>5,6</sup> this focus is necessary but not sufficient to address pockets of vulnerability within populations. Universal health coverage is the proposed core mechanism for achievement of SDG3.<sup>73</sup> In view of the increasingly

diverse burden of pregnancy-related health problems and increasing divergence in levels of maternal mortality, health systems will need to be re-engineered for vulnerable groups rather than just improving coverage using current implementation strategies. As Walker and colleagues<sup>83</sup> note, innovative approaches to deliver care can help bend the curve of coverage and accelerate progress, and future improvements might be faster if starting levels are low.<sup>85</sup> Multisectoral approaches offer potential: by acknowledgment of the broader roots of vulnerability, such as gender discrimination, and promotion of opportunities for empowerment, including girls' education, and emphasis of important infrastructural interventions such as roads, and water and sanitation.<sup>97</sup> Crucially, integration of women's own perspectives will be essential to address their expressed needs in the post-2015 era.

### Conclusion

The burden of maternal mortality and morbidity is dynamic, with shifts in the magnitude, causes, and distribution over time. The outcomes and care experiences of the estimated 210 million women who were pregnant in 2015 were different from those at the turn of the millennium. Further differences will be apparent for women who experience pregnancy at the end of the SDG period in 2030. Changes in health status suggest considerable gains have been achieved for the world's population overall. However, these gains and the health rights implied have not been equitable between regions or countries, as we specifically showed for maternal mortality, the most adverse outcome of pregnancy.

Increasing diversity in the levels and causes of maternal health problems between and within populations presents a major challenge to policies and programmes aiming to match diverse needs with diverse care across diverse settings. This diversity, in turn, contributes to divergence in the magnitude of maternal mortality, seen most acutely in vulnerable populations and predominantly in sub-Saharan Africa. Diversity and divergence are thus the defining characteristics of poor maternal health in the 21st century. Political and technical commitment will be required to build an evidence base to track the health equity gap and help push the curve towards convergence. Essential improvements are needed in country capacity for equity-sensitive information systems and for robust research on the broad range of pregnancy-related problems.

Maternal mortality has long been argued as one of the most sensitive indicators of development and of functioning health systems. The importance of maternal mortality for achievement and judging of progress in the post-2015 era of SDGs and universal health coverage is clear. Equitable progress to reduce the disproportionate burden of poor maternal health should lie at the heart of new accountability frameworks:<sup>5</sup> potential gains for current and future generations are beyond words and numbers.

### Contributors

WG, SW, PB, VF, and GG conceptualised the paper. GG, SW, and VF did the literature search. Data analysis was done by WJG, SW, PB, VF, GG, and SV. SV, SW, and GG drew the figures. All authors contributed to data interpretation. WG, SW, PB, VF, and GG wrote the paper, and all other authors commented on multiple versions. The authors alone are responsible for the views expressed in this article and they do not necessarily represent the views, decisions, or policies of the institutions with which they are affiliated.

### Declaration of interest

We declare no competing interests.

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### References

- 1 United Nations, Department of Economic and Social Affairs, Population Division. World Population Prospects: The 2015 Revision, Key Findings and Advance Tables. [https://esa.un.org/unpd/wpp/Publications/Files/Key\\_Findings\\_WPP\\_2015.pdf](https://esa.un.org/unpd/wpp/Publications/Files/Key_Findings_WPP_2015.pdf) (accessed Aug 19, 2015).
- 2 Singh S, Darroch JE, Ashford LS. Adding it up: the costs and benefits of investing in sexual and reproductive health 2014. New York: Guttmacher Institute & UNFPA, 2014.
- 3 United Nations Secretary General. The road to dignity by 2030: ending poverty, transforming all lives and protecting the planet. Synthesis report of the secretary-general on the post-2015 agenda. New York: United Nations, 2014.
- 4 Oakley A. The captured womb: a history of the medical care of pregnant women. Oxford: Blackwell, 1984.
- 5 Temmerman M, Khosla R, Bhutta ZA, Bustreo F. Towards a new Global Strategy for Women's, Children's and Adolescents' Health. *BMJ* 2015; **351**: h4414.
- 6 Chou D, Daelmans B, Jolivet RR, Kinney M, Say L. Ending preventable maternal and newborn mortality and stillbirths. *BMJ* 2015; **351**: h4255.
- 7 Alkema L, Chou D, Hogan D, et al. Global, regional, and national levels and trends in maternal mortality between 1990 and 2015, with scenario-based projections to 2030: a systematic analysis by the UN Maternal Mortality Estimation Inter-Agency Group. *Lancet* 2016; **387**: 462–74.
- 8 Kassebaum NJ, Bertozzi-Villa A, Coggeshall MS, et al. Global, regional, and national levels and causes of maternal mortality during 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet* 2014; **384**: 980–1004.
- 9 Abouzahr C. New estimates of maternal mortality and how to interpret them: choice or confusion? *Reprod Health Matters* 2011; **19**: 117–28.
- 10 Dorrington RE, Bradshaw D. Acknowledging uncertainty about maternal mortality estimates. *Bull World Health Organ* 2016; **94**: 155–56.
- 11 Kassebaum NJ, Lopez AD, Murray CJL, Lozano R. A comparison of maternal mortality estimates from GBD 2013 and WHO. *Lancet* 2014; **384**: 2209–10.
- 12 Smith V, Devane D, Begley CM, Clarke M. Methodology in conducting a systematic review of systematic reviews of healthcare interventions. *BMC Med Res Methodol* 2011; **11**: 15.
- 13 Stroup DF, Berlin JA, Morton SC, et al. Meta-analysis of observational studies in epidemiology: a proposal for reporting. Meta-analysis Of Observational Studies in Epidemiology (MOOSE) group. *JAMA* 2000; **283**: 2008–12.
- 14 Firoz T, Chou D, von Dadelszen P, et al. Measuring maternal health: focus on maternal morbidity. *Bull World Health Organ* 2013; **91**: 794–96.
- 15 Chou D, Tunçalp Ö, Firoz T, et al. Constructing maternal morbidity—towards a standard tool to measure and monitor maternal health beyond mortality. *BMC Pregnancy Childbirth* 2016; **16**: 45.
- 16 WHO. Strategies toward ending preventable maternal mortality (EPMM). Geneva: World Health Organization, 2015.
- 17 United Nations Social and Economic Affairs. Global Sustainable Development Report 2015 Edition. New York: United Nations, 2015.

- 18 Commission on Social Determinants of Health. Closing the gap in a generation: health equity through action on the social determinants of health. Final Report of the Commission on Social Determinants of Health. Geneva: World Health Organization 2008.
- 19 Langer A, Meleis A, Knaul FM, et al. Women and health: the key for sustainable development. *Lancet* 2015; **386**: 1165–210.
- 20 Azenha GS, Parsons-Perez C, Goltz S, et al. Recommendations towards an integrated, life-course approach to women's health in the post-2015 agenda. *Bull World Health Organ* 2013; **91**: 704–06.
- 21 Black RE, Victora CG, Walker SP, et al. Maternal and child undernutrition and overweight in low-income and middle-income countries. *Lancet* 2013; **382**: 427–51.
- 22 Requejo JH, Bhutta ZA. The post-2015 agenda: staying the course in maternal and child survival. *Arch Dis Child* 2015; **100** (suppl 1): 76–81.
- 23 UNICEF. Adolescence: an age of opportunity. New York: UNICEF, 2011.
- 24 Mahler H. The safe motherhood initiative: a call to action. *Lancet* 1987; **1**: 668–70.
- 25 Ronsmans C, Graham WJ, for the *Lancet* Maternal Survival Series steering group. Maternal mortality: who, when, where, and why. *Lancet* 2006; **368**: 1189–200.
- 26 Lawn JE, Blencowe H, Oza S, et al. Every Newborn: progress, priorities, and potential beyond survival. *Lancet* 2014; **384**: 189–205.
- 27 ten Hoop-Bender P, de Bernis L, Campbell J, et al. Improvement of maternal and newborn health through midwifery. *Lancet* 2014; **384**: 1226–35.
- 28 Oded G. The demographic transition: causes and consequences. *Cliometrica* 2012; **6**: 1–28.
- 29 Omran AR. The epidemiologic transition. A theory of the epidemiology of population change. *Milbank Mem Fund Q* 1971; **49**: 509–38.
- 30 Souza JP, Gülmezoglu AM, Vogel J, et al. Moving beyond essential interventions for reduction of maternal mortality (the WHO Multicountry Survey on Maternal and Newborn Health): a cross-sectional study. *Lancet* 2013; **381**: 1747–55.
- 31 Högberg U. The decline in maternal mortality in Sweden: the role of community midwifery. *Am J Public Health* 2004; **94**: 1312–20.
- 32 Frenk J, Bobadilla JL, Stern C, Frejka T, Lozano R. Elements for a theory of the health transition. *Health Transit Rev* 1991; **1**: 21–38.
- 33 Watts N, Adger NA, Agnolucci P, et al. Health and climate change: policy responses to protect public health. *Lancet* 2015; **386**: 1861–914.
- 34 Oomman N, Mehl G, Berg M, Silverman R. Modernising vital registration systems: why now? *Lancet* 2013; **381**: 1336–37.
- 35 Byass P. The unequal world of health data. *PLoS Med* 2009; **6**: e1000155.
- 36 Say L, Chou D, Gemmill A, et al. Global causes of maternal death: a WHO systematic analysis. *Lancet Glob Health* 2014; **2**: e323–33.
- 37 Hounton S, De Bernis L, Hussein J, et al. Towards elimination of maternal deaths: maternal deaths surveillance and response. *Reprod Health* 2013; **10**: 1.
- 38 AbouZahr C, de Savigny D, Mikkelsen L, et al. Civil registration and vital statistics: progress in the data revolution for counting and accountability. *Lancet* 2015; **386**: 1373–85.
- 39 Byass P. Uncounted causes of death. *Lancet* 2016; **387**: 26–27.
- 40 Independent Expert Review Group (iERG). Every Woman, Every Child, Every Adolescent: Achievements and Prospects. Geneva: World Health Organization, 2015.
- 41 Zaba B, Calvert C, Marston M, et al. Effect of HIV infection on pregnancy-related mortality in sub-Saharan Africa: secondary analyses of pooled community-based data from the network for Analysing Longitudinal Population-based HIV/AIDS data on Africa (ALPHA). *Lancet* 2013; **381**: 1763–71.
- 42 Sedgh G, Singh S, Shah IH, AAhman E, Henshaw SK, Bankole A. Induced abortion: incidence and trends worldwide from 1995 to 2008. *Lancet* 2012; **379**: 625–32.
- 43 Murray CJL, Barber RM, Foreman KJ, et al. Global, regional, and national disability-adjusted life years (DALYs) for 306 diseases and injuries and healthy life expectancy (HALE) for 188 countries, 1990–2013: quantifying the epidemiological transition. *Lancet* 2015; **386**: 2145–91.
- 44 Say L, Souza JP, Pattinson RC, for the WHO working group on maternal mortality and morbidity classifications. Maternal near miss – towards a standard tool for monitoring quality of maternal health care. *Best Pract Res Clin Obstet Gynaecol* 2009; **23**: 287–96.
- 45 Filippi V, Chou D, Ronsmans C, Graham W, Say L. Levels and causes of maternal morbidity and mortality. In: Disease control priorities. Washington, DC: World Bank, 2016.
- 46 Ronsmans C, Achadi E, Cohen S, Zazri A. Women's recall of obstetric complications in south Kalimantan, Indonesia. *Stud Fam Plann* 1997; **28**: 203–14.
- 47 Lagro M, Liche A, Mumba T, Ntebeka R, van Roosmalen J. Postpartum health among rural Zambian women. *Afr J Reprod Health* 2003; **7**: 41–48.
- 48 Filippi V, Ganaba R, Baggaley RF, et al. Health of women after severe obstetric complications in Burkina Faso: a longitudinal study. *Lancet* 2007; **370**: 1329–37.
- 49 Saurel-Cubizolles MJ, Romito P, Lelong N, Ancel PY. Women's health after childbirth: a longitudinal study in France and Italy. *BJOG* 2000; **107**: 1202–09.
- 50 GBD 2013 Mortality and Causes of Death Collaborators. Global, regional, and national age-sex specific all-cause and cause-specific mortality for 240 causes of death, 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet* 2015; **385**: 117–71.
- 51 Khan KS, Wojdyla D, Say L, Gülmezoglu AM, Van Look PFA. WHO analysis of causes of maternal death: a systematic review. *Lancet* 2006; **367**: 1066–74.
- 52 Streatfield PK, Alam N, Compaoré Y, et al. Pregnancy-related mortality in Africa and Asia: evidence from INDEPTH Health and Demographic Surveillance System sites. *Glob Health Action* 2014; **7**: 25368.
- 53 Soma-Pillay P, Pattinson RC, Langa-Mlambo L, Nkosi BS, Macdonald AP. Maternal near miss and maternal death in the Pretoria Academic Complex, South Africa – a population-based study. *S Afr Med J* 2015; **105**: 578–63.
- 54 Vogel J, Souza J, Mori R, et al. Maternal complications and perinatal mortality: findings of the World Health Organization Multicountry Survey on Maternal and Newborn Health. *BJOG* 2014; **121**: 76–88.
- 55 Sheldon WR, Blum J, Vogel JP, Souza JP, Gülmezoglu AM, Winikoff B. Postpartum haemorrhage management, risks, and maternal outcomes: findings from the World Health Organization Multicountry Survey on Maternal and Newborn Health. *BJOG* 2014; **121**: 5–13.
- 56 Abalos E, Cuesta C, Carroli G, et al. Pre-eclampsia, eclampsia and adverse maternal and perinatal outcomes: a secondary analysis of the World Health Organization Multicountry Survey on Maternal and Newborn Health. *BJOG* 2014; **121** (suppl 1): 14–24.
- 57 Lumbiganon P, Laopaiboon M, Intarut N, et al. Indirect causes of severe adverse maternal outcomes: a secondary analysis of the WHO Multicountry Survey on Maternal and Newborn Health. *BJOG* 2014; **121** (suppl 1): 32–39.
- 58 Dragoman M, Sheldon W, Qureshi Z, et al. Overview of abortion cases with severe maternal outcomes in the WHO Multicountry Survey on Maternal and Newborn Health: a descriptive analysis. *BJOG* 2014; **121**: 25–31.
- 59 Mwanri AW, Kinabo J, Ramaiya K, Feskens EJM. Gestational diabetes mellitus in sub-Saharan Africa: systematic review and meta-regression on prevalence and risk factors. *Trop Med Int Health* 2015; **20**: 983–1002.
- 60 Kanguru L, Bezawada N, Hussein J, Bell J. The burden of diabetes mellitus during pregnancy in low- and middle-income countries: a systematic review. *Glob Health Action* 2014; **7**: 23987.
- 61 Einarson TR, Piwko C, Koren G. Quantifying the global rates of nausea and vomiting of pregnancy: a meta-analysis. *J Popul Ther Clin Pharmacol* 2013; **20**: e171–83.
- 62 Prince M, Patel V, Saxena S, et al. No health without mental health. *Lancet* 2007; **370**: 859–77.
- 63 Norhayati MN, Hazlina NHN, Asrenee AR, Emilin WMAW. Magnitude and risk factors for postpartum symptoms: a literature review. *J Affect Disord* 2015; **175**: 34–52.
- 64 Blencowe H, Cousens S, Bianchi Jassir F, et al. National, regional, and worldwide estimates of stillbirth rates in 2015, with trends from 2000: a systematic analysis. *Lancet Glob Health* 2016; **4**: e98–108.
- 65 Allanson ER, Muller M, Pattinson RC. Causes of perinatal mortality and associated maternal complications in a South African province: challenges in predicting poor outcomes. *BMC Pregnancy Childbirth* 2015; **15**: 37.

- 66 Boots C, Stephenson MD. Does obesity increase the risk of miscarriage in spontaneous conception: a systematic review. *Semin Reprod Med* 2011; **29**: 507–13.
- 67 Torloni MR, Betrán AP, Horta BL, et al. Prepregnancy BMI and the risk of gestational diabetes: a systematic review of the literature with meta-analysis. *Obes Rev* 2009; **10**: 194–203.
- 68 Poobalan AS, Aucott LS, Gurung T, Smith WCS, Bhattacharya S. Obesity as an independent risk factor for elective and emergency caesarean delivery in nulliparous women—systematic review and meta-analysis of cohort studies. *Obes Rev* 2009; **10**: 28–35.
- 69 Molyneaux E, Poston L, Ashurst-Williams S, Howard LM. Obesity and mental disorders during pregnancy and postpartum: a systematic review and meta-analysis. *Obstet Gynecol* 2014; **123**: 857–67.
- 70 Rasmussen SA, Chu SY, Kim SY, Schmid CH, Lau J. Maternal obesity and risk of neural tube defects: a metaanalysis. *Am J Obstet Gynecol* 2008; **198**: 611–19.
- 71 Faucher MA, Barger MK. Gestational weight gain in obese women by class of obesity and select maternal/newborn outcomes: A systematic review. *Women Birth* 2015; **28**: e70–79.
- 72 Gaudet L, Ferraro ZM, Wen SW, Walker M. Maternal obesity and occurrence of fetal macrosomia: a systematic review and meta-analysis. *Biomed Res Int* 2014; **2014**: 640291.
- 73 Meehan S, Beck CR, Mair-Jenkins J, Leonardi-Bee J, Puleston R. Maternal obesity and infant mortality: a meta-analysis. *Pediatrics* 2014; **133**: 863–71.
- 74 Kanadys WM, Leszczyńska-Gorzela B, Jedrych M, Oleszczuk J. Maternal pre-pregnancy obesity and the risk of preterm birth: a systematic overview of cohort studies with meta-analysis. *Ginekol Pol* 2012; **83**: 270–79.
- 75 Graham WJ, Dancer SJ, Gould IM, Stones W. Childbed fever: history repeats itself? *BJOG* 2015; **122**: 156–85.
- 76 Godefay H, Kinsman J, Admasu K, Byass P. Can innovative ambulance transport avert pregnancy-related deaths? One-year operational assessment in Ethiopia. *J Glob Health* 2016; **6**: 010410.
- 77 Jamison DT, Summers LH, Alleyne G, et al. Global health 2035: a world converging within a generation. *Lancet* 2013; **382**: 1898–955.
- 78 Byass P. A transition towards a healthier global population? *Lancet* 2015; **386**: 2121–22.
- 79 Mahbubani K. The great convergence. Asia, the West, and the logic of one world. New York: Public Affairs, 2013.
- 80 Piot P, Abdool Karim SS, Hecht R, et al. Defeating AIDS-advancing global health. *Lancet* 2015; **386**: 171–218.
- 81 GBD 2013 Risk Factors Collaborators. Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks in 188 countries, 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet* 2015; **386**: 2287–323.
- 82 Lim SS, Vos T, Flaxman AD, et al. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet* 2012; **380**: 2224–60.
- 83 Walker N, Yenokyan G, Friberg IK, Bryce J. Patterns in coverage of maternal, newborn, and child health interventions: projections of neonatal and under-5 mortality to 2035. *Lancet* 2013; **382**: 1029–38.
- 84 Goli S, Arokiasamy P. Maternal and child mortality indicators across 187 countries of the world: converging or diverging. *Glob Public Health* 2014; **9**: 342–60.
- 85 World Health Organization, International Center for Equity in Health. State of inequality: reproductive, maternal, newborn and child health: interactive visualization of health data. 2015.
- 86 Victora CG, Requejo JH, Barros AJD, et al. Countdown to 2015: a decade of tracking progress for maternal, newborn, and child survival. *Lancet* 2016; **387**: 2047–59.
- 87 Godefay H, Byass P, Graham WJ, Kinsman J, Mulugeta A. Risk factors for maternal mortality in rural Tigray, northern Ethiopia: A case-control study. *PLoS One* 2015; **10**: e0144975.
- 88 Graham WJ, Fitzmaurice AE, Bell JS, Cairns JA. The familial technique for linking maternal death with poverty. *Lancet* 2004; **363**: 23–27.
- 89 Graham WJ, Witter S. Counting what counts for maternal mortality. *Lancet* 2014; **384**: 933–35.
- 90 The Partnership for Maternal, Newborn & Child Health. A global review of the key interventions related to reproductive, maternal, newborn and child health. Geneva: PMNCH, 2011.
- 91 Victora CG, Barros AJ, Axelson H, et al. How changes in coverage affect equity in maternal and child health interventions in 35 Countdown to 2015 countries: an analysis of national surveys. *Lancet* 2012; **380**: 1149–56.
- 92 Graham WJ, McCaw-Binns A, Munjanja S. Translating coverage gains into health gains for all women and children: the quality care opportunity. *PLoS Med* 2013; **10**: e1001368.
- 93 Tunçalp Ö, Souza J, Hindin M, et al. Education and severe maternal outcomes in developing countries: a multicountry cross-sectional survey. *BJOG* 2014; **121**: 57–65.
- 94 Kruk ME, Kujawski S, Mbaruku G, Ramsey K, Moyo W, Freedman LP. Disrespectful and abusive treatment during facility delivery in Tanzania: a facility and community survey. *Health Policy Plan* 2014; published online Oct 1. DOI:10.1093/heapol/czu079.
- 95 Freedman LP, Kruk ME. Disrespect and abuse of women in childbirth: challenging the global quality and accountability agendas. *Lancet* 2014; **384**: e42–44.
- 96 Messner JJ, Haken N, Taft P, et al. Fragile State Index 2015. Washington, DC: Fund for Peace, 2015.
- 97 Velleman Y, Mason E, Graham W, et al. From joint thinking to joint action: a call to action on improving water, sanitation, and hygiene for maternal and newborn health. *PLoS Med* 2014; **11**: e1001771.