

# A prospective study of maternal, fetal and neonatal deaths in low- and middle-income countries

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**Objective** To quantify maternal, fetal and neonatal mortality in low- and middle-income countries, to identify when deaths occur and to identify relationships between maternal deaths and stillbirths and neonatal deaths.

**Methods** A prospective study of pregnancy outcomes was performed in 106 communities at seven sites in Argentina, Guatemala, India, Kenya, Pakistan and Zambia. Pregnant women were enrolled and followed until six weeks postpartum.

**Findings** Between 2010 and 2012, 214 070 of 220 235 enrolled women (97.2%) completed follow-up. The maternal mortality ratio was 168 per 100 000 live births, ranging from 69 per 100 000 in Argentina to 316 per 100 000 in Pakistan. Overall, 29% (98/336) of maternal deaths occurred around the time of delivery: most were attributed to haemorrhage (86/336), pre-eclampsia or eclampsia (55/336) or sepsis (39/336). Around 70% (4349/6213) of stillbirths were probably intrapartum; 34% (1804/5230) of neonates died on the day of delivery and 14% (755/5230) died the day after. Stillbirths were more common in women who died than in those alive six weeks postpartum (risk ratio, RR: 9.48; 95% confidence interval, CI: 7.97–11.27), as were perinatal deaths (RR: 4.30; 95% CI: 3.26–5.67) and 7-day (RR: 3.94; 95% CI: 2.74–5.65) and 28-day neonatal deaths (RR: 7.36; 95% CI: 5.54–9.77).

**Conclusion** Most maternal, fetal and neonatal deaths occurred at or around delivery and were attributed to preventable causes. Maternal death increased the risk of perinatal and neonatal death. Improving obstetric and neonatal care around the time of birth offers the greatest chance of reducing mortality.

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## Introduction

An estimated 340 000 maternal deaths, 2.7 million stillbirths and 3.1 million neonatal deaths occur worldwide each year – almost all in low-income countries.<sup>1–4</sup> In some parts of sub-Saharan Africa, a woman's lifetime risk of dying in childbirth is as high as one in seven.<sup>2</sup> Although women may die at any time during pregnancy and up to six weeks postpartum, the majority die during the last trimester or within the first week following birth.<sup>5</sup> Similarly, it has been estimated that, in low-income countries almost half of stillbirths occur during or around the time of delivery and nearly three quarters of neonatal deaths take place within the first few days following

birth.<sup>6–9</sup> Thus, the period around delivery is thought to be the time when the woman and her fetus or infant are at the highest risk of dying.

Although the timing of the mother's death will, in itself, have a substantial influence on the risk of a fetal or neonatal death, the conditions that cause maternal death will also contribute to the risk.<sup>4,10–19</sup> For example, pre-eclampsia and eclampsia are important causes of maternal death and major contributors to fetal and neonatal mortality because of their association with asphyxia and preterm birth.<sup>13,18</sup> Haemorrhage and obstructed labour increase the risk of both stillbirth and early neonatal death associated with birth asphyxia.<sup>19</sup> In addition, intrapartum stillbirth is usually attributed to obstetric

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conditions.<sup>14–17</sup> Rates of maternal death, stillbirth – especially intrapartum stillbirth – and early neonatal death have all declined markedly in high- and some middle-income countries, primarily because of improved obstetric care. However, similar reductions have not yet been achieved in low-income countries, where maternal, fetal and neonatal mortality rates remain high.<sup>11,20</sup>

In low-income countries, one half to two thirds of births occur either at home or in community health clinics, often without a skilled health-care worker being present.<sup>9,21,22</sup> In these situations, it may not always be possible to transfer a woman to an emergency obstetric care facility in time to perform a life-saving procedure should the need arise.<sup>23–25</sup> Furthermore, as more emphasis is placed on delivery at health-care facilities and as women become more aware of the benefits, there has been an increase in the workload at referral hospitals in low-resource areas, many of which are under-equipped and understaffed.<sup>25–27</sup> Thus, even when a referral is made, the quality of care is often inadequate, especially for women who arrive late with a complication.<sup>10</sup>

However, maternal deaths are relatively rare even in areas with a high maternal mortality rate and, as a result, few studies have investigated maternal deaths and their relationship to fetal and newborn outcomes. Those that have been performed have generally been limited to hospital births and have included only a small number of deaths.<sup>27–30</sup> Consequently, it is difficult to generalize their findings. One ecological study, which used demographic and health surveillance data to evaluate the association between childhood and maternal deaths in Bangladesh, found that the probability of survival to the age of 10 years was 24% for children whose mothers died compared with 89% for those whose mothers were still alive at their tenth birthday.<sup>28</sup>

Since there is a lack of population based studies on maternal and perinatal mortality we wanted to determine the rate and timing of maternal death among a large group of women who gave birth in the community in several low- and middle income countries and to investigate associations between maternal death and stillbirth and neonatal death.

## Methods

Between 2010 to 2012, as part of a prospective, maternal newborn health

study of all pregnancies, we documented maternal, fetal and neonatal deaths that occurred up to six weeks postpartum. The study was done in 106 communities at six sites in five low-income countries (Chimaltenango, Guatemala; Nagpur District and Karnataka District, India; Western Province, Kenya; Thatta District, Pakistan; and Lusaka, Zambia) and at one site in a middle-income country (Corrientes, Argentina).<sup>9</sup> These seven sites were selected by the Eunice Kennedy Shriver National Institute of Child Health and Human Development in the United States of America (USA), which supports the Global Network for Women's and Children's Health Research, to represent rural or semi-urban geographical areas served by government health services. Each site included between six and 24 distinct communities. In general, each community represented the catchment area of a primary health-care centre and, in each, 300 to 500 births took place annually. Beginning in 2009, the study investigators at each site initiated an ongoing, prospective maternal and newborn health registry of pregnant women for each community. The objective was to enrol pregnant women by 20 weeks' gestation and to obtain data on pregnancy outcomes for all deliveries that took place in the community. Each community employed a registry administrator who identified and tracked pregnancies and their outcomes in coordination with community elders, birth attendants and other health-care workers.

All pregnant women resident in study communities were eligible for inclusion. Women were enrolled during pregnancy and data on pregnancy outcomes were collected by the trained registry administrators – usually nurses or health workers – who were supervised by study site investigators. At each site, efforts were made to verify that all pregnant women residing in the study communities were included in the registry and that data on all outcomes had been obtained. The study coordinators, who were generally nurses or physicians, monitored enrolment and follow-up to ensure that the data collected were consistent, complete and of a high quality. For hospital births, registry administrators reviewed hospital birth records routinely to identify deliveries to women from the study communities. In addition, culturally appropriate strategies were used at each site to ensure that all

outcomes were reported. For example, elders or chiefs in one village used mobile phones to send text messages when women enrolled in the study gave birth. Such strategies increased the likelihood that we were able to identify all pregnancies and maternal and fetal outcomes.

Demographic and medical data were obtained for each woman by either the registry administrator or the study coordinator. All deaths that occurred during pregnancy or in the six weeks postpartum were reported using World Health Organization (WHO) classifications.<sup>31</sup> The cause of each maternal death was assigned by the registry administrator on the basis of clinical and other information provided by the birth attendant and the woman's family. All death reports were reviewed by the supervising physician at the study site. For deaths for which a definite cause could not be established, we undertook a secondary investigation to identify contributing factors, such as haemorrhage, pre-eclampsia, eclampsia or obstructed labour, and classified the cause accordingly. Details of this procedure have been described elsewhere.<sup>9</sup>

Study data were entered onto Microsoft Access computer files (Microsoft, Redmond, USA) at each study site and data were edited before transmission to the central data centre at RTI International in the United States, where additional data edits were performed and the data were analysed using SAS version 9.2 (SAS Institute, Cary, USA). The study findings were reported using descriptive statistics and risk ratios were calculated for maternal, fetal and neonatal outcomes. Generalized estimation equations were used to adjust for the characteristics of each site and for clustering.

The study was approved by university review boards at each local site, by partner universities in the United States and by RTI International and was registered as trial NCT01073475 at the ClinicalTrials.gov registry (United States National Library of Medicine, Bethesda, USA). All women provided informed consent before enrolment.

## Results

Between 2010 and 2012, 224 234 pregnant women were considered for enrolment in the study and 220 365 were regarded as eligible. Of these, 220 235 were enrolled since 130 refused

Table 1. Details of births in six countries, by study site, 2010–2012

Study site	No. of women enrolled	No. (%) of births by attendant				No. (%) of births by place				No. (%) of caesarean sections performed
		Physician	Nurse	Traditional birth attendant	Family member	Hospital	Health clinic	Home	Other <sup>a</sup>	
Argentina	8861	6381 (72.2)	2410 (27.3)	3 (0.0)	47 (0.5)	8757 (98.9)	14 (0.2)	20 (0.2)	63 (0.7)	3048 (34.4)
Guatemala	19725	7023 (35.6)	374 (1.9)	12276 (62.2)	51 (0.3)	6632 (33.6)	718 (3.6)	12308 (62.4)	66 (0.3)	2939 (14.9)
India										
Belgaum	65810	37518 (57.0)	22412 (34.1)	1864 (2.8)	3997 (6.1)	42885 (65.2)	16506 (25.1)	6053 (9.2)	304 (0.5)	7963 (12.1)
Nagpur	30938	17741 (57.4)	10788 (34.9)	1109 (3.6)	1281 (4.1)	19969 (64.6)	8351 (27.0)	2564 (8.3)	32 (0.1)	5383 (17.4)
Kenya	27072	503 (1.9)	10341 (38.2)	12882 (47.6)	3345 (12.4)	3247 (12.0)	7293 (26.9)	16153 (59.7)	376 (1.4)	376 (1.4)
Pakistan	40656	9800 (24.1)	10654 (26.2)	18449 (45.5)	1687 (4.2)	10995 (27.1)	9809 (24.2)	19487 (48.0)	308 (0.8)	3374 (8.3)
Zambia	21008	559 (2.7)	10812 (51.5)	5960 (28.4)	3676 (17.5)	1609 (7.7)	10542 (50.2)	8567 (40.8)	289 (1.4)	231 (1.1)
<b>Total</b>	<b>214070</b>	<b>79525 (37.1)</b>	<b>67791 (31.7)</b>	<b>52543 (24.5)</b>	<b>14084 (6.6)</b>	<b>94094 (44.0)</b>	<b>53233 (24.9)</b>	<b>65152 (30.4)</b>	<b>1438 (0.7)</b>	<b>23314 (10.9)</b>

<sup>a</sup> Delivery occurred during transit to a health-care facility or information was not available.

Table 2. Maternal, fetal and neonatal deaths in six countries, by study site, 2010–2012

Study site	No. of women enrolled	No. of maternal deaths	Maternal mortality ratio, deaths per 100 000 live births (95% CI)	Stillbirths		7-day neonatal deaths		Perinatal deaths <sup>a</sup>		28-day neonatal deaths	
				No.	Per 1000 births (95% CI)	No.	Mortality rate, deaths per 1000 live births (95% CI)	No.	Mortality rate, deaths per 1000 births (95% CI)	No.	Mortality rate, deaths per 1000 live births (95% CI)
Argentina	8861	6	69 (14–125)	126	14.1 (11.7–16.6)	71	8.2 (6.3–10.0)	197	22.3 (19.2–25.4)	88	10.1 (8.0–12.2)
Guatemala	19725	21	109 (63–156)	398	20.0 (18.1–22.0)	302	15.6 (13.9–17.4)	700	35.4 (32.9–38.0)	417	21.6 (19.5–23.6)
India											
Belgaum	65810	84	139 (109–168)	1607	25.7 (24.4–26.9)	1178	19.3 (18.2–20.4)	2785	44.5 (42.9–46.1)	1429	23.4 (22.2–24.6)
Nagpur	30938	44	155 (109–201)	824	27.9 (26.1–29.8)	507	17.8 (16.3–19.3)	1331	45.4 (43.0–47.8)	638	22.4 (20.7–24.1)
Kenya	27072	36	136 (92–180)	581	21.2 (19.5–22.9)	325	12.1 (10.8–13.5)	906	33.1 (31.0–35.2)	416	15.5 (14.1–17.0)
Pakistan	40656	116	316 (259–374)	2237	56.1 (53.8–58.3)	1505	40.6 (38.6–42.7)	342	95.3 (92.4–98.2)	1858	50.2 (48.0–52.4)
Zambia	21008	29	144 (92–197)	440	21.0 (19.1–23.0)	320	15.8 (14.1–17.5)	760	36.7 (34.1–39.2)	384	18.9 (17.1–20.8)
<b>Total</b>	<b>214070</b>	<b>336</b>	<b>168 (150–186)</b>	<b>6213</b>	<b>29.7 (29.0–30.4)</b>	<b>4208</b>	<b>20.9 (20.2–21.5)</b>	<b>10421</b>	<b>50.1 (49.2–51.1)</b>	<b>5230</b>	<b>25.9 (25.2–26.6)</b>

CI: confidence interval.

<sup>a</sup> Perinatal deaths included stillbirths and neonatal deaths occurring in the seven days after delivery.

to give consent. Data on outcomes up to six weeks after delivery were available for 214 070 of the 220 235 women (97.2%). The proportion of deliveries conducted by a physician ranged from 1.9% (503/27 072) in Kenya to 72.2% (6381/8861) in Argentina (Table 1). Deliveries by traditional birth attendants were rarely reported in Argentina, whereas 62.2% (12 276/19 724) of births in Guatemala were conducted by such attendants. The proportion of deliveries that took place in a hospital ranged from 7.7% (1609/21 008) in Zambia to 98.9% (8757/8861) in Argentina. Across all study sites, 44.0% (94 094/214 070) of deliveries took place in a hospital, compared with 30.4% (65 152/214 070) at home and 24.9% (53 233/214 070) in a health clinic. The caesarean section rate ranged from 34.4% (3048/8861) in Argentina to 1.1% (231/21 008) in Zambia.

In total, 336 maternal deaths occurred among the 214 070 women, which corresponded to an overall maternal mortality ratio of 168 per 100 000 live births. The ratio ranged from 69 per 100 000 live births in Argentina to 316 per 100 000 in Pakistan (Table 2). Around 21% (72/336) of pregnant women who died did so before delivery, whereas 29% (98/336) died during or immediately following delivery and an additional 9% (31/336) died on the day after delivery. Maternal deaths were due to: haemorrhage in 86/336 women (26%); pre-eclampsia or eclampsia in 55/336 (16%); sepsis in 39/336 (12%); suicide or accident in 23/336 (6.8%); anaemia in 22/336 (6.5%); infection with, for example, malaria or HIV in 21/336 (6.3%); heart disease in 16/336 (4.8%); obstructed labour in 12 (3.6%); other medical causes such as gestational diabetes or cancer in 5/336 (1.5%); and an unknown cause in 57/336 (17%).

Overall there were 6213 stillbirths, which corresponded to a rate of 29.7 per 1000 births; the figure ranged from 14.1 per 1000 births in Argentina to 56.1 per 1000 in Pakistan (Table 2). There were 4208 7-day neonatal deaths, which corresponded to a rate of 20.9 per 1000 live births; the figure ranged from 8.2 per 1000 live births in Argentina to 40.6 per 1000 in Pakistan. Altogether, there were more than 10 000 perinatal deaths (i.e. stillbirths and neonatal deaths up to 7 days after delivery) and the overall perinatal mortality rate was

50.1 per 1000 births; the figure ranged from 22.3 per 1000 births in Argentina to 95.3 per 1000 in Pakistan. In total, 34% (1804/5230) of neonatal deaths occurred on the day of delivery, 14% (755/5230) occurred on the following day and an additional 28% (1464/5230) occurred during the remainder of the first week of life. We assumed that fetal death occurred before labour in the 30% (1864/6213) of stillbirths that were macerated. The remaining 70% (4349/6213) probably occurred close to delivery or while the woman was in labour. While approximately 64% (137, 404/214 070) of deliveries took place at Asian sites, between 73% (244/336) and 75% (7858/10 421) of maternal, fetal and neonatal deaths occurred in this region.

We examined the association between perinatal and neonatal outcomes and the death of the mother. A total of 345 fetuses or neonates were recorded for the 336 women who died. Among those born to women who died, 110 were stillborn, 42 died by day 28 and 154 survived for more than 28 days (Table 3). In addition, there were 28 miscarriages or medically terminated pregnancies and the status of 11 fetuses or neonates was unknown. In total, 152 of 336 maternal deaths (45%) were associated with a stillbirth or a neonatal death. Among women who died, the stillbirth rate was 241 per 1000 births compared with 29 per 1000 in women who were still alive after six weeks. Moreover, the 7-day neonatal mortality rate was 159 per 1000 live births in women who died compared with 26 per 1000 in those who were still alive after six weeks. Finally, we calculated the association between the mother's death and the risk of stillbirth and neonatal death (Table 3). The risk of a stillbirth was significantly higher in women who died than in those who were still alive after six weeks (risk ratio, RR: 9.48; 95% confidence interval, CI: 7.97–11.27), as were the risks of perinatal death (RR: 4.30; CI: 3.26–5.67), neonatal death within 7 days (RR: 3.94; CI: 2.74–5.65) and neonatal death within 28 days (RR: 7.36; CI: 5.54–9.77).

## Discussion

We had three primary goals. The first was to determine maternal, fetal and neonatal mortality rates across the seven

study sites. The two extremes were Argentina and Pakistan, where Pakistan had generally 4-fold to 5-fold higher mortality than Argentina. The second goal was to establish when maternal, fetal and neonatal deaths occurred. We found that nearly 20% of maternal deaths occurred before the day of delivery and another 30% occurred on the day of delivery. Thereafter, the number of maternal deaths decreased slowly throughout the following six weeks. The timing is consistent with our observation that the main causes of maternal death were haemorrhage, pre-eclampsia and eclampsia. Approximately two thirds of stillbirths were regarded as occurring around the time of delivery since these fetuses showed no signs of maceration. Moreover, approximately one third of neonatal deaths occurred on the day of delivery and another 25% occurred in the two days following delivery. Our third goal was to identify relationships between maternal deaths and stillbirths and neonatal deaths. Overall, if the mother died during pregnancy or in the six weeks after delivery, about half of their fetuses or neonates also died. However, it is important to note that half of their neonates survived the neonatal period. Previous research has suggested that infants who have lost their mothers have significantly higher risks of death and disease well into childhood and that maternal death also has an adverse effect on other siblings and on the extended family.<sup>15,28–30,32,33</sup>

Our study is a prospective, international, population-based research to assess the relationship between maternal and perinatal deaths. This study has several strengths. First, we prospectively registered all pregnant women in defined geographical catchment areas and the follow-up rate was high. In addition, the study was population-based and took place in areas where a substantial proportion of births occurred at home. Thus data from this study are likely to be more representative of these areas than many hospital-based studies of maternal mortality. Moreover, we employed trained coordinators to help ensure that the quality of the data collected on fetal, newborn and maternal outcomes was high. The follow-up rate to 28 days postpartum was very high (97%), which means that very few neonatal deaths were missed. Although maternal deaths are rare, we were able to calculate ma-



Table 3. Stillbirths, neonatal and perinatal deaths in six countries,<sup>a</sup> by maternal outcome, 2010–2012

Pregnancy outcome	Women who died (No. = 345)		Women alive six weeks after delivery (No. = 214 221)		Risk ratio (95% CI)
	No.	Per 1000 live births <sup>b</sup>	No.	Per 1000 live births <sup>b</sup>	
Stillbirth <sup>c</sup>	110	318.8	6 083	28.4	9.48 (7.97–11.27)
Neonatal death before day 7	31	89.9	4 139	19.3	3.94 (2.74–5.65)
Neonatal death before day 28	42	121.7	5 150	24.0	7.36 (5.54–9.77)
Perinatal death <sup>d</sup>	141	408.7	10 222	47.7	4.30 (3.26–5.67)
Miscarriage <sup>e</sup> or medically terminated pregnancy	28	81.2	6 720	31.4	ND
Infant alive at 28 days	154	446.4	196 221	916.0	ND
Unknown <sup>f</sup>	11	31.9	47	0.2	ND

CI: confidence interval; ND: not determined.

<sup>a</sup> The countries were Argentina, Guatemala, India, Kenya, Pakistan and Zambia.

<sup>b</sup> All values are for deaths per 1000 live births except for stillbirths and perinatal deaths, where values are for deaths per 1000 births.

<sup>c</sup> The pregnancy outcome was classified as a stillbirth in 47 cases in which the mother died after 20 weeks' gestation and no data were available on the status of the fetus or neonate.

<sup>d</sup> Perinatal deaths included stillbirths and neonatal deaths occurring in the seven days after delivery.

<sup>e</sup> The pregnancy outcome was classified as a miscarriage in 11 cases in which the mother died before 20 weeks' gestation and no data were available on the status of the fetus.

<sup>f</sup> The pregnancy outcome was classified as unknown if no data were available on the status of the fetus or neonate at delivery or on the status of the neonate during follow-up after a live birth.

ternal mortality ratios and to assess the timing of maternal death and its association with perinatal or neonatal death because our study included more than 200 000 pregnant women.

One of the study's limitations was that, since enrolment began at 16 weeks gestation, we may have missed some maternal deaths that occurred early in gestation, before the pregnancy had been recognized. Therefore, we may have underestimated maternal death rates, especially among women with early pregnancy losses, including those due to abortion. Additionally, although we asked each site to use WHO criteria to assign the cause of death, no specific methods were provided and thus each site probably interpreted the criteria slightly differently. Nevertheless, our study is one of the few that has prospectively registered pregnant women in low-income areas and followed them through to six weeks postpartum, thereby enabling maternal mortality to be estimated in the whole population. We did not analyse the relationship between maternal death and perinatal outcomes by country because the number of maternal deaths was small. However, we recognize that regional differences are an important area for future research.

Although maternal mortality has decreased significantly worldwide for several decades, the maternal mortality

ratio remains high, especially in low-income countries, and is particularly high in sub-Saharan Africa and south Asia. These areas also have some of the highest rates and some of the highest absolute numbers of stillbirths and neonatal deaths. Our findings have important implications for the timing of interventions. We found, in agreement with other researchers, that the period of highest risk for both the mother and her fetus or neonate is around the time of delivery.<sup>5–8</sup> Additionally, we also found that the majority of maternal deaths were attributed to causes associated with labour or delivery, such as haemorrhage, pre-eclampsia, eclampsia and sepsis.<sup>30</sup> In 2011, other studies showed that maternal, fetal and newborn deaths are often due to the same causes and that interventions that reduce stillbirth and early neonatal mortality also reduce maternal mortality.<sup>34,35</sup> Since then, others have described the possible connection between maternal and perinatal outcomes in greater detail.<sup>4,36,37</sup>

Our study confirms that the mother's death has important implications for the risk that her fetus or neonate will also die. Since most deaths occurred near to delivery and because most obstetric complications are not recognized in advance, the intervention most likely, by far, to reduce mortality is the provision of high-quality emergency obstetric and neonatal care in hospitals capable

of carrying out deliveries by caesarean section, blood transfusion and neonatal resuscitation in addition to other key elements of obstetric care, such as uterine evacuation of the retained products of conception, manual removal of the placenta, assisted vaginal delivery by forceps or vacuum and the administration of oxytocin, anticonvulsants and antibiotics. Although the provision of health-care services in homes and clinics is an important component of the overall system of obstetric and newborn care, programmes that focus on improving obstetric and neonatal care close to the time of birth appear to have the greatest chance of reducing all three types of pregnancy-related mortality: maternal, fetal and neonatal. ■

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## ملخص

دراسة استطلاعية عن وفيات الأمومة والأجنة والولدان في البلدان المنخفضة والمتوسطة الدخل أثناء الوضع، وتوفيت نسبة 34٪ من الولدان (5230/1804) في يوم الولادة وتوفيت نسبة 14٪ من الولدان (5230/755) في اليوم الذي يليه. وكانت حالات الإملاص أكثر شيوعاً لدى النساء اللاتي لقين حتفهن عن اللواتي عشن ستة أسابيع بعد الوضع (نسبة الخطورة: 9.48؛ فاصل الثقة 95٪، فاصل الثقة: 7.97 - 11.27)، وهو نفس الوضع مع الوفيات في الفترة المحيطة بالولادة (نسبة الخطورة: 4.30؛ فاصل الثقة 95٪: 3.26 - 5.67) ووفيات الولدان في اليوم السابع (نسبة الخطورة: 3.94؛ فاصل الثقة 95٪: 2.74 - 5.65) ووفيات الولدان في اليوم الثامن والعشرين (نسبة الخطورة: 7.36؛ فاصل الثقة 95٪: 5.54 - 9.77).

الاستنتاج حدثت معظم وفيات الأمومة والأجنة والولدان عند الولادة أو في الفترة المحيطة بالولادة وتعزى إلى أسباب يمكن توقيها. وأدت وفيات الأمومة إلى زيادة خطورة وفيات الولدان والوفيات في الفترة المحيطة بالولادة. ويوفر تحسين الرعاية التوليدية والوليدية في الفترة المحيطة بالولادة أعظم فرصة لتقليل معدل الوفيات.

الغرض قياس مقدار وفيات الأمومة والأجنة والولدان في البلدان المنخفضة والمتوسطة الدخل لتحديد أوقات حدوث الوفيات ولتحديد العلاقات بين وفيات الأمومة وحالات الإملاص ووفيات الولدان.

الطريقة تم إجراء دراسة استطلاعية عن حصائل الحمل في 106 مجتمعاً محلياً في سبعة مواقع في الأرجنتين وغواتيمالا والهند وكينيا وباكستان وزامبيا. وتم تسجيل النساء الحوامل ومتابعتهن حتى ستة أسابيع بعد الوضع.

النتائج بين عامي 2010 و2012، أكملت 214070 سيدة من إجمالي 220235 سيدة مسجلة (97.2٪) المتابعة. وكانت نسبة وفيات الأمومة 168 لكل 100000 وليد حي، وتراوح من 69 لكل 100000 وليد حي في الأرجنتين إلى 316 لكل 100000 وليد حي في باكستان. وبشكل عام، حدثت نسبة 29٪ (98/336) من وفيات الأمومة في الفترة المحيطة بالولادة: يعزى معظم هذه الحالات إلى النزف (86/336) أو مقدمات الارتعاج أو الارتعاج (55/336) أو الإلتان (39/336). ومن المرجح أن حوالي 70٪ من حالات الإملاص (4349/6213) كانت

## الخلاصة

### مدرسة استطلاعية عن وفيات الأمومة والأجنة والولدان في البلدان المنخفضة والمتوسطة الدخل

**الغرض** قياس مقدار وفيات الأمومة والأجنة والولدان في البلدان المنخفضة والمتوسطة الدخل لتحديد أوقات حدوث الوفيات ولتحديد العلاقات بين وفيات الأمومة وحالات الإملاص ووفيات الولدان.

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## Résumé

### Une étude prospective de la mortalité maternelle, foetale et néonatale dans les pays à revenus faible et intermédiaire

**Objectif** Quantifier la mortalité maternelle, foetale et néonatale dans les pays à revenus faible et intermédiaire pour identifier à quel moment survient le décès et pour analyser les relations entre les décès maternels et les mortinaissances/décès néonataux.

**Méthodes** Une étude prospective sur des grossesses a été effectuée dans 106 collectivités sur 7 sites: Argentine, Guatemala, Inde, Kenya, Pakistan et Zambie. Les femmes enceintes ont été inscrites et suivies jusqu'à 6 semaines après leur accouchement.

**Résultats** Entre 2010 et 2012, 214 070 femmes inscrites sur 220 235

(97,2%) ont participé au suivi. Le taux de mortalité maternelle était de 168 pour 100 000 naissances d'enfants vivants, allant de 69 pour 100 000 en Argentine à 316 pour 100 000 au Pakistan. Dans l'ensemble, 29% (98/336) des décès maternels ont eu lieu au moment de la naissance: la plupart des décès ont été dus à une hémorragie (86/336), une prééclampsie ou une éclampsie (55/336), ou encore une septicémie (39/336). Environ 70% (4349/6213) des enfants sont morts-nés intrapartum; 34% (1804/5230) des nouveau-nés sont morts le jour de leur naissance et 14% (755/5230) le lendemain. Les mortinaissances

étaient plus fréquentes chez les femmes qui ont aussi perdu la vie que chez celles qui ont survécu 6 semaines après l'accouchement (risque relatif, RR: 9,48; intervalle de confiance à 95%, IC: 7,97–11,27), pour les décès périnataux (RR: 4,30; IC à 95%: 3,26–5,67), à 7 jours (RR: 3,94; IC à 95%: 2,74–5,65), et à 28 jours (RR: 7,36; IC à 95%: 5,54–9,77).

**Conclusion** La plupart des cas de mortalité maternelle, foetale et

néonatale se sont produits pendant ou peu avant ou après la naissance et ont été attribués à des causes évitables. La mortalité maternelle a augmenté le risque de mort périnatale et néonatale. L'amélioration des soins obstétricaux et néonataux au moment de la naissance offre les meilleures chances de réduire cette mortalité.

## Резюме

### Проспективное исследование материнской, внутриутробной и неонатальной смертности в странах с низким и средним уровнем дохода

**Цель** Определить уровень материнской, внутриутробной и неонатальной смертности в странах с низким и средним уровнем дохода, выяснить, когда происходят эти смерти и выявить связи между материнской смертностью, мертворождениями и неонатальной смертностью.

**Методы** Проспективное исследование исходов беременности было проведено в 106 общинах в семи районах Аргентины, Гватемалы, Индии, Кении, Пакистана и Замбии. Включение в исследование и наблюдение за беременными женщинами велось до шестинедельного послеродового периода.

**Результаты** В 2010–2012 годах наблюдение прошли 214 070 из 220 235 включенных в исследование женщин (97,2%). Коэффициент материнской смертности составлял 168 смертей на 100 000 живорождений, варьируясь в пределах от 69 смертей на 100 000 живорождений в Аргентине до 316 смертей на 100 000 живорождений в Пакистане. В общем, во время родов было зарегистрировано 29% (98/336) материнских смертей: причиной большинства из них были кровотечения (86/336), преэклампсия или эклампсия (55/336) или сепсис (39/336).

Около 70% (4349/6213) мертворождений, вероятно, произошли во время родов; 34% (1804/5230) новорожденных умерли в день родов и 14% (755/5230) умерли на следующий день после родов. Мертворожденность чаще всего отмечалась у умерших в ходе родов женщин, чем у женщин, которые оставались в живых спустя шесть недель после родов (отношение рисков, ОР: 9,48; 95% доверительный интервал, ДИ: 7,97–11,27). То же самое касается перинатальной смертности (ОР: 4,30; 95% ДИ: 3,26–5,67) и 7-дневной (ОР: 3,94; 95% ДИ: 2,74–5,65) и 28-дневной неонатальной смертности (ОР: 7,36; 95% ДИ: 5,54–9,77).

**Вывод** Наибольшее число материнских, внутриутробных и неонатальных смертей зарегистрировано в момент родов или в дородовой или послеродовой период и объяснялись предотвратимыми причинами. Материнская смертность увеличивала риск перинатальной и неонатальной смерти. Совершенствование акушерской и неонатальной помощи во время родов открывает наилучшие возможности для снижения смертности.

## Resumen

### Un estudio prospectivo de las muertes maternas, fetales y neonatales en países de ingresos bajos y medios

**Objetivo** Cuantificar la mortalidad materna, fetal y neonatal en países de ingresos bajos y medios a fin de identificar cuándo se producen muertes y las relaciones entre las muertes maternas y la mortalidad prenatal y neonatal.

**Métodos** Se realizó un estudio prospectivo de los resultados del embarazo en 106 comunidades en siete lugares en Argentina, Guatemala, India, Kenya, Pakistán y Zambia. Se inscribieron mujeres embarazadas, de las que se hizo un seguimiento hasta seis semanas tras el parto.

**Resultados** Entre 2010 y 2012, 214 070 de las 220 235 mujeres inscritas (97,2%) completaron el seguimiento. La tasa de mortalidad materna fue de 168 por 100 000 nacidos vivos, con una variación que va desde 69 por 100 000 en Argentina a 316 por 100 000 en Pakistán. En general, el 29% (98/336) de las muertes maternas se produjo en torno al momento del parto: la mayoría se atribuyó a hemorragias (86/336), preeclampsia

o eclampsia (55/336), o sepsis (39/336). Alrededor del 70% (4349/6213) de las muertes prenatales se produjo probablemente en el parto; el 34% (1804/5230) de los recién nacidos murieron el día del parto y el 14% (755/5230), al día siguiente. Las muertes prenatales fueron más comunes en las mujeres que fallecieron que en aquellas con vida seis semanas después del parto (riesgo relativo, RR: 9,48; intervalo de confianza 95%, IC: 7,97–11,27), al igual que las muertes perinatales (RR: 4,30; IC del 95%: 3,26–5,67) y las muertes de neonatos a 7 días (RR: 3,94; IC del 95%: 2,74–5,65) y a 28 días (RR: 7,36; IC del 95%: 5,54–9,77).

**Conclusión** La mayoría de las muertes maternas, prenatales y neonatales ocurrieron en o en torno al parto y se atribuyeron a causas evitables. La muerte materna aumentó el riesgo de muerte perinatal y neonatal. Mejorar la atención obstétrica y neonatal en el momento del nacimiento ofrece las mayores posibilidades para reducir la mortalidad.

## References

- Hogan MC, Foreman KJ, Naghavi M, Ahn SY, Wang M, Makela SM, et al. Maternal mortality for 181 countries, 1980–2008: a systematic analysis of progress towards Millennium Development Goal 5. *Lancet*. 2010;375(9726):1609–23. doi: [http://dx.doi.org/10.1016/S0140-6736\(10\)60518-1](http://dx.doi.org/10.1016/S0140-6736(10)60518-1) PMID: 20382417
- Khan KS, Wojdyla D, Say L, Gülmezoglu AM, Van Look PF. WHO analysis of causes of maternal death: a systematic review. *Lancet*. 2006;367(9516):1066–74. doi: [http://dx.doi.org/10.1016/S0140-6736\(06\)68397-9](http://dx.doi.org/10.1016/S0140-6736(06)68397-9) PMID: 16581405
- Hill K, You D, Inoue M, Oestergaard MZ; Technical Advisory Group of United Nations Inter-agency Group for Child Mortality Estimation. Child mortality estimation: accelerated progress in reducing global child mortality, 1990–2010. *PLoS Med*. 2012;9(8):e1001303. doi: <http://dx.doi.org/10.1371/journal.pmed.1001303> PMID: 22952441
- Bhutta ZA, Black RE. Global maternal, newborn, and child health—so near and yet so far. *N Engl J Med*. 2013;369(23):2226–35. doi: <http://dx.doi.org/10.1056/NEJMra1111853> PMID: 24304052

5. Lawn J, McClure EM, Blencowe H. Birth outcomes: a global perspective. In: Katz DL, Elmore JG, Wild DMG, Lucan SC, editors. *Epidemiology, biostatistics, preventive medicine, and public health*. Philadelphia: Elsevier; 2013. pp. 272–88.
6. Khat M, Ronsmans C. Deaths attributable to childbearing in Matlab, Bangladesh: indirect causes of maternal mortality questioned. *Am J Epidemiol*. 2000;151(3):300–6. doi: <http://dx.doi.org/10.1093/oxfordjournals.aje.a010206> PMID: 10670555
7. Bartlett LA, Mawji S, Whitehead S, Crouse C, Dalil S, Ionete D, et al.; Afghan Maternal Mortality Study Team. Where giving birth is a forecast of death: maternal mortality in four districts of Afghanistan, 1999–2002. *Lancet*. 2005;365(9462):864–70. doi: [http://dx.doi.org/10.1016/S0140-6736\(05\)71044-8](http://dx.doi.org/10.1016/S0140-6736(05)71044-8) PMID: 15752530
8. Belizán JM, McClure EM, Goudar SS, Pasha O, Esamai F, Patel A, et al. Neonatal death in low- to middle-income countries: a global network study. *Am J Perinatol*. 2012;29(8):649–56. doi: <http://dx.doi.org/10.1055/s-0032-1314885> PMID: 22644832
9. Goudar SS, Carlo WA, McClure EM, Pasha O, Patel A, Esamai F, et al. The Maternal and Newborn Health Registry Study of the Global Network for Women's and Children's Health Research. *Int J Gynaecol Obstet*. 2012;118(3):190–3. doi: <http://dx.doi.org/10.1016/j.ijgo.2012.04.022> PMID: 22738806
10. Souza JP, Gülmezoglu AM, Vogel J, Carroli G, Lumbiganon P, Qureshi Z, 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(9879):1747–55. doi: [http://dx.doi.org/10.1016/S0140-6736\(13\)60686-8](http://dx.doi.org/10.1016/S0140-6736(13)60686-8) PMID: 23683641
11. Goldenberg RL, McClure EM. Maternal mortality. *Am J Obstet Gynecol*. 2011;205(4):293–5. doi: <http://dx.doi.org/10.1016/j.ajog.2011.07.045> PMID: 22083050
12. Mmbaga BT, Lie RT, Olomi R, Mahande MJ, Olola O, Daltveit AK. Causes of perinatal death at a tertiary care hospital in Northern Tanzania 2000–2010: a registry based study. *BMC Pregnancy Childbirth*. 2012;12(1):139. doi: <http://dx.doi.org/10.1186/1471-2393-12-139> PMID: 23199181
13. Goldenberg RL, McClure EM, Macquire ER, Kamath BD, Jobe AH. Lessons for low-income regions following the reduction in hypertension-related maternal mortality in high-income countries. *Int J Gynaecol Obstet*. 2011;113(2):91–5. doi: <http://dx.doi.org/10.1016/j.ijgo.2011.01.002> PMID: 21349517
14. McClure EM, Pasha O, Goudar SS, Chomba E, Garces A, Tshefu A, et al.; Global Network Investigators. Epidemiology of stillbirth in low-middle income countries: a Global Network Study. *Acta Obstet Gynecol Scand*. 2011;90(12):1379–85. doi: <http://dx.doi.org/10.1111/j.1600-0412.2011.01275.x> PMID: 21916854
15. Ellis M, Azad K, Banerjee B, Shaha SK, Prost A, Rego AR, et al. Intrapartum-related stillbirths and neonatal deaths in rural Bangladesh: a prospective, community-based cohort study. *Pediatrics*. 2011;127(5):e1182–90. doi: <http://dx.doi.org/10.1542/peds.2010-0842> PMID: 21502233
16. Goldenberg RL, McClure EM, Bann CM. The relationship of intrapartum and antepartum stillbirth rates to measures of obstetric care in developed and developing countries. *Acta Obstet Gynecol Scand*. 2007;86(11):1303–9. doi: <http://dx.doi.org/10.1080/00016340701644876> PMID: 17963057
17. Lawn JE, Lee AC, Kinney M, Sibley L, Carlo WA, Paul VK, et al. Two million intrapartum-related stillbirths and neonatal deaths: where, why, and what can be done? *Int J Gynaecol Obstet*. 2009 Oct;107 Suppl 1:S5–18, S19. doi: <http://dx.doi.org/10.1016/j.ijgo.2009.07.016> PMID: 19815202
18. Yakasai IA, Gaya SA. Maternal and fetal outcome in patients with eclampsia at Murtala Muhammad specialist Hospital Kano, Nigeria. *Ann Afr Med*. 2011;10(4):305–9. doi: <http://dx.doi.org/10.4103/1596-3519.87049> PMID: 22064258
19. Beltman J, van den Akker T, van Lonkhuijzen L, Schmidt A, Chidakwani R, van Roosmalen J. Beyond maternal mortality: obstetric hemorrhage in a Malawian district. *Acta Obstet Gynecol Scand*. 2011;90(12):1423–7. doi: <http://dx.doi.org/10.1111/j.1600-0412.2011.01219.x> PMID: 21682698
20. Goldenberg RL, McClure EM, Belizán JM. Commentary: reducing the world's stillbirths. *BMC Pregnancy Childbirth*. 2009;9 Suppl 1:S1. doi: <http://dx.doi.org/10.1186/1471-2393-9-S1-S1> PMID: 19426464
21. Darmstadt GL, Lee AC, Cousens S, Sibley L, Bhutta ZA, Donnan F, et al. 60 Million non-facility births: who can deliver in community settings to reduce intrapartum-related deaths? *Int J Gynaecol Obstet*. 2009 Oct;107 Suppl 1:S89–112. doi: <http://dx.doi.org/10.1016/j.ijgo.2009.07.010> PMID: 19815200
22. Garces A, McClure EM, Chomba E, Patel A, Pasha O, Tshefu A, et al. Home birth attendants in low income countries: who are they and what do they do? *BMC Pregnancy Childbirth*. 2012;12(1):34. doi: <http://dx.doi.org/10.1186/1471-2393-12-34> PMID: 22583622
23. Hussein J, Newlands D, D'Ambruoso L, Thaver I, Talukder R, Besana G. Identifying practices and ideas to improve the implementation of maternal mortality reduction programmes: findings from five South Asian countries. *BJOG*. 2010;117(3):304–13. doi: <http://dx.doi.org/10.1111/j.1471-0528.2009.02457.x> PMID: 20015302
24. Bhutta ZA, Darmstadt GL, Haws RA, Yakoob MY, Lawn JE. Delivering interventions to reduce the global burden of stillbirths: improving service supply and community demand. *BMC Pregnancy Childbirth*. 2009;9 Suppl 1:S7. doi: <http://dx.doi.org/10.1186/1471-2393-9-S1-S7> PMID: 19426470
25. Shah A, Fawole B, M'imunya JM, Amokrane F, Nafou I, Wolomby JJ, et al. Cesarean delivery outcomes from the WHO global survey on maternal and perinatal health in Africa. *Int J Gynaecol Obstet*. 2009;107(3):191–7. doi: <http://dx.doi.org/10.1016/j.ijgo.2009.08.013> PMID: 19782977
26. Althabe F, Sosa C, Belizán JM, Gibbons L, Jacqueroiz F, Bergel E. Cesarean section rates and maternal and neonatal mortality in low-, medium-, and high-income countries: an ecological study. *Birth*. 2006;33(4):270–7. doi: <http://dx.doi.org/10.1111/j.1523-536X.2006.00118.x> PMID: 17150064
27. Lassey AT, Obed SA. Trends in concurrent maternal and perinatal deaths at a teaching hospital in Ghana: the facts and prevention strategies. *J Obstet Gynaecol Can*. 2004;26(9):799–804. PMID: 15361275
28. Ronsmans C, Chowdhury ME, Dasgupta SK, Ahmed A, Koblinsky M. Effect of parent's death on child survival in rural Bangladesh: a cohort study. *Lancet*. 2010;375(9730):2024–31. doi: [http://dx.doi.org/10.1016/S0140-6736\(10\)60704-0](http://dx.doi.org/10.1016/S0140-6736(10)60704-0) PMID: 20569842
29. Clark SJ, Kahn K, Houle B, Arteche A, Collinson MA, Tollman SM, et al. Young children's probability of dying before and after their mother's death: a rural South African population-based surveillance study. *PLoS Med*. 2013;10(3):e1001409. doi: <http://dx.doi.org/10.1371/journal.pmed.1001409> PMID: 23555200
30. Desai M, Phillips-Howard PA, Odhiambo FO, Katana A, Ouma P, Hamel MJ, et al. An analysis of pregnancy-related mortality in the KEMRI/CDC health and demographic surveillance system in western Kenya. *PLoS One*. 2013;8(7):e68733. doi: <http://dx.doi.org/10.1371/journal.pone.0068733> PMID: 23874741
31. International Statistical Classification of Diseases and Related Health Problems 10th Revision. Geneva: World Health Organization; 1994. Available from: <http://www.who.int/classifications/icd/en/> [cited 2014 May 25].
32. Lassi ZS, Majeed A, Rashid S, Yakoob MY, Bhutta ZA. The interconnections between maternal and newborn health—evidence and implications for policy. *J Matern Fetal Neonatal Med*. 2013;26(S1) Suppl 1:3–53. doi: <http://dx.doi.org/10.3109/14767058.2013.784737> PMID: 23617260
33. Koblinsky M, Chowdhury ME, Moran A, Ronsmans C. Maternal morbidity and disability and their consequences: neglected agenda in maternal health. *J Health Popul Nutr*. 2012;30(2):124–30. doi: <http://dx.doi.org/10.3329/jhpn.v30i2.11294> PMID: 22838155
34. Pattinson R, Kerber K, Buchmann E, Friberg IK, Belizan M, Lansky S et al.; Lancet's Stillbirths Series steering committee. Stillbirths: how can health systems deliver for mothers and babies? *Lancet*. 2011;377(9777):1610–23. doi: [http://dx.doi.org/10.1016/S0140-6736\(10\)62306-9](http://dx.doi.org/10.1016/S0140-6736(10)62306-9) PMID: 21496910
35. Goldenberg RL, McClure EM, Bhutta ZA, Belizán JM, Reddy UM, Rubens CE, et al.; Lancet's Stillbirths Series steering committee. Stillbirths: the vision for 2020. *Lancet*. 2011;377(9779):1798–805. doi: [http://dx.doi.org/10.1016/S0140-6736\(10\)62235-0](http://dx.doi.org/10.1016/S0140-6736(10)62235-0) PMID: 21496912
36. Goldenberg RL, McClure EM. Disparities in interventions for child and maternal mortality. *Lancet*. 2012 Mar 31;379(9822):1178–80. doi: [http://dx.doi.org/10.1016/S0140-6736\(12\)60474-7](http://dx.doi.org/10.1016/S0140-6736(12)60474-7) PMID: 22464372
37. Goldenberg RL, McClure EM, Kodkany B, Wembodinga G, Pasha O, Esamai F, et al. A multi-country study of the “intrapartum stillbirth and early neonatal death indicator” in hospitals in low-resource settings. *Int J Gynaecol Obstet*. 2013;122(3):230–3. doi: <http://dx.doi.org/10.1016/j.ijgo.2013.04.008> PMID: 23796259