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Original article

Risk factors for spontaneous and provider-initiated preterm delivery in high and low Human Development Index countries: a secondary analysis of the World Health Organization Multicountry Survey on Maternal and Newborn Health

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Objective To evaluate how the effect of maternal complications on preterm birth varies between spontaneous and provider-initiated births, as well as among different countries.

Design Secondary analysis of a cross-sectional study.

Setting Twenty-nine countries participating in the World Health Organization Multicountry Survey on Maternal and Newborn Health.

Population 299 878 singleton deliveries of live neonates or fresh stillbirths.

Methods Countries were categorised into very high, high, medium and low developed countries using the Human Development Index (HDI) of 2012 by the World Bank. We described the prevalence and risk of maternal complications, their effect on outcomes and their variability by country development.

Main outcome measures Preterm birth, fresh stillbirth and early neonatal death.

Results The proportion of provider-initiated births among preterm deliveries increased with development: 19% in low to 40% in very high HDI countries. Among preterm deliveries, the socially disadvantaged were less likely, and the medically high risk were more likely, to have a provider-initiated delivery. The effects of anaemia [adjusted odds ratio (AOR), 2.03; 95% confidence interval (CI), 1.84; 2.25], chronic hypertension (AOR, 2.28; 95% CI, 1.94; 2.68) and pre-eclampsia/eclampsia (AOR, 5.03; 95% CI, 4.72; 5.37) on preterm birth were similar among all four HDI subgroups.

Conclusions The provision of adequate obstetric care, including optimal timing for delivery in high-risk pregnancies, especially to the socially disadvantaged, could improve pregnancy outcomes. Avoiding preterm delivery in women when maternal complications, such as anaemia or hypertensive disorders, are present is important for countries at various stages of development, but may be more challenging to achieve.

Keywords Preterm birth, scheduled delivery, spontaneous labour.

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Introduction

As a primary cause of neonatal death, preterm birth presents a major public health problem, with an estimated 15 million births, or 11% of all births worldwide, occurring preterm.[1] Approximately 90% of these preterm births are concentrated in developing countries, with 11 million (85%) in Africa and Asia, and 0.9 million in Latin America and the Caribbean.[2] Although multiple pregnancies and improved management of high-risk pregnancies leading to improved neonatal outcomes may account for the rise in preterm delivery in developed countries,[3–5] the highest preterm birth rates occur in low-income settings,[6] where the majority of preterm deliveries are caused by spontaneous labour, and it is estimated that avoidance of preterm delivery could save over 1 million neonatal deaths each year.[7]

Maternal complications, such as infectious diseases and hypertension, are the most common direct causes of preterm delivery.[8] Malaria is the most widespread infectious disease that is known to contribute to spontaneous preterm labour and preterm birth[9]; bacterial infections leading to chorioamnionitis are also associated with a large proportion of very preterm births,[10] and HIV has been reported as a risk factor for preterm delivery.[11,12] However, hypertension is the leading cause of provider-initiated preterm delivery,[8] with the definitive management of eclampsia and gestational hypertension being termination of pregnancy.

Although maternal complications and social settings play a substantial role in the underlying risk of preterm delivery,[13] it is less clear how the risk of maternal complications of preterm birth varies between spontaneous and provider-initiated delivery, and whether better interventions and treatment of these complications would improve pregnancy outcomes.

Therefore, by utilising an international dataset of developed and developing countries, we sought to understand the risk factors and outcomes of spontaneous and provider-initiated preterm birth, and their variety, by demographic and socio-economic features.

Methods

Study population

We conducted a secondary data analysis of the WHO Multicountry Survey on Maternal and Newborn Health. The survey was carried out in 359 health facilities from 29 countries in Africa, Asia, Latin America and the Middle East. A multistage cluster sampling method was applied to acquire samples of health facilities in two randomly selected provinces as well as the capital city of the 29 countries. We have included full methodological details of this survey in previous papers.[14,15] The survey recruited all women who were admitted for delivery, as well as all women with severe maternal outcomes, irrespective of gestational age. Trained medical staff sourced individual data on demographics and reproductive characteristics, medical conditions during pregnancy, birth outcomes, and complications and received interventions from the women's medical records. Health facility capacity data were obtained, including laboratory tests, human resources and training, and the capabilities of obstetrics and neonatal healthcare services. Data were collected over a period of 2 months from May 2010 to December 2011 in institutions with ≥6000 annual deliveries and 3 months in institutions with <6000 annual deliveries. In countries in which <3000 deliveries were anticipated, it was extended to 4 months in all institutions. The average number of deliveries in an institution over the study period was 463 (range, 17–6002).

There were 318 534 deliveries observed in our study. We restricted our analysis to 302 376 deliveries of singletons of over 22 completed weeks of gestation who weighed over 500 g and were alive before labour and delivery, excluding all macerated fetal deaths. We further excluded deliveries with congenital malformations (2115) or with missing data on labour (381), with a total of 299 878 deliveries retained in the analysis.

Variables and definitions

We collected data on the best clinical estimate of gestational age in weeks, and categorised delivery at gestational age 22–36 weeks as preterm, 37–41 weeks as term and 42 weeks and over as post-term. We defined provider-initiated delivery as delivery in which induction of labour or caesarean section was performed without any preceding spontaneous labour. Our main outcome of interest was delivery timing, categorised as 'spontaneous preterm birth', 'provider-initiated preterm birth', 'spontaneous term birth', 'provider-initiated term birth' and 'post-term birth'.

For risk factors of spontaneous preterm birth and provider-initiated preterm birth, we considered the following variables as exposures at the individual level: maternal age at delivery; marital status; educational attainment, parity; previous caesarean section; infant sex; severe anaemia, defined as haemoglobin <7 mg/dl; bacterial infections, defined as pyelonephritis, sepsis or other systemic infection; HIV or AIDS; malaria or dengue; chronic hypertension; pre-eclampsia or eclampsia; and other maternal conditions, defined as the presence of diseases or injuries affecting the heart, lungs, liver or kidneys. Infant sex and best clinical estimate of gestational age were considered as confounders associated with stillbirth and early neonatal death.

In addition, in our analysis, we adjusted for the 'facility capacity index' category – a proxy for the institution's capacity to provide obstetric care – comprising six areas reflecting the standard of facility and basic services, medical services, emergency obstetric services, laboratory tests, hospital practices and human resources, calculated into a

continuous index and categorised as 'good', 'poor' or 'very poor'. Countries were categorised into very high, high, medium and low developed countries using the Human Development Index (HDI) of 2012 by the World Bank.[16]

In this study, we considered stillbirths and intra-hospital early neonatal deaths as perinatal outcomes. We defined early neonatal deaths as intra-hospital deaths that occurred on or before the seventh day after delivery.

Statistical analysis

First, we examined the distribution of the duration of pregnancy and the risk of spontaneous delivery in preterm birth stratified by the duration of pregnancy within each HDI group. Next, we compared the timing of delivery with maternal characteristics by performing adjusted chi-squared tests, taking into account the survey design.

To determine the effect of maternal complications on spontaneous and provider-initiated preterm delivery, we constructed multilevel, multinomial, multivariate logistic regression models comparing the five delivery outcomes, as well as multivariate logistic regression models comparing spontaneous with provider-initiated delivery in preterm and term deliveries separately. We also adjusted for individual maternal characteristics (see Table 1) and for random effects at each level: country (level 1), facility (level 2) and individual (level 3). We repeated this analysis in HDI subgroups across country (level 1) and individual (level 2) levels, and adjusted for facility capacity, which was quantified using a scale of available utilities and interventions in each facility.

For outcomes of preterm birth, we examined the risk of intrapartum-related stillbirth, defined as fresh stillbirth (delivery of a dead fetus that does not show any sign of

Table 1. Maternal characteristics stratified by timing and initiation of delivery: analysis of 299 878 singleton deliveries in 29 countries

Maternal characteristics	All deliveries, *n*	Preterm delivery		Term delivery		Post-term delivery, *n* (%)	Adjusted χ^2 *P*
		Provider-initiated delivery, *n* (%)	Spontaneous labour, *n* (%)	Provider-initiated delivery, *n* (%)	Spontaneous labour, *n* (%)		
N	299878	5315	14916	60968	213881	4798	
Age (years)							
<20	30923	479 (2)	2014 (8)	4620 (15)	23261 (75)	550 (2)	<0.001
20–34	232462	3786 (2)	1599 (6)	47310 (20)	166349 (72)	3761 (2)	
≥35	36493	1031 (3)	11259 (6)	8922 (25)	23635 (66)	470 (1)	
Marital status							
Single	30597	581 (2)	1780 (6)	5292(17)	22240 (73)	687 (2)	0.001
Married/cohabiting	267427	4683 (2)	13032 (5)	55084 (21)	190180 (71)	4093 (2)	
Education (years)							
0	45040	508 (1)	2487 (6)	4501 (10)	36796 (82)	679 (2)	<0.001
1–6	39216	649 (2)	2182 (6)	6639 (17)	28917 (74)	741 (2)	
7–9	57112	881 (2)	3246 (6)	10506 (18)	41284 (72)	1133 (2)	
10–12	87175	1672 (2)	4204 (5)	19192 (22)	60444 (69)	1557 (2)	
>12	48876	1092 (2)	1616 (3)	14504 (30)	31084 (64)	554 (1)	
Parity							
0	127880	2298 (2)	6653 (5)	28847 (23)	87895 (69)	2049 (2)	<0.001
1–2	124446	2216 (2)	6010 (5)	26289 (21)	87858 (71)	1917 (2)	
≥3	47544	792 (2)	2240 (5)	5733 (12)	37873 (80)	828 (2)	
Previous caesarean section	36645	1302 (4)	1562 (4)	16366 (45)	16909 (46)	394 (1)	<0.001
Anaemia (haemoglobin <7 mg/dl)	4077	323 (8)	498 (12)	941 (23)	2268 (46)	37 (1)	<0.001
Infection							
Puerperal endometritis	254	17 (7)	25 (10)	59 (23)	150 (59)	3 (1)	<0.001
Systemic bacterial infection	1393	97 (7)	228 (16)	325 (23)	720 (56)	21 (2)	<0.001
HIV/AIDs	1109	34 (3)	88 (8)	236 (21)	729 (52)	22 (2)	<0.001
Malaria/dengue	312	38 (12)	49 (16)	70 (22)	150 (66)	5 (2)	<0.001
Hypertensive disorders							
Chronic hypertension	1148	173 (15)	125 (11)	415 (36)	425 (48)	10 (1)	<0.001
Pre-eclampsia/eclampsia	6299	87 (1)	766 (5)	2258 (20)	2693 (72)	69 (2)	<0.001
Other maternal conditions*	1957	240 (12)	204 (10)	658 (34)	843 (43)	8 (0)	<0.001

*Any chronic or acute injury or disorder affecting the kidneys, heart, lungs or liver.

maceration), and early neonatal mortality, defined as death before discharge or within 7 days of hospitalisation, in both spontaneous preterm and provider-initiated preterm deliveries by HDI group. As deliveries before 28 completed weeks of gestation are considered as stillbirths in some countries, we restricted this analysis to 19 333 singletons born above 28 weeks of gestation. Using multilevel, multivariate logistic regression models adjusted for maternal characteristics, as shown in Table 1, as well as the method of delivery and fetal presentation, we calculated the risk of stillbirth and early neonatal death in spontaneous preterm delivery compared with provider-initiated preterm delivery. We further stratified this analysis by HDI subgroup. Statistical analysis was conducted using Stata/MP version 12.0 (Stata Corp LP, College Station, TX, USA), and $P < 0.05$ was considered to be statistically significant.

Results

Of the 29 9878 singleton deliveries, 6.7% were preterm. The proportion of preterm births among all deliveries was not necessarily higher in lower HDI countries, and varied largely in the range 1–10% by country (shown in Table S1). Alternatively, the proportion of preterm births that were provider initiated increased as HDI increased, with the percentage being 20% in low HDI countries and 40% in high HDI countries. This difference persisted through subgroups of length of gestation (Table 2), with HDI ranking and proportion of provider-initiated deliveries showing a mild significant correlation ($R = 0.25$, $P = 0.007$) (Figure 1).

Table 1 illustrates the distribution of the timing of delivery by maternal characteristics. Mothers who were unmarried, had a low number of previous births, had a previous caesarean section, anaemia, or any infection or chronic hypertension showed a higher prevalence of spontaneous and provider-initiated preterm delivery. Mothers who received less education and who were younger had a higher proportion of spontaneous preterm delivery, but not provider-initiated preterm delivery. However, older mothers had a higher prevalence of provider-initiated preterm delivery, but not spontaneous preterm delivery.

To estimate the effect of the maternal characteristics shown in Table 1 on preterm delivery, we used a multivariate, multilevel, multinomial logistic regression model. In Table 3, we show the difference in prevalence and effect of maternal complications, stratified by HDI groups. The prevalence of HIV/

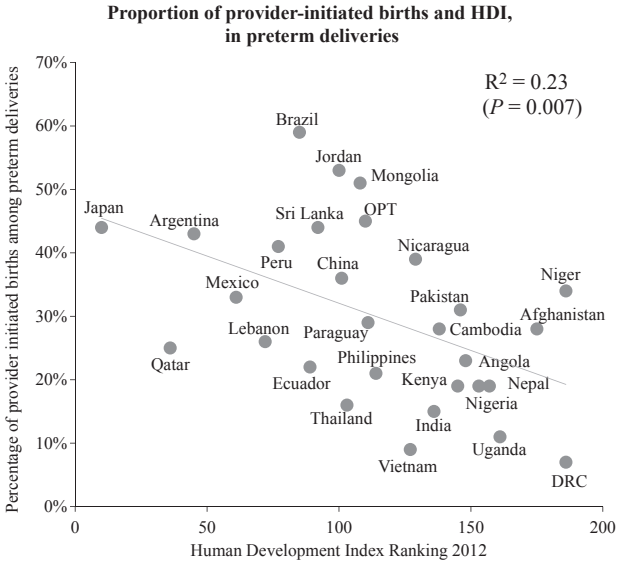

Figure 1. Proportion of provider-initiated births and Human Development Index (HDI) in preterm deliveries. DRC, Democratic Republic of Congo; OPT, Occupied Palestinian Territory.

Table 2. Proportion of provider-initiated delivery among preterm deliveries, stratified by the duration of pregnancy and Human Development Index (HDI)

	HDI group			
	Very high	**High**	**Medium**	**Low**
	Provider-initiated births (*n*)/All births (*N*) [proportion of provider-initiated births (%)]			
All preterm deliveries (%)	369/921 (40)	1856/4945 (38)	1720/7675 (22)	1370/6690 (20)
Extremely premature deliveries (22–27 weeks)	19/41 (46)	61/228 (27)	66/271 (24)	81/358 (23)
Severely premature deliveries (28–31 weeks)	37/75 (49)	195/508 (38)	260/994 (26)	234/995 (24)
Moderately preterm deliveries (32–33 weeks)	37/85 (44)	260/680 (38)	276/1139 (24)	207/783 (26)
Late preterm deliveries (34–36 weeks)	276/720 (38)	1340/3529 (38)	1118/5271 (21)	848/4554 (19)

Very high HDI countries included Japan, Qatar and Argentina; high HDI countries included Mexico, Lebanon, Peru, Brazil, Ecuador and Sri Lanka; medium HDI countries included Jordan, China, Thailand, Mongolia, Occupied Palestinian Territory, Paraguay, Philippines, Vietnam, Nicaragua, India and Cambodia; low HDI countries included Kenya, Pakistan, Angola, Nigeria, Nepal, Uganda, Afghanistan, Democratic Republic of Congo and Niger.

AIDS and malaria/dengue was higher, and that of chronic hypertension, pre-eclampsia, eclampsia, systemic infection and puerperal endometritis was lower, in low HDI countries. The effects of anaemia and hypertension were significant in all HDI groups, and the risk of preterm delivery caused by these complications did not decrease despite higher levels of country development. The effects of all bacterial infections (pyelonephritis, puerperal endometritis, systemic infection) were strongest in the high HDI country group, and the effect of HIV/AIDs was larger in the higher HDI groups.

Detailed data on associations between all maternal characteristics and spontaneous and provider-initiated preterm delivery are shown in Table S2. Individual risk factors for both spontaneous and provider-initiated preterm delivery included lower (<20 years) and higher (>35 years) maternal age, unmarried status, poorer education, severe anaemia, systemic bacterial infection, malaria and/or dengue, hypertensive disorders (chronic hypertension, pre-eclampsia or eclampsia) and other maternal conditions. No significant differences were observed by difference in parity or presence of HIV/AIDS.

To further estimate the effect of maternal characteristics on spontaneous labour compared with provider-initiated delivery in preterm, as well as term, deliveries, we used a multilevel, multivariate logistic regression model comparing these two outcomes. In Table 4, we show the results. Mothers of lower age, poorer education or with pyelonephritis were more likely to have spontaneous labour, and

Table 3. Variation in prevalence (A) and adjusted odds ratios (B) of selected maternal medical conditions of preterm birth by country with the Human Development Index (HDI): analysis of 299 878 singleton deliveries in 29 countries

Maternal condition	All countries (%)***	Very high HDI (%)****	High HDI (%)****	Medium HDI (%)****	Low HDI (%)****
(A) Prevalence of selected maternal medical conditions					
Anaemia	4077 (1.4)	181 (1.0)	164 (1.7)	208 (1.4)	151 (1.2)
Infection					
Pyelonephritis	453 (0.2)	18 (0.1)	96 (0.1)	235 (0.2)	104 (0.1)
Puerperal endometritis	270 (0.1)	93 (0.6)	67 (0.1)	58 (0.1)	52 (0.0)
Systemic infection	966 (0.3)	137 (0.8)	249 (0.4)	355 (0.4)	225 (0.2)
HIV/AIDS	1109 (0.4)	27 (0.2)	86 (0.1)	113 (0.1)	883 (0.8)
Malaria/dengue	312 (0.1)	2 (0.0)	13 (0.0)	52 (0.1)	245 (0.2)
Hypertensive disorders					
Chronic hypertension	1148 (0.4)	83 (0.5)	346 (0.5)	446 (0.4)	273 (0.2)
Pre-eclampsia/eclampsia	7066 (2.4)	445 (2.7)	1908 (2.9)	2811 (2.9)	1902 (6)
(B) Adjusted odds ratios and 95% confidence intervals for estimates of effect of maternal medical conditions on preterm delivery					
Anaemia	2.0 (1.8; 2.2)**	2.0 (1.3; 3.0)*	1.8 (1.3; 2.5)*	2.0 (1.7; 2.3)**	2.3 (2.0;2.7)**
Infection					
Pyelonephritis	1.5 (1.1; 2.0)*	0.6 (0.1; 5.4)	6.4 (3.5; 12)**	1.3 (0.8; 2.1)	1.1 (0.7; 1.9)
Puerperal endometritis	1.8 (1.2; 2.7)	0.4 (0.1; 1.3)	3.7 (1.9; 7.1)**	1.5 (0.6; 3.8)	2.7 (1.3;5.8)*
Systemic infection	2.8 (2.3; 3.4)**	1.6 (0.8; 3.1)	5.8 (3.9; 8.6)**	2.4 (1.8; 3.2)**	2.7 (1.9;4.0)**
HIV/AIDS	1.2 (1.0; 1.5)	5.5 (2.0; 15)*	1.4 (0.6; 3.5)	1.0 (0.5; 1.9)	1.2 (0.9; 1.6)
Malaria/dengue	4.4 (3.2; 6.13)**	NE*****	3.2 (0.5; 19)	2.5 (1.3; 4.8)**	5.4 (3.6; 8.0)**
Hypertensive disorders					
Chronic hypertension	2.3 (1.9; 2.7)**	3.0 (1.5; 6.0)*	3.3 (2.5; 4.3)**	2.3 (1.8; 2.9)**	1.1 (0.8; 1.7)
Pre-eclampsia/eclampsia	5.0 (4.7; 5.4)**	5.0 (3.8; 6.6)**	6.1 (5.4; 6.9)**	3.7 (3.3; 4.1)**	6.7 (5.9; 7.5)**

Very high HDI countries included Japan, Qatar and Argentina; high HDI countries included Mexico, Lebanon, Peru, Brazil, Ecuador and Sri Lanka; medium HDI countries included Jordan, China, Thailand, Mongolia, Occupied Palestinian Territory, Paraguay, Philippines, Vietnam, Nicaragua, India and Cambodia; low HDI countries included Kenya, Pakistan, Angola, Nigeria, Nepal, Uganda, Afghanistan, Democratic Republic of Congo and Niger.
*$P < 0.01$.
**$P < 0.001$.
***Multinomial, multilevel, multivariate logistic regression models were used to obtain adjusted odds ratios (AORs): the outcome was of five categories (spontaneous preterm birth, spontaneous term birth, provider-initiated preterm birth, provider-initiated term birth, post-term birth; reference is spontaneous term birth); multilevel analysis was structured on three levels (individual, health facility, country) with random intercepts, and adjusted for maternal age, marital status, education, parity and previous caesarean section.
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*****Not estimated due to small numbers.

nulliparous mothers, mothers with previous caesarean section or mothers with anaemia, malaria/dengue, chronic hypertension or pre-eclampsia were more likely to have provider-initiated delivery, in both term and preterm deliveries. Multiparity (more than two previous births) was associated with spontaneous delivery only in term births, and pyelonephritis was associated with spontaneous delivery in preterm delivery, but with provider-initiated delivery in term delivery.

Table 5 illustrates the risk of stillbirth and early neonatal death among preterm deliveries for both spontaneous labour and provider-initiated delivery by HDI subgroup. Risks of stillbirth and early neonatal death were both lower in spontaneous preterm deliveries compared with provider-initiated deliveries within all HDI subgroups. Stillbirth and early neonatal death within both spontaneous preterm delivery and provider-initiated preterm delivery decreased as HDI increased. After adjustment for maternal characteristics, the odds ratio of stillbirth in spontaneous delivery compared with provider-initiated delivery was lower in all HDI subgroups, and this effect was larger as HDI increased.

Table 4. Adjusted odds ratios of risk factors for spontaneous compared with provider-initiated delivery, in term and preterm delivery: analysis of 299 878 singleton preterm deliveries in 29 countries

Maternal characteristics	Spontaneous versus provider-initiated delivery [adjusted odds ratio (95% confidence interval)]	
	Preterm delivery	Term delivery
Age (years)		
<20	1.24 (1.08; 1.39)**	1.44 (1.38; 1.51)***
20–34	REF	REF
≥35	0.67 (0.60; 0.76)***	0.66 (0.64; 0.69)***
Marital status		
Single	1.25 (1.08; 1.45)**	1.10 (1.05; 1.15)***
Married	REF	REF
Education		
None	2.28 (1.89; 2.75)***	1.94 (1.83; 2.06)***
1–6 years	1.77 (1.51; 2.07)***	1.40 (1.33; 1.46)***
7–9 years	1.75 (1.51; 2.02)***	1.30 (1.25; 1.36)***
10–12 years	1.35 (1.19; 1.53)***	1.25 (1.21; 1.30)***
>12 years	REF	REF
Parity		
0	0.79 (0.72; 0.87)***	0.51 (0.49; 0.52)***
1–2	REF	REF
≥3	1.02 (0.89; 1.15)	1.46 (1.40; 1.52)***
Previous caesarean section	0.37 (0.33; 0.41)***	0.15 (0.15; 0.16)***
Infant sex (female)	0.97 (0.90; 1.05)	1.04 (1.03; 1.07)***
Severe anaemia (haemoglobin <7 mg/dl)	0.54 (0.44; 0.65)***	0.83 (0.76; 0.91)***
Infection		
Pyelonephritis	2.21 (1.17; 4.15)*	0.76 (0.58; 0.99)*
Puerperal endometritis	1.10 (0.54; 2.26)	0.90 (0.64; 1.27)
Systemic bacterial infection	0.81 (0.57; 1.15)	0.80 (0.66; 0.97)*
HIV/AIDs	1.00 (0.61; 1.66)	0.49 (0.41; 0.59)***
Malaria/dengue	0.27 (0.16;0.47)***	0.48 (0.33; 0.68)***
Hypertension		
Chronic hypertension	0.60 (0.45; 0.81)**	0.34 (0.29; 0.41)***
Pre-eclampsia/ eclampsia	0.20 (0.18; 0.22)***	0.32 (0.30; 0.34)***

Multilevel, multivariate logistic regression models were used to obtain adjusted odds ratios: the outcome was preterm delivery; multilevel analysis was structured on three-levels (individual, health facility, country) with random intercepts, and adjusted for maternal age, marital status, education, parity and previous caesarean section.
*$P < 0.05$.
**$P < 0.01$.
***$P < 0.001$.

Discussion

Main findings

In our study, we found an increase in the percentage of provider-initiated preterm delivery, as well as a decrease in stillbirth and early neonatal mortality, in higher HDI groups. Younger mothers and those who received less education were also less likely to have a provider-initiated delivery for a preterm birth.

However, we did not observe a decrease in preterm birth associated with improved human development of the country, and the effects of maternal complications, such as anaemia or hypertensive disorders, on preterm delivery were similar across countries.

Once obstetric complications are present, the avoidance of preterm delivery may be difficult, even with the care standards of more developed countries. On top of an increased effort to prevent pregnancy complications, developing countries and those socially disadvantaged may benefit from management care, including interventions to optimise the timing of delivery.

Interpretation

Recent reports have shown an increase in provider-initiated preterm delivery and improved neonatal outcomes in developed countries.[17,18] In the USA, provider-initiated delivery increased from 30% to 42% of all preterm deliveries during 1995–2005,[3] with stillbirths and neonatal mortality also decreasing. In our study, we observed an increase in provider-initiated preterm delivery associated with country HDI, as well as a decrease in the risk of stillbirth in spontaneous preterm deliveries compared with provider-initiated preterm deliveries in higher HDI countries, even after controlling for maternal and infant characteristics.

Table 5. Neonatal outcomes of spontaneous labour and provider-initiated preterm delivery: analysis of 19 333 singleton preterm deliveries above 28 weeks of gestation in 29 countries

	Human Development Index (HDI) group				
	All countries (19 333)	**Very high (921)**	**High (4945)**	**Medium (7675)**	**Low (6690)**
	Stillbirths/preterm deliveries (%)				
(A) Fresh stillbirths					
Spontaneous preterm deliveries	781/14245 (5.4)	4/530 (0.8)	62/2922 (2.1)	284/5750 (4.9)	431/5043 (8.5)
Provider-initiated preterm deliveries	374/5088 (7.4)	17/350 (4.9)	77/1795 (4.3)	105/1654 (6.4)	175/1289 (13.6)
Adjusted odds ratio****	0.69 (0.58; 0.81)***	0.18 (0.04; 0.78)*	0.42 (0.28; 0.65)***	0.71 (0.53; 0.96)*	0.85 (0.67; 1.09)
	HDI group				
	All countries (18178)	**Very high (859)**	**High (4578)**	**Medium (7015)**	**Low (5726)**
	Early neonatal deaths/live preterm births (%)				
(B) Early neonatal deaths					
Spontaneous preterm deliveries	623/13464 (4.6)	6/526 (1.1)	68/2860 (2.4)	259/5466 (4.7)	290/4612 (6.3)
Provider-initiated preterm deliveries	249/4714 (5.3)	5/333 (1.5)	38/1718 (2.2)	97/1549 (6.3)	109/1114 (9.8)
Adjusted odds ratio****	0.73 (0.59; 0.90)**	0.39 (0.10; 1.45)	0.73 (0.45; 1.18)	0.80 (0.58; 1.09)	0.78 (0.56; 1.06)

Very high HDI countries included Japan, Qatar and Argentina; high HDI countries included Mexico, Lebanon, Peru, Brazil, Ecuador and Sri Lanka; medium HDI countries included Jordan, China, Thailand, Mongolia, Occupied Palestinian Territory, Paraguay, Philippines, Vietnam, Nicaragua, India and Cambodia; low HDI countries included Kenya, Pakistan, Angola, Nigeria, Nepal, Uganda, Afghanistan, Democratic Republic of Congo and Niger.

*$P < 0.05$.

**$P < 0.01$.

***$P < 0.001$.

****Multilevel, multivariate logistic regression models were used to obtain adjusted odds ratio of spontaneous preterm delivery compared with provider-initiated delivery. Multilevel analysis was structured on two levels (individual, country) with random intercepts, and adjusted for facility capacity index, maternal characteristics (maternal age, marital status, education, parity, previous caesarean section and maternal medical conditions) and infant characteristics (sex, gestational age).

Our results also support previous findings which show that lower socio-economic status is a strong factor for increased risk of preterm birth[8] and preterm labour,[19] and for increased risk of not receiving pregnancy terminations when needed.[20] We found that younger mothers and those with a poorer education were at a lower risk of receiving a provider-initiated preterm delivery compared with spontaneous labour, even though most complications were risk factors for both spontaneous and provider-initiated preterm birth, and high-risk pregnancies with hypertensive disorders, malaria or dengue were more likely to receive a provider-initiated delivery. It is important to expand the provision of skilled birth attendance and emergency obstetric care and increase accessibility for the disadvantaged.[21]

However, we found that the risk of preterm delivery remained high in most developed countries, which underscores the fact that preterm delivery is a global health problem for countries at all stages of development. In addition, though anaemia and hypertensive disorders were associated with both spontaneous and indicated preterm birth in all HDI groups, the risk of preterm delivery caused by these complications did not decrease with higher HDI.

Our findings may be supportive of previous studies which observed that few medical interventions aimed at reducing maternal complications can successfully prevent preterm birth. Peña-Rosas et al.[22] reported that, although antenatal iron supplementation decreased maternal anaemia and increased birthweight, it did not significantly reduce

preterm birth. Thangaratinam et al.[23] reported that, currently, there is no test sufficiently accurate for the early recognition of women at risk of pre-eclampsia and, although supplemental calcium significantly reduced the risk of pre-eclampsia, it did not decrease the risk of preterm birth.

Interestingly, AIDS did not have a significant effect overall on preterm birth (adjusted odds ratio [AOR], 1.21; 95% confidence interval [CI], 0.97; 1.51), which contradicted previous studies.[11,12] Yet, the effect of AIDS on preterm deliveries was higher in countries with high HDI, and was a significant risk factor for preterm delivery in very high HDI countries. A similar effect has been observed in the USA,[12] and may be explained by behavioural, socio-economic characteristics associated with having HIV in a setting in which prevalence is low.

Strengths and limitations

Our study has several limitations. First, we did not collect data on fetal indications for the termination of pregnancy, including fetal distress and intrauterine growth restriction, or prolonged rupture of membranes (PROM). These are important factors leading to spontaneous and provider-initiated preterm delivery, and the absence of this information prevented us from focusing on the direct causes of provider-initiated delivery, as well as from calculating the coverage of provider-initiated delivery in pregnancies with indications. Therefore, we focused on effects of maternal age, education and complications and their effect on preterm delivery.

Second, we also lacked data on maternal characteristics associated with preterm delivery, such as smoking, malnutrition, and familial and maternal history of recent preterm delivery. As previous studies have found that these characteristics are mostly associated with lower socio-economic status, as well as preterm delivery,[13,24,25] the lack of adjustment for these confounders may have led to an overestimation of the risk of preterm delivery in mothers of a younger age, a lower level of education or from less developed countries. The additional risk observed in mothers with a lower socio-economic status in our study can be interpreted by considering adverse behaviour, such as smoking, which has been reported to be associated with lower societal status and preterm birth, but not measured in our survey.[25–27]

Third, as routine hospital records served as the primary data source, the prevalence of maternal complications in our data could have been affected by a lack of documented diagnosis because of the inability to diagnose the condition, failure to recognise the condition or failure to document the diagnosis, and the skill of the personnel involved in data collection. However, to minimise this bias, we trained the data collectors, double-checked the data collection forms before data entry and asked medical staff to complete the information in the record in the case of unclear or missing information, in order to reduce methodological heterogeneity and increase data quality as much as possible.

Finally, as this study was facility based, with facilities being mainly secondary and tertiary facilities, we were likely to have an over-representation of maternal complications and perinatal deaths, and a higher coverage of interventions, compared with smaller facilities in the community, with the magnitude of bias varying between countries. Therefore, our data are not representative of the population, and can only be extrapolated to similar settings.

Conclusions

Our study shows that preterm delivery is less likely to be provider initiated in less well developed countries, even when limited to facilities in which caesarean section and induction of labour can be performed. When maternal complications, such as anaemia or hypertensive disorders, are present, the impact on preterm delivery is difficult to reduce even with the care standards of more highly developed countries.

To improve pregnancy outcomes, it is important to provide adequate obstetric care, including optimal timing for delivery in high-risk pregnancies, especially to the socially disadvantaged. There is a need for further interventions that aim to prevent maternal complications and improve the capacity to manage provider-initiated delivery in low-income countries.

Disclosure of interests

The authors declare that they have no competing interests or conflicts of interest.

Contribution to authorship

RM, NM, EO and GT initiated the concept. NM, GT and EO contributed to the design of the study. NM performed the data analysis and wrote the initial manuscript. JPV, JPS, CJRH and KJ provided advice to the study design and edited the manuscript. All authors read and approved the final version of the manuscript.

Details of ethics approval

The UNDP/UNFPA/UNICEF/WHO/World Bank Special Programme of Research, Development and Research Training in Human Reproduction (HRP) Specialist Panel on Epidemiological Research reviewed and approved the study protocol for technical content. This study was approved by the WHO Ethical Review Committee and the relevant ethical clearance mechanisms in all countries (protocol ID: A65661; date of approval 27 October 2009).

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Table S1. Prevalence of preterm delivery by country. Analysis of 299 878 singleton deliveries in 29 countries.

Table S2. Adjusted odds ratios for risk factors for spontaneous labour and provider-initiated preterm delivery. Analysis of 16 474 singleton preterm deliveries in 29 countries. ■

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The World Health Organization Multicountry Survey on Maternal and Newborn Health project at a glance: the power of collaboration

In the early 2000s, the World Health Organization (WHO) initiated an ambitious research project aimed at establishing a global network of health facilities providing maternity services. This network would not only enable WHO to generate knowledge related to maternal and perinatal health at the global level, but also aimed to foster collaboration and strengthen research capacity across the world. Between 2004 and 2008, the first round of research was implemented in 24 countries from Africa, Asia, and Latin America. The 2004–2008 Global Survey on Maternal and Perinatal Health resulted in a strong worldwide collaboration that produced over 25 research papers, several local and global policy briefs, and a number of master's and doctorates at various universities around the world.[1,2]

Considering the success of the Global Survey project and the network's momentum and motivation, preparations for a second round of research were initiated in 2008. The project steering committee, together with the project coordinators at the country and regional levels, opted to focus on issues related to severe maternal and newborn morbidity and mortality, and to expand the network. Through a participatory process, a research protocol was developed and, between May 2010 and December 2011, data collection for the Multicountry Survey on Maternal and Newborn Health (WHOMCS) was implemented in 359 hospitals from 29 countries located in five WHO regions (i.e. Africa, the Americas, Eastern Mediterranean, South East Asia, and the Western Pacific).[3,4]

The WHOMCS included over 314 000 women and their newborn infants.[5] It is the largest study to date assessing the management of severe maternal complications and the prevalence of maternal near miss. Figure 1 shows the individual countries that participated in the WHOMCS. Implementing a study of this magnitude was a considerable challenge. Internal challenges included, for instance, a relatively small budget and the need to standardise research processes across all research sites. External challenges involved major events such as civil unrest, armed conflict, labour strikes, and disease outbreaks that affected the implementation of the project in some countries; however, the motivation of over 1500 collaborators and the essential contribution of several WHO offices, partners, and donors led to the successful completion of this project.

The first research output of the WHOMCS was published in May 2013. This publication sent a strong message to the international community of researchers, policy makers, and other stakeholders: in order to achieve a substantial reduction in maternal mortality, it is necessary to adopt a comprehensive approach to emergency obstetric care together with overall improvements in the quality of maternal health care.[5] In parallel with the publication of this first peer-reviewed article, the network carried out a coordinated and decentralised effort to conduct several analyses of the study data set covering a wide range of issues, including social determinants of health, major causes of maternal mortality and morbidity, newborn care, and other aspects of maternal and perinatal health. One commentary and 12 scientific papers have been published in this *BJOG* special supplement dedicated to maternal and perinatal health.[6–18] The main conclusions of these analyses are summarised in Box 1.

This supplement demonstrates the strengths of an effective global collabo-

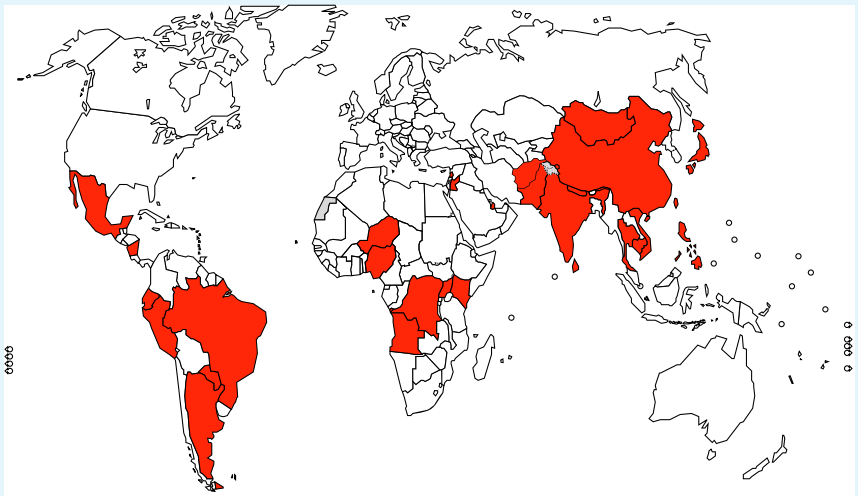

Figure 1. Participating countries and territories (Afghanistan, Angola, Argentina, Brazil, Cambodia, China, Democratic Republic of the Congo, Ecuador, India, Japan, Jordan, Kenya, Lebanon, Mexico, Mongolia, Nepal, Nicaragua, Niger, Nigeria, Occupied Palestinian Territory, Pakistan, Paraguay, Peru, Philippines, Qatar, Sri Lanka, Thailand, Uganda, and Vietnam).

ration of clinicians, researchers, Ministries of Health, and WHO offices. Further efforts will be needed to continue the analytical work of this data set, including the combination of the 2004–2008 Global Survey and the 2010–2011 WHOMCS data sets: together, these databases have recorded data for more than 600 000 women and their newborns. Nevertheless, beyond the scientific articles, greater efforts will be required to put these findings and other valuable information into action, in order to improve the health of families, women, and children around the world. While acknowledging the obstacles, we are confident that with focus, persistence, and collaboration, science and health policy can work together to bring better lives to the most vulnerable populations.

Box 1. Key findings of 12 secondary analyses of the WHOMCS

Postpartum haemorrhage

The use of uterotonics for the prevention and treatment of postpartum haemorrhage is widespread among the health facilities participating in this study, yet additional interventions are often necessary for the management of severe maternal outcomes. Even among hospitals that reported the capacity to provide all of the essential interventions, including emergency obstetric services, disparities in the rates of maternal death and other severe outcomes persist.

Pre-eclampsia and eclampsia

The analysis of this large database provides estimates of the global distribution of the incidence of hypertensive disorders of pregnancy, and information about the most frequent complications (including organ dysfunctions) associated with pre-eclampsia and eclampsia. This information can be used for developing health systems strategies related to the management of severe complications arising from pre-eclampsia and eclampsia.

Abortion

Young women (<20 years of age), single women, and women undergoing abortions at later gestational ages presented a higher risk of maternal death. The highest burden of abortion-related severe maternal outcomes was seen in low or medium Human Development Index countries.

Indirect causes of maternal mortality

Indirect causes were responsible for about 20 and 25% of severe maternal outcomes and maternal deaths, respectively. Women with underlying indirect medical conditions during pregnancy had significantly increased risks of obstetric complications, severe maternal outcomes, maternal near miss, maternal death, and perinatal morbidity and mortality.

Adolescent pregnancy

Adolescent pregnancy is associated with higher risks of adverse pregnancy outcomes. Preventive strategies in early pregnancy, in conjunction with improvement of healthcare interventions, are crucial to reduce adverse pregnancy outcomes among adolescent women in low- and middle-income countries.

Advanced maternal age

Advanced maternal age significantly increases the risk of maternal near miss, maternal death, and severe maternal outcomes. It also slightly increases the risk of fetal and perinatal mortality.

Maternal education

Women with lower levels of education are at greater risk for severe maternal outcomes, even after adjustment for key confounding factors. This is particularly true for women in countries that have poorer markers of social and economic development.

Infection and caesarean section

Prophylactic antibiotic coverage for caesarean delivery may be related to the importance attributed to guidelines and clinical audits in the health facility. There may also be a tendency to use prophylactic antibiotics when caesarean delivery has been scheduled, and the use of antibiotic prophylaxis was already included in the routine clinical protocol.

Intrapartum-related perinatal mortality

The prevention of intrapartum-related perinatal death goes beyond caesarean section coverage, requiring a comprehensive approach to quality intrapartum care. The majority of perinatal deaths occur in women with complications: early identification and management could improve both maternal and perinatal outcomes. Improving the continuum of care between the community-based antenatal identification of maternal complications (such as pre-eclampsia and severe anaemia) and the quality of intrapartum care is therefore essential.

Twin pregnancy

The pre-labour caesarean delivery rate for twins varied largely between countries, probably because of the overuse of caesarean delivery in wealthier countries, as well as its lack of availability in low-income countries. Pre-labour delivery may be beneficial when the first twin is non-vertex or when pregnancy has exceeded 38 weeks of gestation.

Preterm birth

Providing adequate obstetric care, including the optimal timing for delivery in high-risk pregnancies, especially to the socially disadvantaged, could improve pregnancy outcomes. Decreasing provider-initiated preterm delivery in women once maternal complications such as anaemia or hypertensive disorders are present is important for countries at various stages of development, but may be more challenging to achieve.

Neonatal near miss

Survivors of selected markers of severe neonatal morbidities could be appropriately labelled as neonatal near-miss cases. The definition developed in the present analysis is a basis for future applications in neonatal health.

Disclosure of interests

The authors declare no conflicts of interest.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Appendix S1. The WHOMCS Research Network.

JP Souza on behalf of the WHO Multicountry Survey on Maternal and Newborn Health Research Network*

UNDP/UNFPA/UNICEF/WHO/World Bank Special Programme of Research, Development and Research Training in Human Reproduction (HRP), Department of Reproductive Health and Research, World Health Organization, Geneva, Switzerland

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*See Appendix S1 for a full list of contributors.

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Appendix S1. The WHO MCS Research Network

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