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Summary

Background Rates of caesarean section surgery are rising worldwide, but the determinants of this increase, especially in low-income and middle-income countries, are controversial. In this study, we aimed to analyse the contribution of specific obstetric populations to changes in caesarean section rates, by using the Robson classification in two WHO multicountry surveys of deliveries in health-care facilities. The Robson system classifies all deliveries into one of ten groups on the basis of five parameters: obstetric history, onset of labour, fetal lie, number of neonates, and gestational age.

Methods We studied deliveries in 287 facilities in 21 countries that were included in both the WHO Global Survey of Maternal and Perinatal Health (WHOGS; 2004–08) and the WHO Multi-Country Survey of Maternal and Newborn Health (WHOMCS; 2010–11). We used the data from these surveys to establish the average annual percentage change (AAPC) in caesarean section rates per country. Countries were stratified according to Human Development Index (HDI) group (very high/high, medium, or low) and the Robson criteria were applied to both datasets. We report the relative size of each Robson group, the caesarean section rate in each Robson group, and the absolute and relative contributions made by each to the overall caesarean section rate.

Findings The caesarean section rate increased overall between the two surveys (from 26·4% in the WHOGS to 31·2% in the WHOMCS, p=0·003) and in all countries except Japan. Use of obstetric interventions (induction, prelabour caesarean section, and overall caesarean section) increased over time. Caesarean section rates increased across most Robson groups in all HDI categories. Use of induction and prelabour caesarean section increased in very high/high and low HDI countries, and the caesarean section rate after induction in multiparous women increased significantly across all HDI groups. The proportion of women who had previously had a caesarean section increased in moderate and low HDI countries, as did the caesarean section rate in these women.

Interpretation Use of the Robson criteria allows standardised comparisons of data across countries and timepoints and identifies the subpopulations driving changes in caesarean section rates. Women who have previously had a caesarean section are an increasingly important determinant of overall caesarean section rates in countries with a moderate or low HDI. Strategies to reduce the frequency of the procedure should include avoidance of medically unnecessary primary caesarean section. Improved case selection for induction and prelabour caesarean section could also reduce caesarean section rates.

Funding None.

Introduction

The crude rate of caesarean section surgery is an important global indicator for measuring access to obstetric services.[1] In many countries (especially high-income countries), rates of caesarean section have increased steadily during the past three decades.[2] The 1985 WHO statement that regional caesarean section rates should not exceed 10–15%[3] was based on evidence available at that time; however, the validity of this threshold has since been questioned.[2] Conversely, in many lower-income countries, inadequate access to safe and timely caesarean section is a substantial barrier to improving the outcomes of mothers and neonates.[4] These nations are often hampered by an absence of reliable epidemiological data about births and mode of delivery.[5]

The determinants of rising caesarean section trends worldwide are controversial. Some authors have argued

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that the increase is driven largely by the rising use of non-medically indicated caesarean section,[6] which can pose unnecessary risks to mothers and neonates.[7] A deeper understanding of these drivers across countries has been complicated by an absence of international consensus regarding a universal caesarean section classification system. A 2011 systematic review by Torloni and colleagues[8] of 27 caesarean section classification systems identified the ten-group classification system proposed by Robson in 2001[9] as the most appropriate to compare surgery rates. Robson's system classifies all deliveries into one of ten groups on the basis of five parameters: obstetric history (parity and previous caesarean section), onset of labour (spontaneous, induced, or caesarean section before onset of labour), fetal presentation or lie (cephalic, breech, or transverse), number of neonates, and gestational age (preterm or term; panel 1). The ten Robson categories are mutually exclusive, totally inclusive, and can be applied prospectively, since each woman admitted for delivery can be classified immediately on the basis of a few variables that are generally routinely recorded. This system helps institution-specific monitoring and auditing, and offers a standardised comparison method between institutions, countries, and timepoints. The Robson classification has been used to analyse trends and determinants of caesarean section use in health-care facilities in both high-income and low-income countries,[10–12] and has also been applied to state, national, and international datasets, including data from eight Latin American countries in the WHO Global Survey of Maternal and Perinatal Health.[13–16]

To explore global caesarean section patterns and possible drivers of these trends, we analysed changes in the characteristics of the obstetric populations in two WHO multicountry surveys and used the Robson classification to assess trends in group-specific caesarean section rates and the changes in the absolute and relative contribution of Robson groups to overall caesarean section rates over time.

Methods

Study design and participants

In the past decade, WHO has done two cross-sectional, facility-based, multi-country surveys of deliveries using very similar methods. The WHO Global Survey of Maternal and Perinatal Health (WHOGS) was undertaken in 2004–05 (in Latin America and African countries) and in 2007–08 (in Asian countries).[17–19] The primary aim of WHOGS was to explore the association between the use of caesarean section and maternal and perinatal outcomes.[20–22] A stratified, multistage, cluster-sampling approach was used to obtain a sample of deliveries in 24 countries from Africa, Asia, and Latin America. Within each country, the capital city was sampled, along with two randomly selected provinces (probability of selection proportional to population size). From these countries, seven facilities with more than 1000 deliveries per year

and the capacity to perform caesarean section were randomly selected (and if fewer than seven facilities were available, all of these were selected). Data were gathered for 2 months in institutions with at least 6000 deliveries per year and for 3 months in institutions with fewer than 6000 annual deliveries. Data about the sociodemographic, obstetric, delivery, and labour characteristics of all women, and a range of maternal and perinatal outcomes, were captured from all women who delivered babies during the data collection period. The WHOGS captured data for 287 036 women (290 610 deliveries) delivering in 373 facilities in 24 countries.

The WHO Multi-Country Survey of Maternal and Newborn Health (WHOMCS) followed the WHOGS, and was done between May, 2010, and December, 2011. The primary aim of the WHOMCS was to characterise severe maternal, perinatal, and neonatal morbidity in a worldwide network of health facilities, with a particular focus on the WHO maternal near-miss indicators.[23] The WHOMCS methods have been described elsewhere;[23–25] however, it built on the existing WHOGS network of health facilities. WHOGS countries were invited to participate in the WHOMCS; two countries (Cuba and Algeria) were unable to participate. Within the remaining 22 countries, 32 facilities with very poor recruitment, data quality issues, or that were unable to participate were not included in the WHOMCS. Seven new countries were added to improve global representation, to include a total of 29 countries in Africa, Asia, Latin America, and the Middle East. The WHOMCS used the same data collection process as the WHOGS. During the data collection period in each facility, data were collected for all deliveries, and from all women who had a severe maternal outcome from pregnancy or delivery (including those related to ectopic or aborted pregnancies). The WHOMCS collected data for 314 623 women (318 534 deliveries) from 359 facilities in 29 countries.

In both surveys, data were collected prospectively from time of presentation at the facility until discharge or the seventh day post partum (whichever occurred first). Maternal or perinatal adverse outcomes that occurred after discharge or day 7 or during a post-partum referral were not recorded. Data collectors reviewed medical records daily and abstracted de-identified data from these records into an individual data form. Additionally, in both surveys an institutional data form was completed for each participating facility, in consultation with the head of the department of obstetrics on available obstetric and newborn services. However, in view of the differing aims of the two surveys, only a few variables (such as location and level of facility) were common to both institutional data forms.

To study changes in obstetric populations and the caesarean section rate over time, we used institutional information to identify the countries and facilities that participated in both surveys, and facilities that participated in only one survey were excluded.

Clarification was occasionally sought from the relevant country coordinators when this information was incomplete. Although Angola participated in both surveys, the surgical capacity in its participating facilities changed significantly in the time between the two surveys, and the WHOGS gestational age data from Angola were quite poor. Consequently, data from Angola were excluded from our analysis. In both datasets, women delivering at less than 22 weeks or with an unknown gestational age were excluded.

The technical content of both protocols was reviewed by specialist panels at the UNDP/UNFPA/UNICEF/WHO/World Bank Special Programme of Research, Development and Research Training in Human Reproduction. The Specialist Panel on Epidemiological Research reviewed and approved the WHOGS study protocol for technical content; the Research Project Review Panel (name of panel was changed in 2010) reviewed and approved the technical content of the WHOMCS. The WHOGS and WHOMCS were approved by the WHO Ethical Review Committee and the relevant ethical clearance bodies in participating countries and facilities. Written consent from individual women was not needed because there was no contact between the data collectors (who extracted routine medical record data) and individual women.

Variables, data sources, and measurement

The WHOGS and the WHOMCS both gathered information about several individual variables, including maternal sociodemographic characteristics (age, years of education, and marital status), obstetric history (parity and previous caesarean section), onset of labour (spontaneous, induced, or caesarean section before labour), mode of delivery, fetal presentation, number of neonates, and gestational age. The variables necessary for the application of the Robson classification were therefore available in both datasets and were applied according to the standard methods recommended by Robson.[17] An additional category of women who could not be classified was reported separately as group X. This group included women with missing information for at least one of the key variables for Robson classification, and those with contradictory information in Robson classification variables—ie, nulliparous women with a history of caesarean section and women who did not undergo labour due to caesarean section but were reported to have a vaginal delivery.

Statistical analysis

We reported the individual characteristics of women for both datasets and established the proportion of women delivering their babies by caesarean section (ie, the caesarean section rate). With the CSTABULATE function in SPSS 20, we used χ^2 tests (adjusted for clustering of women within facilities, and facilities within countries, because of the hierarchical survey design) to establish whether or not the two datasets differed significantly in
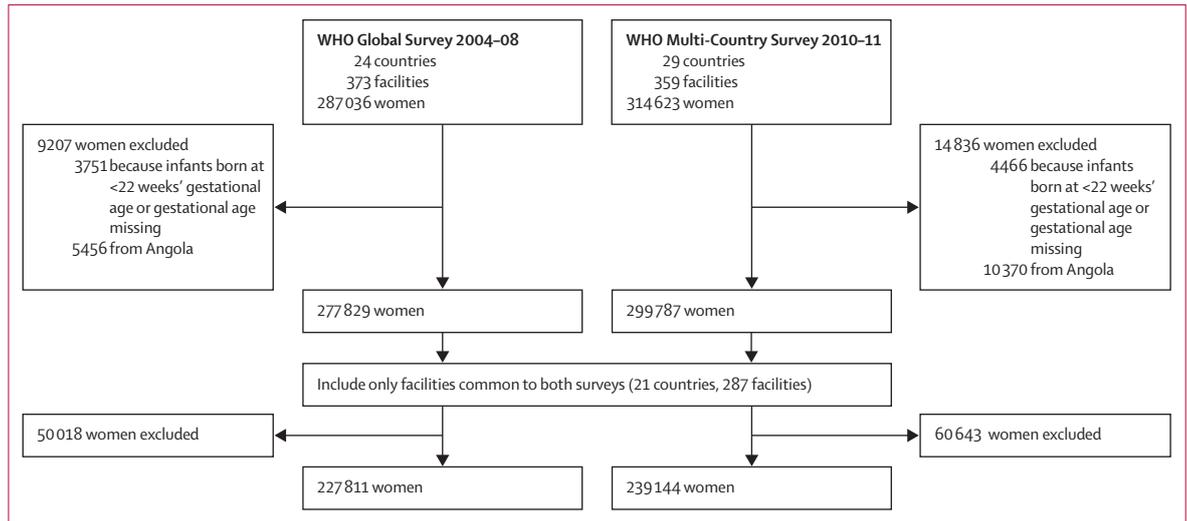
patterns of individual characteristics and caesarean section rates. Because the time difference between the two surveys varied between countries, to ascertain the rate of change in country caesarean section rates we used an average annual percentage change (AAPC) equation:

$$AAPC = \left(\frac{\text{WHOMCS caesarean rate}}{\text{WHOGS caesarean rate}} \right)^{\left(\frac{1}{\text{time difference [years]} \times 100} \right)}$$

WHO uses a similar equation to calculate maternal mortality trends,[26] and the result can be interpreted as the average percentage by which caesarean section rates increased or decreased every year. The AAPC of the caesarean section rate enables comparison between countries, with the assumption that the caesarean section rate has changed linearly during the given time period.

To further explore caesarean section trends, we categorised countries as very high, high, medium, or low Human Development Index (HDI) countries, as per the 2013 Human Development Report.[27] Because of low numbers of countries, countries with a very high HDI (two countries) and those with a high HDI (five countries) were amalgamated into one group (very high/high HDI countries). Aggregation of countries by HDI group is an increasingly common approach because it groups together countries with similar health, education, and standard of living indicators, whereas grouping of countries by geographical region tends to pool dissimilar countries, and thus can potentially hide meaningful epidemiological patterns. The Robson classification

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Panel 1: The Robson ten-group classification system[9]

1 Nulliparous, singleton, cephalic, ≥37 weeks' gestation, in spontaneous labour
2 Nulliparous, singleton, cephalic, ≥37 weeks' gestation, induced labour or caesarean section before labour
  2a Nulliparous, singleton, cephalic, ≥37 weeks' gestation, induced labour
  2b Nulliparous, singleton, cephalic, ≥37 weeks' gestation, caesarean section before labour
3 Multiparous (excluding previous caesarean section), singleton, cephalic, ≥37 weeks' gestation, in spontaneous labour
4 Multiparous without a previous uterine scar, with singleton, cephalic pregnancy, ≥37 weeks' gestation, induced or caesarean section before labour
  4a Multiparous without a previous uterine scar, with singleton, cephalic pregnancy, ≥37 weeks' gestation, induced labour
  4b Multiparous without a previous uterine scar, with singleton, cephalic pregnancy, ≥37 weeks' gestation, caesarean section before labour
5 Previous caesarean section, singleton, cephalic, ≥37 weeks' gestation
6 All nulliparous with a single breech
7 All multiparous with a single breech (including previous caesarean section)
8 All multiple pregnancies (including previous caesarean section)
9 All women with a single pregnancy in transverse or oblique lie (including those with previous caesarean section)
10 All singleton, cephalic, <37 weeks' gestation pregnancies (including previous caesarean section)

For more on the **CSTABULATE function in SPSS 20** see https://www.ibm.com/software/analytics/spss/

Figure 1: **Study flowchart**

See **Online** for appendix

	WHO Global Survey 2004–08 (n=227 811)	WHO Multi-Country Survey 2010–11 (n=239 144)	χ² p value*
Maternal age (years)			0·25
<20	27 381 (12%)	26 069 (11%)	
20–35	182 722 (80%)	192 693 (81%)	
>35	17 263 (8%)	19 905 (8%)	
Missing	445 (<1%)	477 (<1%)	
Marital status			0·59
Without partner	25 178 (11%)	24 322 (10%)	
With partner	202 095 (89%)	213 100 (89%)	
Missing	538 (<1%)	1722 (1%)	
Years of education			0·005
0	18 072 (8%)	24 774 (10%)	
1–6	43 023 (19%)	30 597 (13%)	
7–9	50 999 (22%)	48 877 (20%)	
10–12	71 714 (32%)	74 997 (31%)	
>12	31 348 (14%)	41 223 (17%)	
Missing	12 655 (6%)	293 (<1%)	
Parity			0·26
0 (nulliparous)	99 595 (44%)	108 694 (46%)	
1–2	97 272 (43%)	101 380 (42%)	
>2	30 182 (13%)	28 777 (12%)	
Missing	762 (<1%)	293 (<1%)	
Previous caesarean section			0·092
No	203 026 (89%)	207 053 (87%)	
Yes	23 564 (10%)	30 397 (13%)	
Missing	1221 (1%)	1694 (1%)	
Onset of labour			0·14
Spontaneous	183 315 (81%)	185 044 (77%)	
Induced	20 958 (9%)	24 653 (10%)	
No labour (ie, prelabour caesarean section)	23 435 (10%)	29 251 (12%)	
Missing	103 (<1%)	196 (<1%)	
			(Table 1 continues on next page)

system was then applied separately to both survey datasets in each HDI group. As per the recommended Robson approach,[17,19] in both datasets we determined: the relative size of each Robson group; the caesarean section rate in each group; the absolute contribution to the overall caesarean section rate (ie, the percentage contributed to the overall caesarean section rate by a particular group); and the relative contribution to the overall caesarean section rate (ie, the absolute contribution expressed as a percentage of the overall rate). To compare changes over time, we established the absolute change (WHOMCS value–WHOGS value) in relative size, caesarean section rate, and absolute contribution (with 95% CI) of each Robson group. We created Robson tables for separate HDI groups and for each country (appendix). We decided to focus our reporting on Robson groups 1–5, since Robson groups 6–10 accounted for only 15% of the obstetric population and 20% of the relative contribution to the overall caesarean section rate. We used SPSS version 20.0.0 for statistical analyses. Our report was prepared in accordance with the STROBE guidelines.[24]

Role of the funding source

The funders of the study had no role in data collection, analysis, or interpretation; writing of the report; or the decision to submit for publication.

Results

287 facilities in 21 countries were identified as participating in both surveys. The countries were: Argentina, Brazil, Cambodia, China, Democratic Republic of the Congo, Ecuador, India, Japan, Kenya, Mexico, Nepal, Nicaragua, Niger, Nigeria, Paraguay, Peru, Philippines, Sri Lanka, Thailand, Uganda, and Vietnam. Of the 287 included facilities, nearly 70% (199) were in

urban areas, with a mix of tertiary (102 [35%]), secondary (128 [45%]), and primary (27 [9%]) health-care facilities. The remaining 30 facilities were other referral level (16 facilities [6%]) or missing (14 facilities [5%])

3751 women (1·3%) from the WHOGS and 4466 women (1·4%) from the WHOMCS were excluded because they delivered at less than 22 weeks' gestation or with an unknown gestational age, leaving 227 811 women (79% of the dataset) included from the WHOGS and 239 144 women (76% of the dataset) from the WHOMCS (figure 1). The individual baseline characteristics of women in the two datasets were similar (table 1). Most women in both datasets were 20–35 years of age, multiparous, and had spontaneous onset of labour (table 1). Compared with the first survey (WHOGS), the second survey (WHOMCS) had significantly more women with multiple pregnancy (p=0·002) and term deliveries (p=0·003). The overall rate of caesarean delivery was significantly higher in the WHOMCS survey (31·2%) than in the WHOGS survey (26·4%; p=0·003 [table 1]). The caesarean section rate ranged from 5·3% in Niger to 46·2% in China in the WHOGS (2004–08) and from 9·8% in Niger to 47·6% in China in the WHOMCS (2010–11; table 2). The time difference between the two surveys varied between the different countries, ranging from 2·5 years (in Japan) to 7·0 years (in Uganda). Most countries had a positive AAPC in caesarean section rate, which ranged from +1·0% per year (China) to +16·8% per year (Cambodia), except for Japan, which had a negative rate of –2·5% per year. We applied the Robson classification system to both survey datasets (figure 2) in the seven very high/high HDI countries, eight medium HDI countries, and six low HDI countries (all tables and individual country tables are available in the appendix). In all three HDI groups, nulliparous women (Robson groups 1 and 2) were the single largest relative contributor to the overall caesarean section rate, accounting for about a third of all caesarean section rates, followed by women who had previously had a caesarean section (group 5) who accounted for roughly a quarter of the rates. The relative contribution to the overall caesarean section rate of groups 6–10 decreased between surveys in all three HDI groups, accounting for about 22·5% in the WHOGS (23·7% in very high/high HDI countries, 20·6% in moderate HDI countries, and 24·2% in low HDI countries) and 20% in the WHOMCS (21·6% in very high/high HDI countries, 18·2% in moderate HDI countries, and 19·1% in low HDI countries). A small group of women in both surveys (3140 [1·4%] women in the WHOGS and 5921 [2·5%] in the WHOMCS) could not be classified because of missing or contradictory data (and were therefore classified as group X).

In very high/high HDI countries, the overall caesarean section rate increased from 34·4% in the WHOGS to 40·0% in the WHOMCS (table 2). Japan was the only exception to this trend (where the rate decreased from 19·8% in the WHOGS to 18·6% in the WHOMCS). The

	WHO Global Survey 2004–08 (n=227 811)	WHO Multi-Country Survey 2010–11 (n=239 144)	χ^2 p value*
(Continued from previous page)			
Mode of delivery			0·003
Vaginal	167 699 (74%)	164 188 (69%)	
Caesarean	60 090 (26%)	74 582 (31%)	
Missing	22 (<1%)	374 (<1%)	
Fetal presentation			0·59
Cephalic	216 296 (95%)	227 587 (95%)	
Breech	8641 (4%)	8534 (4%)	
Other (oblique/transverse)	2634 (1%)	2587 (1%)	
Missing	240 (<1%)	436 (<1%)	
Number of neonates			0·002
Singleton	225 066 (99%)	235 380 (98%)	
Multiple	2745 (1%)	3685 (2%)	
Missing	0	79 (<1%)	
Birthweight at delivery (g)			0·22
<1500	2954 (1%)	3565 (2%)	
1500–2499	22 398 (10%)	26 141 (11%)	
2500–3999	193 588 (85%)	200 489 (84%)	
≥4000	8262 (4%)	8200 (3%)	
Missing	609 (<1%)	749 (<1%)	
Gestational age at delivery			0·003
<37 weeks (preterm)	23 662 (10%)	19 599 (8%)	
≥37 weeks (term)	204 149 (90%)	219 545 (92%)	
Missing	0	0	

Data are n (%). Some percentages in this table do not add up to 100% because of rounding errors. *χ^2 p value calculation adjusted for clustering because of hierarchical survey design.

Table 1: Individual characteristics of women delivering in facilities in 21 countries surveyed by the WHO Global Survey and the WHO Multi-Country Survey

proportion of multiparous women decreased overall between the surveys, with a concomitant increase in the proportion of nulliparous women. The proportion of women who had spontaneous labour (groups 1 and 3) decreased significantly between the surveys, in favour of women who delivered after induction or had a caesarean section before labour (groups 2 and 4; figure 2A). This decrease was larger in multiparous women (a reduction from 28·9% to 25·0%) than in nulliparous women (from 25·2% to 24·0%). The caesarean section rate remained stable or increased significantly between the surveys in all Robson groups (figure 2B). The overall rate increase was attributable to significant increases in the absolute contribution of induced or prelabour caesarean section nulliparous women (group 2: +2·1% [95% CI 1·9–2·2]), whereas women who went into labour spontaneously (groups 1 and 3) had little change between the surveys (group 1: +0·3% [0·2–0·4]; group 3: 0·0% [0·0–0·1]) (figure 2C). The reduced contribution to the overall caesarean section rate of women who had previously had a caesarean section (group 5: –0·2% [95% CI –0·4 to 0·0]) should be interpreted with caution, both because of the shift towards nulliparity in the population, and because

	Number of facilities	WHO Global Survey		WHO Multi-Country Survey		Time difference (years)*	Average change in caesarean section rate (% per year)*
		Deliveries, n (% of total deliveries)	Caesarean section rate, n (%)	Deliveries, n (% of total deliveries)	Caesarean section rate, n (%)		
Very high HDI countries							
Japan	10	3300 (1·4%)	653 (19·8%)	3536 (1·5%)	656 (18·6%)	2·50	–2·5%
Argentina	14	10673 (4·7%)	3747 (35·1%)	9785 (4·1%)	3799 (38·8%)	5·67	1·8%
High HDI countries							
Mexico	13	13724 (6·0%)	5463 (39·8%)	12682 (5·3%)	6023 (47·5%)	5·92	3·0%
Peru	16	15876 (7·0%)	5451 (34·3%)	15198 (6·4%)	6301 (41·5%)	5·67	3·4%
Brazil	5	5506 (2·4%)	1485 (27·0%)	5897 (2·5%)	2770 (47·0%)	6·83	8·5%
Ecuador	18	12372 (5·4%)	4989 (40·3%)	10197 (4·3%)	4639 (45·5%)	5·58	2·2%
Sri Lanka	13	14706 (6·5%)	4390 (29·9%)	17607 (7·4%)	5803 (33·0%)	3·58	2·8%
Sub-total for very high HDI and high HDI countries	89	76157 (33·4%)	26178 (34·4%)	74902 (31·3%)	29991 (40·0%)	..	..
Moderate HDI countries							
China	21	14532 (6·4%)	6711 (46·2%)	13249 (5·5%)	6304 (47·6%)	3·00	1·0%
Thailand	12	9745 (4·3%)	3321 (34·1%)	8952 (3·7%)	3531 (39·4%)	3·00	5·0%
Paraguay	6	3455 (1·5%)	1446 (41·9%)	3607 (1·5%)	1689 (46·8%)	5·75	2·0%
Philippines	14	11011 (4·8%)	1975 (17·9%)	10734 (4·5%)	2679 (25·0%)	2·58	13·6%
Vietnam	15	13077 (5·7%)	4690 (35·9%)	15427 (6·5%)	6466 (41·9%)	3·67	4·3%
Nicaragua	7	4341 (1·9%)	1161 (26·7%)	5244 (2·2%)	2353 (44·9%)	5·75	9·4%
India	20	24695 (10·8%)	4377 (17·7%)	30608 (12·8%)	5915 (19·3%)	3·83	2·3%
Cambodia	5	5534 (2·4%)	812 (14·7%)	4691 (2·0%)	1069 (22·8%)	2·83	16·8%
Sub-total for moderate HDI countries	100	86390 (37·9%)	24493 (28·4%)	92512 (38·7%)	30006 (32·4%)	..	..
Low HDI countries							
Kenya	20	19070 (8·4%)	3043 (16·0%)	20305 (8·5%)	4813 (23·7%)	6·83	6·0%
Nigeria	21	8895 (3·9%)	1286 (14·5%)	12053 (5·0%)	2462 (20·4%)	6·83	5·2%
Uganda	17	12102 (5·3%)	1823 (15·1%)	8753 (3·7%)	1766 (20·2%)	7·00	4·3%
Democratic Republic of the Congo	21	8575 (3·8%)	1125 (13·1%)	8345 (3·5%)	1782 (21·4%)	6·58	7·7%
Niger	11	8276 (3·6%)	440 (5·3%)	11032 (4·6%)	1080 (9·8%)	6·92	9·2%
Nepal	8	8346 (3·7%)	1702 (20·4%)	11242 (4·7%)	2682 (23·9%)	3·50	4·6%
Sub-total for low HDI countries	98	65264 (28·6%)	9419 (14·4%)	71730 (30·0%)	14585 (20·3%)	..	..
Overall total	287	227811 (100·0%)	60090 (26·4%)	239144 (100·0%)	74582 (31·2%)	..	..

HDI=Human Development Index. *Because the time difference between the two surveys varied between countries, to establish the rate of change in country caesarean section rates we used an average annual percentage change (AAPC) equation, in which: AAPC = [(WHOMCS caesarean rate/WHOGS caesarean rate)] ^ (1 / time difference (years))*100. This calculation allows comparison between countries with different time periods between the surveys, but assumes a linear change in caesarean section rate over time.

Table 2: **Changes in caesarean section rate between the two surveys, by country**

this group had the greatest relative contribution to overall caesarean section rates in both surveys (29·2% in WHOGS and 24·5% in WHOMCS), which far exceeded the second-largest relative contribution of group 1 (16·4% and 14·8%, respectively). Notably, prelabour caesarean section in nulliparous women (group 2b) was the third-leading relative contributor to the overall caesarean section rate (figure 2C).

In moderate HDI countries, the overall caesarean section rate increased from 28·4% to 32·4% between the surveys (table 2). Roughly two-thirds of the obstetric population had spontaneous labour (groups 1 and 3) in both datasets (figure 2A). The proportion of women with a previous caesarean section increased between the surveys (from 6·9% in WHOGS to 8·9% in WHOMCS), whereas

those with preterm deliveries (group 10) decreased (from 10·0% to 7·1%). Caesarean section rates increased in all Robson groups (except for 2b and 4b, in which the caesarean section rate is 100%). Although the proportion of women induced (both nulliparous and multiparous) was lower in the moderate HDI countries than in the very high/high HDI countries, the intrapartum caesarean section rate was higher in the moderate HDI countries. Similarly, although fewer women in moderate HDI countries had a previous caesarean section than in very high/high HDI countries, the caesarean section rate in this group was higher (figure 2B). Women with a previous caesarean section had the largest change in absolute contribution to the caesarean section rate (+1·9% [95% CI 1·7–2·0]). Nulliparous women who went into labour
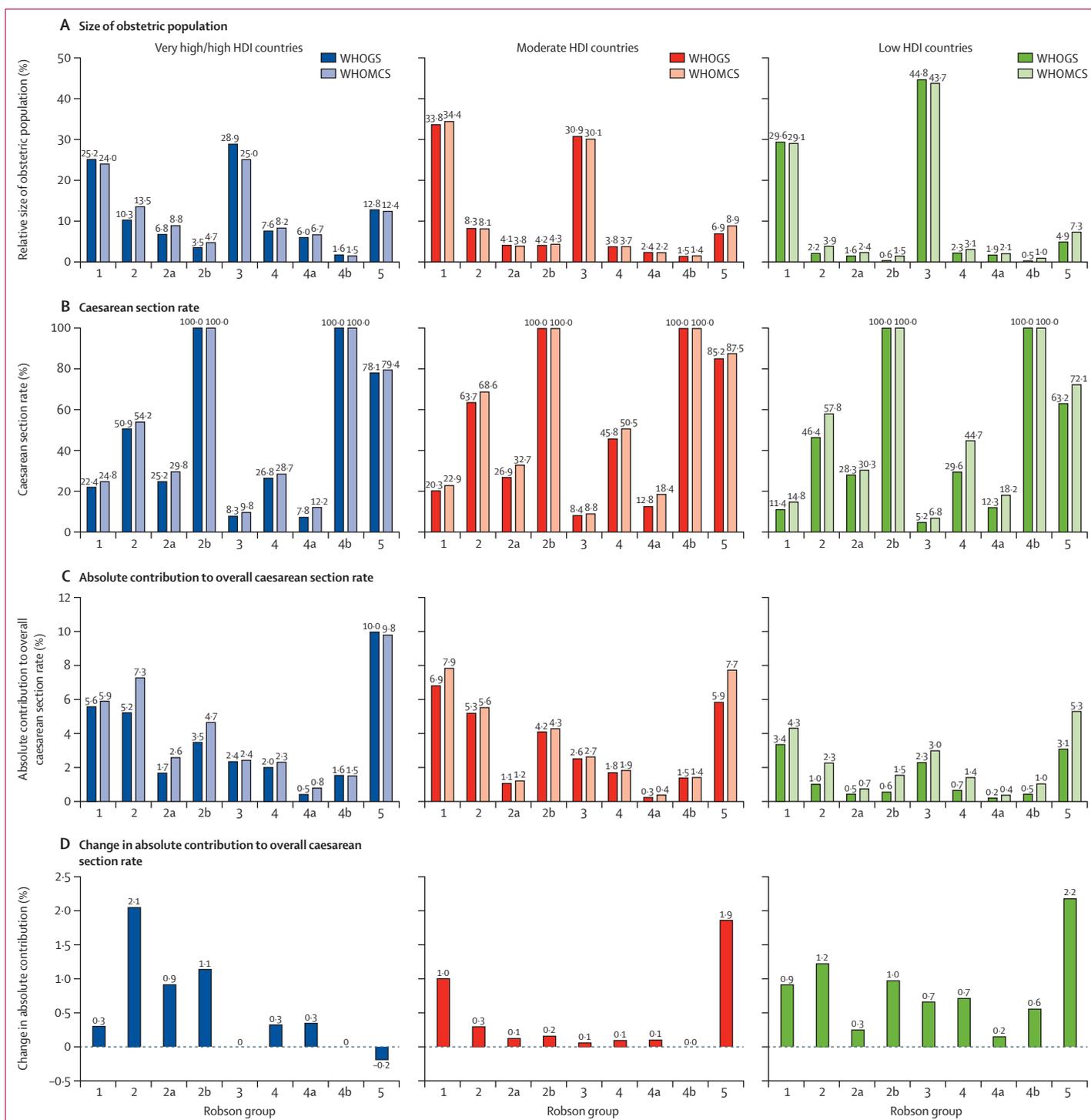
Figure 2: **Robson groups in WHOGS and WHOMCS, stratified by HDI group**
(A) Size of obstetric population in each Robson group. (B) Caesarean section rate in each Robson group. (C) Absolute contribution of each Robson group to the overall caesarean section rate. (D) Change in absolute contribution of each Robson group to the overall caesarean section rate. Only Robson groups 1–5 are presented; groups 6–10 account for only 15% of the obstetric population and 20% of the relative contribution to the overall caesarean section rate. HDI=Human Development Index. WHOGS=WHO Global Survey. WHOMCS=WHO Multi-Country Survey.

spontaneously and women with previous caesarean section accounted for 50% of all caesarean section procedures in these countries (appendix).

For both surveys in low HDI countries, three-quarters of the obstetric population had spontaneous labour and nearly half were multiparous (appendix). The caesarean

section rate increased by 6% between the two surveys (from 14·4% in WHOGS to 20·3% in WHOMCS). Although the proportion of women who had induction or prelabour caesarean section (groups 2a and 4a) was lower in low HDI countries than in higher HDI countries, it increased over time (from 1·6% to 2·4% for group 2a and from 1·9% to 2·1% for group 4a), in addition to a rising proportion of women with previous caesarean section (group 5: 4·9% to 7·3%; figure 2A). Caesarean section rates increased in all Robson groups (except for group 9), with a striking increase in women with previous caesarean section (from 63·2% in WHOGS to 72·1% in WHOMCS; figure 2B). The largest changes in absolute contribution to the overall caesarean section rate were recorded in group 5 (+2·2% [95% CI 2·1–2·3]), group 2b (+1·0% [0·9–1·1]), and group 1 (+0·9% [0·8–1·0]; figure 2D). In the WHOGS, group 1 was the largest contributor to the overall caesarean section rate (23·4%), but in the WHOMCS, group 5 became the largest contributor (26·1%; figure 2C).

Discussion

We compared caesarean section rates in health-care facilities in 21 countries using the Robson classification system and found that caesarean section rates increased over time between the two WHO surveys in all countries except Japan. Although increased caesarean section rates are not a novel finding, the greatest increases in caesarean section rates were generally recorded in the least developed countries where—compared with the high-income countries—the caesarean section rates of the first survey were lower, and a higher unmet need for caesarean section probably exists. Notably, some countries with high initial caesarean section rates still had high rates of growth of the procedure, such as Nicaragua (AAPC of caesarean section rate +9·4%) and Brazil (+8·5%), which supports previous reports of high caesarean section rates in many Latin American countries.[28,29]

Increased use of caesarean section surgery occurred across all HDI groups and most Robson groups, including an increase in the proportion of women undergoing a prelabour caesarean section (in very high/high and low HDI countries) and a rise in the proportion of women with a previous caesarean section (in moderate and low HDI countries). The nulliparous population was the largest contributor to the overall caesarean section rate, and therefore increasing use of obstetric interventions in this group (in very high/high and low HDI countries) drove rates higher. This situation is especially true in the very high/high HDI countries, where the proportion of nulliparous women increased, which probably represents a trend towards reduced parity in women in the higher HDI countries. This overall pattern suggests that the threshold for medically indicated caesarean section has become lower over time, or the use of elective caesarean section surgery has risen, or both. Increased use of this surgery without medical indication can potentially cause harm[7] and increase the need for caesarean section in

subsequent pregnancies that could otherwise have been avoided. Some authors have cited fear of litigation, intolerance of adverse outcomes related to vaginal deliveries, and popularity of caesarean section in women as reasons underpinning these trends.[30–32]

Similar to the use of caesarean section, the incidence of labour induction has risen in recent decades and its contribution to the overall caesarean section rates remains a controversial issue.[33] Although the use of labour induction in very high/high and low HDI countries increased in both nulliparous and multiparous women (groups 2a and 4a), the caesarean section rates in induced multiparous women (group 4a) increased between the surveys in all three HDI groups, whereas the rate of caesarean section in induced nulliparous women (group 2a) increased in very high/high and moderate HDI countries. We were surprised at the quite high caesarean section rates in induced multiparous women, which exceeded 12% in all HDI groups in the second survey and varied substantially between countries. Robson reports that caesarean section rates in group 4a are usually low (eg, 4–6%).[19] This finding could be attributable to documentation error, such as women whose labour is augmented rather than truly induced. Women with contradictory data (group X) might also belong in group 4a. Alternatively, this finding could suggest that case selection and mode of induction are suboptimal in some countries,[17,19,33] the clinical threshold for caesarean section after induction might be falling over time, or elective induction might be increasingly used. If this is the case, improved criteria and methods for inducing labour are not only safer for women but might also mitigate increased caesarean section rates. Improvement of the use of evidence-based guidelines and clinical protocols for monitoring inductions is also important to optimise outcomes.

As has been reported in other countries and facilities worldwide,[14,34–36] our analysis showed that the absolute contribution of women with a previous caesarean section (group 5) in medium and low HDI countries to the overall caesarean section rate increased substantially, and that in all three HDI groups the caesarean section rate in these women increased over time. Although this group has a heterogeneous composition (including women with one or more previous caesarean sections, and some with a history of vaginal delivery), the risk of uterine rupture means that attempts at a vaginal birth need to be considered with care.[37,38] Our analysis clearly captures the so-called domino effect of caesarean section use: as caesarean section rates increase, more women in the obstetric population are in need of repeat caesarean section, as indicated by the escalating contribution of group 5 to overall caesarean section rates over time. To address this problem, evidence-based interventions and programmes to reduce both primary and repeat caesarean sections are needed. Although interventions such as mandatory secondary opinions and post-caesarean

surveillance programmes to reduce repeat caesarean section have been studied, a Cochrane review[39] emphasised that few studies have been done in resource-poor settings, and the complexity of caesarean section decision-making (involving women, their families, and their health-care providers) and contextual factors can complicate their use in other settings. In Japan, the only country in which a reduction in caesarean section rate was recorded, decreases occurred in the contribution of spontaneous or induced nulliparous women (groups 1 and 2a) and women with previous caesarean section (group 5) to the overall rate.

Use of the Robson criteria can inform efforts to manage caesarean section rates at both the individual facility and national level by identifying how use of this intervention in specific obstetric subpopulations affects overall caesarean section rates, and how obstetric populations and intervention rates change with time.[8,17] Our findings show that the necessary data collection and application of the Robson classification can be done quite simply and effectively, and in a range of settings and countries. Furthermore, the Robson classification can be used for routine monitoring and assessment purposes at national and facility levels, both for cross-sectional and longitudinal data. Use of the Robson classification in these datasets allows not only an assessment of drivers of trends in caesarean section use, but also an assessment of data quality available from medical records.[19]

Although intervention rates vary between facilities according to their capacities, resources, and case mix, efforts to reduce unnecessary obstetric interventions and await spontaneous labour should be considered.[19,40] Evidence from some settings suggests that increased use of obstetric interventions in labour and delivery have not improved outcomes for mothers or neonates.[20,21,28] Although we have not studied the association between caesarean section and maternal and perinatal outcomes, a separate forthcoming analysis will specifically study trends in the use of caesarean section and associated trends in outcomes. As expected, the caesarean section rate in breech pregnancies was high (>85%) in the very high/high HDI group; however, in view of the findings of the Term Breech Trial[41] the low breech caesarean section rate in medium (<75%) and low (<60%) HDI countries could be interpreted as an unmet need for caesarean section surgery.

To our knowledge, our study is the largest application of the Robson classification to a multicountry dataset for the purpose of exploring caesarean section trends (panel 2). The main strengths of our study include the large sample size, consistency in the study methods, and definitions of the variables collected across facilities. These results will also allow future standardised comparisons with other datasets in these countries. However, our analysis is not without limitations. We are unable to assess changes in the obstetric care capacity (gain or loss of infrastructure, availability of essential interventions, staffing, or other factors) over time and how these could have affected

caesarean section use. Suboptimal medical record keeping in facilities might have adversely affected data quality. A small group of women in both datasets could not be classified because of inconsistencies or missing values in Robson criteria. This extra group allows for assessment of quality of the data and validity of the interpretation.[13,43] Although small, this situation seemed to occur disproportionately more frequently in women who delivered their babies by caesarean section (a common reason for misclassification[17,43]) and is therefore a source of possible bias. The higher numbers of women in group X in a few countries (eg, Argentina, Ecuador, Mexico, and Nicaragua) were almost entirely caused by contradictory data. Another indicator of poor data collection is that the caesarean section rates were lower than 100% in group 9 (fetus in transverse or oblique lie) for all three HDI groups, especially in the low HDI group (75·9% and 75·5%). Both datasets recorded data about lie at delivery (not at initial assessment); however, given that the size of group 9 in all three HDI groups is larger than expected compared with 0·4–0·6%, according to Robson,[19] we think it is likely that a group of women have been misclassified as abnormal lie at delivery. Classification of fetal presentation and position have been identified in a recent review[42] as a challenge to improving data quality in the use of Robson classification. The reason for the decrease in the overall preterm birth rate between the two surveys is not clear, especially in view of the higher multiple pregnancy rate in the WHOMCS compared with the WHOGS. However, this reduction in overall preterm birth rate might be due to inconsistencies or changes in gestational age estimation over time, or a chance finding as a consequence of the sampling methods.

Panel 2: Research in context

Systematic review

A 2011 systematic review[8] identified the ten-group classification system proposed by Robson[9] as the most appropriate to compare caesarean rates at a facility and national level, and a 2013 systematic review[42] synthesised the experience of users on implementing the Robson classification and suggested adaptations.

Interpretation

Our study shows that routine data collection in obstetric units in a range of countries, facilities, and income levels can be used for application of the Robson classification to data from several different timepoints. The classification can be used to assess the underlying trends and drivers in caesarean section use in these settings. Our findings are the largest application of the Robson classification to routine data from low-income countries so far, and show how women with a previous caesarean section are an increasingly important determinant of overall caesarean section rates in countries with a medium or low Human Development Index.

The findings of this analysis are not nationally representative because the facility sampling methods did not include facilities with fewer than 1000 deliveries annually, which has probably led to an over-representation of women receiving obstetric interventions. Since the WHOMCS built on the WHOGS network of health facilities, a possible bias might be present because additional training and repeated data collection could have improved data quality or increased reporting of outcomes of interest in the WHOMCS compared with the WHOGS.

Clear evidence shows increasing rates of obstetric intervention in the facilities included in our analysis. Caesarean section rates increased across most Robson groups in all HDI groups. Additionally, induced and prelabour caesarean section in nulliparous and multiparous women rose significantly in moderate and low HDI countries over time. Improved case selection for labour induction and prelabour caesarean section could also reduce caesarean section rates in all HDI groups. The proportion of women with a previous caesarean section increased in moderate and low HDI countries, as did the caesarean section rate in these women. Women who have previously had a caesarean section are an increasingly important determinant of overall caesarean section rates. Therefore, implementation of evidence-based strategies to avoid medically unnecessary primary caesarean section, and to encourage the safe and appropriate use of vaginal birth after caesarean section, is needed.

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