Caesarean delivery rates and pregnancy outcomes: the 2005 WHO global survey on maternal and perinatal health in Latin America

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Summary

Background **Caesarean delivery rates continue to increase worldwide. Our aim was to assess the association between caesarean delivery and pregnancy outcome at the institutional level, adjusting for the pregnant population and institutional characteristics.**

Methods **For the 2005 WHO global survey on maternal and perinatal health, we assessed a multistage stratified sample, comprising 24 geographic regions in eight countries in Latin America. We obtained individual data for all women admitted for delivery over 3 months to 120 institutions randomly selected from of 410 identified institutions. We also obtained institutional-level data.**

Findings **We obtained data for 97 095 of 106 546 deliveries (91% coverage). The median rate of caesarean delivery was 33% (quartile range 24–43), with the highest rates of caesarean delivery noted in private hospitals (51%, 43–57). Institution-specific rates of caesarean delivery were affected by primiparity, previous caesarean delivery, and institutional complexity. Rate of caesarean delivery was positively associated with postpartum antibiotic treatment and severe maternal morbidity and mortality, even after adjustment for risk factors. Increase in the rate of caesarean delivery was associated with an increase in fetal mortality rates and higher numbers of babies admitted to intensive care for 7 days or longer even after adjustment for preterm delivery. Rates of preterm delivery and neonatal mortality both rose at rates of caesarean delivery of between 10% and 20%.**

Interpretation **High rates of caesarean delivery do not necessarily indicate better perinatal care and can be associated with harm.**

Introduction

Rates of caesarean delivery have risen from about 5% in developed countries in the early 1970s[1–5] to more than 50% in some regions of the world in the late 1990s.[6] Many factors have contributed to this rise, including improved surgical and anaesthetic techniques, reduced risk of post-operative complications, demographic and nutritional factors,[7,8] providers' and patients' perception of the safety of the procedure,[9] obstetricians' defensive practice,[10] changes in health systems,[11] and patient demand.[12,13] Caesarean delivery is thought to protect against urinary incontinence, prolapse, and sexual dissatisfaction, increasing its appeal.[14,15] Finally, the rise in numbers of women opting for a caesarean might also be affected by obstetricians' defence of women's rights to choose their method of delivery.[16]

Medical strategies, such as mandatory second opinion before doing a caesarean section, have not reduced the numbers of caesarean deliveries,[17] and a randomised trial to compare perinatal outcomes and satisfaction of caesarean delivery on demand for all women versus caesarean delivery only when clinically indicated is being contemplated.[18] Before such practice can be assessed and an appropriate trial designed, however, the optimum proportion of caesarean deliveries for any particular institution, based on the risk profile of that institution's pregnant population, needs to be identified.[13,19,20]

Our aim was to assess the association between rates of caesarean delivery and maternal and perinatal outcomes at the institutional level.

Methods

Population

We designed the 2005 WHO global survey on maternal and perinatal health to explore the relation between rates of caesarean delivery and perinatal outcomes in the medical institutions of eight randomly selected countries in the region of the Americas, using a multistage stratified sampling procedure. We obtained data between Sept 1, 2004, and March 30, 2005.

After country selection, we identified a representative sample of geographic areas within each country and, within these geographic areas, a representative sample of care units. We selected countries with a probability proportional to the population of the country, provinces with a probability proportional to the population of the province, and health institutions with a probability proportional to the number of deliveries per year. Here, we present results from the eight countries in Latin

America; we will report results of a similar survey done in Africa separately. In 2006, we will prepare the survey for Asia and Canada.

We initially stratified each country by its capital city (always included) and two other randomly-selected administrative geographic areas (provinces or states). Within these three areas, we undertook a census of hospitals that reported more than 1000 deliveries in the previous year. We then stratified data by province or state, choosing a representative sample of up to seven institutions each. If there were seven or fewer eligible institutions, we included them all. We included all women admitted to the selected institutions for delivery during a fixed data collection period of either 2 or 3 months, depending on the total number of expected deliveries per institution for the complete year (3 months if ≤6000 per year; 2 months if >6000 per year).

We did not obtain individual informed consent from women, since ours was an institutional-level analysis; we obtained all individual-level data from medical records and did not identify participants. Institutional informed consent was obtained from the responsible authority of the participating health facilities. The ethical committee of WHO and of each country, as well as those of all hospitals in Brazil and some of the large hospitals in Mexico and Argentina, independently approved the protocol.

For the **study protocol and a detailed description of the selection process** see http://www.medscinet.com/who

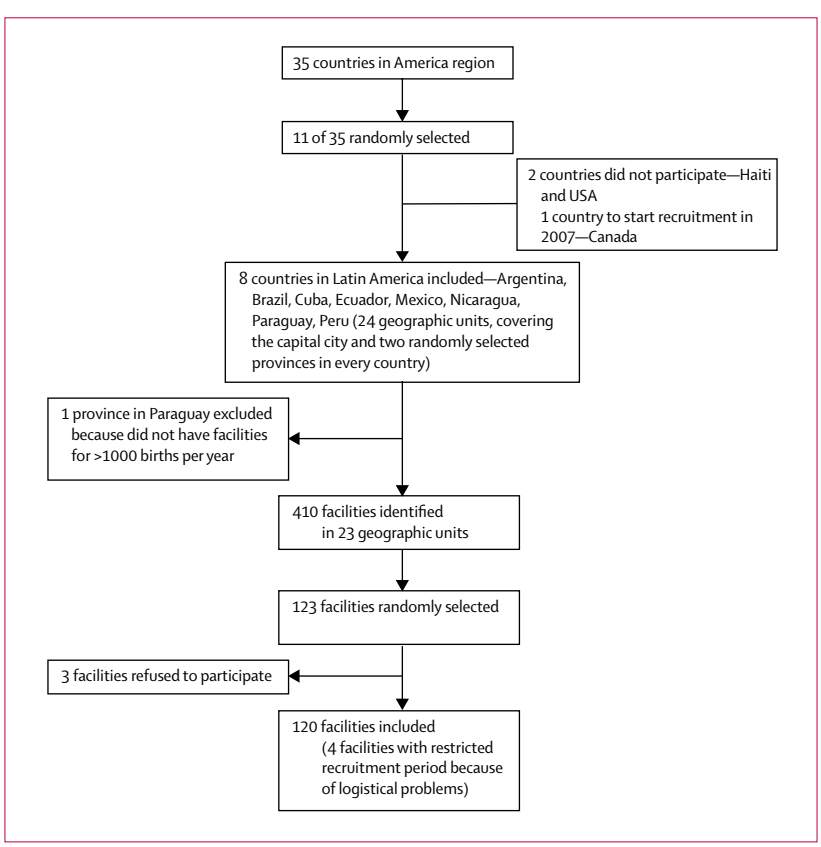

Figure 1: **Trial profile**

Procedures

We collected data at two levels—institutional and individual. At the institutional level, we gathered data on one occasion only, with the aim of obtaining a detailed description of the health facility and its resources for obstetric care. The country or regional coordinator filled in a form during a visit to the institution, in consultation with the hospital coordinator, director, or head of obstetrics. At the individual level, we obtained from all women's medical records information to complete a two-page pre-coded form, summarising obstetric and perinatal events. Trained staff reviewed the medical records of all women within a day after delivery and abstracted data to their individual data collection forms, which were completed during the period that the woman and newborn baby remained in hospital. A nurse or midwife working on the labour or postpartum ward at each institution was responsible for data collection on a day-to-day basis. A hospital coordinator supervised data collection, resolving or clarifying unclear medical notes before forms were sent for data entry. Attending staff updated incomplete records before discharge.

We used the individual-level form to obtain information about demographic characteristics, maternal risk, pregnancy events, mode of delivery, and outcomes up to hospital discharge. The institutional-level form was used to obtain data on characteristics associated with maternal and perinatal care and outcomes, including: laboratory tests; details of anaesthesiology resources; services for intrapartum care, delivery, and care of the newborn baby; and presence or absence of basic emergency medical and obstetric care facilities, intensive care units, and human and teaching resources. Criteria for data abstraction were defined in the manual of operations,[21] which was also available for training staff and monitoring data quality, reducing to a minimum the need for judgment and interpretation. The manual contained definitions of all terms used and synonyms of medical and obstetric terms, and described questions and precoded corresponding answers. We pretested both data forms in four countries during July and August, 2004.

We classified caesarean deliveries as: a) emergency, if the woman was referred before onset of labour with a diagnosis of acute fetal distress, vaginal bleeding, uterine rupture, maternal death with fetus alive, or eclampsia; b) intrapartum, if indicated during labour, whether labour was spontaneous or induced; c) elective, if decision to do the operation was made before onset of labour and the woman was referred either from an antenatal clinic or a high-risk ward (if the timing of the decision was unclear, we did not identify as elective those caesareans done in women whose labour had been induced or those done in women who received anaesthetic during a spontaneously initiated labour).

We recorded the following perinatal outcomes as potentially affected by caesarean delivery: intrapartum

fetal death, preterm delivery (<37 weeks), admission to neonatal intensive care unit for 7 days or longer, and neonatal death before hospital discharge of the newborn baby. We assessed maternal morbidity with proxy events, mostly severe conditions, rather than the clinical diagnosis itself, because of problems in standardising definitions. For example, we assumed that blood transfusion and hysterectomy indicated severe postpartum haemorrhage; maternal admission to an intensive care unit, maternal death, or maternal hospital stay for longer than 7 days denoted severe complications. We constructed a summary index—severe maternal morbidity and mortality index—if at least one of the above complications was present and used it as the primary maternal morbidity outcome. We assessed postpartum treatment with antibiotics (except prophylactic) separately as an indicator of postpartum infections. Third and fourth degree perine laceration and postpartum fistulae were also maternal outcomes.

We classified health institutions as private or belonging to the public-health system or the social-security system, as reported by the institutions' authorities. We included state university hospitals as public institutions and all labour-union hospitals as social-security institutions. We classified religious institutions according to the patients' main mechanism of payment. Most deliveries in the areas studied are facility-based, with only a small proportion of women having home deliveries.

Statistical analysis

The provincial or country coordinator of the survey checked forms for completeness and accuracy, and any queries were addressed immediately or in consultation with coordinators. We collated all data via the internet at the country coordinator level, using an online data management system based on MedSciNet's clinical trial framework (MedSciNet, Stockholm, Sweden) in collaboration with WHO. We calculated coverage of the survey by comparing the number of forms completed during the study with the number of deliveries recorded in the logbook of each hospital. Analyses are based on institution-level variables, with individual data aggregated by calculating proportions per institution. We prepared a conceptual framework to guide data analysis.

We developed a hospital complexity index, summarising an institution's capacity to provide different levels of care, depending on its ratings for eight categories: building, general medical care, laboratory, anaesthesiology, screening test, human resources, basic obstetric services, and continuous medical education. For each category, we identified a set of minimum essential services or resources; we classified hospitals without any of these services or resources as low level (rating score 0). For most categories, we also identified an additional set of optional services or resources, classifying facilities that had both essential and optional services or resources as high level (rating score 2) and those that were lacking some of the optional services or resources, but had all essentials, as medium level (rating score 1). An overall unweighted score (0–16) was calculated for all institutions. We judged hospitals with a total score of 9 or less of low complexity, those with scores of between 10 and 12 of medium complexity, and those with scores of 13 or more of high complexity. We recorded institutions as providing

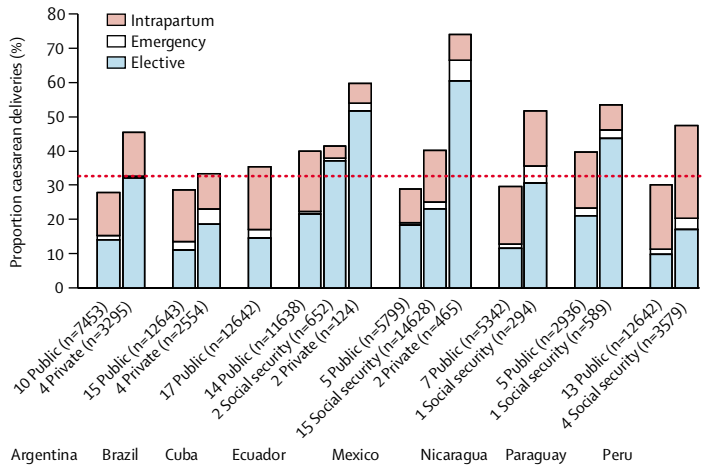

Figure 2: **Proportion of elective, emergency, and intrapartum caesarean deliveries done, according to type of institution and country**
Dotted line=median level for all institutions.

	All (n = 34266)	Public (n=23020)	Social security (n=8285)	Private (n=2961)
Cephalopelvic disproportion, dystocia, failure to progress	26% (8982)	25% (5792)	27% (2213)	33% (977)
Fetal distress	20% (6751)	21% (4805)	20% (1646)	10% (300)
Previous caesarean delivery without complications in current pregnancy	16% (5305)	16% (3627)	13% (1110)	19% (568)
Previous caesarean delivery with complications in current pregnancy	15% (5140)	14% (3223)	16% (1326)	12% (355)
Other pregnancy complications	12% (3968)	12% (2691)	10% (845)	15% (432)
Breech or other malpresentations	11% (3620)	12% (2647)	9% (778)	7% (195)
Pre-eclampsia or eclampsia	11% (3603)	10% (2248)	14% (1186)	6% (169)
Other fetal indications	9% (2926)	9% (1999)	9% (751)	6% (176)
Other medical complications	8% (2592)	8% (1816)	8% (620)	5% (156)
Tubal ligation or sterilisation	6% (2015)	7% (1484)	6% (485)	2% (46)
Failure to induce labour	4% (1292)	4% (804)	4% (366)	4% (122)
Intrauterine growth restriction	3% (959)	3% (646)	2% (186)	4% (127)
Third trimester vaginal bleeding	3% (864)	3% (576)	3% (225)	2% (63)
Multiple pregnancy	2% (720)	2% (465)	2% (193)	2% (62)
Post-term (>42 weeks)	2% (627)	2% (443)	2% (148)	1% (36)
Genital herpes or extensive condyloma acuminata	<1% (270)	<1% (206)	<1% (54)	<1% (10)
Suspected or imminent uterine rupture	<1% (231)	<1% (171)	<1% (54)	<1% (6)
Postmortem caesarean section	<1% (153)	<1% (121)	<1% (26)	<1% (6)
HIV positive	<1% (126)	<1% (102)	<1% (10)	<1% (14)
Maternal request without any other indication	<1% (60)	<1% (31)	<1% (3)	<1% (26)
Previous repaired fistula	<1% (15)	<1% (12)	<1% (3)	0

Data are percentage (number). Sum of percentages in columns exceeds 100% because some women had multiple indications.

Table 1: **Indication for caesarean delivery, according to type of institution**

For **MedSciNet** see http://www.medscinet.com/who

For **more details of the hospital complexity index** see http://www.crep.com.ar

	Median (%; 10th–90th percentiles)
Previous pregnancy	
Marital status single	14·7 (4·1–63·0)
Age ≤16 years	4·0 (0·3–8·5)
Age ≥35 years	10·2 (5·4–17·1)
<7 years of education	24·5 (2·1–54·7)
Primigravidas	34·5 (22·6–42·7)
Primiparous	41·0 (30·7–50·3)
Previous child with low birthweight	3·3 (1·0–6·6)
Previous neonatal death or stillbirth	1·2 (0·3–2·4)
Previous fistula or uterus-cervix surgery	4·6 (0·2–18·9)
Previous caesarean delivery	12·5 (4·3–20·6)
Current pregnancy	
Any pathology before index pregnancy*	2·7 (0·4–12·1)
Any pathology during current pregnancy*	31·6 (14·9–50·0)
Gestational hypertension, pre-eclampsia, eclampsia	7·5 (2·4–14·0)
Vaginal bleeding in second half of pregnancy	1·9 (0·8–7·2)
Urinary tract infection	11·1 (1·3–36·0)
Condyloma acuminate	0·3 (0·0–1·2)
Suspected intrauterine growth restriction	0·6 (0·0–3·1)
Other medical condition	5·4 (1·0–20·9)
Any antenatal antibiotic treatment	15·9 (2·7–41·4)
Birthweight >4·5 kg	0·40 (0·0–1·2)
Multiple pregnancy	0·8 (0·0–1·8)
Breech or other non-cephalic presentations	4·3 (1·5–7·3)
Delivery	
Referred from other institution for pregnancy complications or delivery	18·2 (0·8–79·6)
Induced labour	7·5 (1·7–25·7)
Epidural anaesthesia during labour	3·5 (0·1–55·2)
Caesarean delivery in present pregnancy	32·6 (15·7–51·8)
Characteristics of institutions	
Institutional complexity index (range 0–16)	11 (8–13)
Public†	86 (71·7%)
Social security†	22 (18·3%)
Private†	12 (10·0%)
Economic incentives for caesarean delivery†	29 (24%)

*Includes pathologies of very low incidence not listed independently. †Data are number (%) of institutions.

Table 2: **Characteristics of populations served and health institutions studied**

an economic incentive to recommend caesarean delivery if they charged their patients fees for delivery and caesarean delivery was either more expensive than vaginal delivery (institutional benefit) or provided additional income to the senior attending staff (staff benefit).

Indicators of the risk of the pregnant population served by each institution (case mix) included the proportion of women in the institution who: were aged 16 years or younger or 35 years or older; had less than 7 years of education; were single; were primiparous; had a history of caesarean delivery, stillbirth, or neonatal death; had had surgery on the uterus or cervix; had had a urinary or gynaecological fistula; or had any medical condition diagnosed before the current pregnancy. We present conditions diagnosed during the current pregnancy as proportions of women in each institution with a multiple pregnancy, gestational hypertension, pre-eclampsia, eclampsia, vaginal bleeding in the second half of pregnancy, condyloma acuminata, HIV, suspected impaired fetal growth, or fetal malpresentation at term. We also note the proportion of women in each institution who were referred from other institutions, whose labour was induced, and those who received an epidural during labour, all of which we judged risk factors for caesarean delivery.

We assessed the crude associations between caesarean delivery and risk factors with the Spearman correlation coefficient. For each subgroup of variables related to previous pregnancy, current pregnancy, and delivery, we fitted a multiple linear regression model[22] to the individual factors judged to be associated with caesarean delivery. We considered significant risk factors from these multiple regression models as possible confounders of the association between caesarean delivery and outcomes in further analyses. We then added the hospital complexity index, type of institution, and economic incentives for caesarean delivery to the regression models.

The association between proportion of caesarean deliveries and maternal and perinatal outcomes was analysed with linear multiple regression models,[22] with these outcomes as the dependent variables and the proportion of caesarean deliveries as the main independent variable. We describe this relation graphically, using the locally weighted scatter plot smoothing technique (LOWESS).[23] We added risk factors identified in the above algorithm to the models to estimate the independent (adjusted) effect of caesarean delivery on maternal and perinatal outcomes. For these analyses, the proportion of outcomes and caesarean deliveries at each institution was transformed to the logit scale, to improve normality.

Role of the funding source

External sponsors to WHO for this study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

Figure 1 shows the trial profile. The number of institutions per geographic region ranged from six in Paraguay to 21 in Mexico; deliveries per country ranged from nearly 3500 in Paraguay to 21000 in Mexico, and five other countries contributed more than 10000 deliveries each to the sample. Most of the health institutions were urban; 50 were tertiary-level, 51 were district hospitals, 11 were primary-care units with surgical facilities, and eight classified as other type of institution. 40 institutions had 70 or more maternity beds, 44 had 30–69, and 36 had fewer than 30. We included all 120 institutions in the regression analyses. The average number of deliveries contributed by

institutions to the study population was similar across countries, ranging from 588 deliveries per hospital in Paraguay to 995 deliveries per hospital in Mexico.

The proportion of missing values at the individual level was higher than 5% only for birthweight of previous infant (23%), maternal height (17%), weight at last prenatal visit (15%), and number of years of schooling (5%). For all the primary variables—caesarean delivery status, birthweight, gestational age, admission of newborn baby to the neonatal intensive care unit, status of baby and mother at discharge, and maternal admission to intensive care—the proportion of missing values was less than 1%.

Most of the hospitals were of medium complexity, with a small number having either limited capacity (n=12) or very complex resources (n=11). 12 hospitals were private, and 86 belonged to the public-health system and 22 to the social-security system. Among the 12 private institutions, only one had a low complexity index, compared with three of the 22 social-security institutions and 25 of the 86 public-health hospitals. Seven of the 12 (58%) private institutions had evidence of economic incentives for caesarean delivery, versus 5% (n=1 of 22) of the social-security institutions and only 24% (n=21) of public hospitals. 99% (33 915 of 34 228) of caesarean deliveries and 63% (39 565 of 62 670) of vaginal births were attended by obstetrician gynaecologists or residents. Others were cared for by midwifes, medical or midwife students, general practitioners, or nurses. 95% of women who needed anaesthetic during labour or delivery were given epidural or spinal preparations (80% of which was provided by specialists in anaesthesiology).

Figure 2 shows caesarean delivery rates according to elective, intrapartum, or emergency without labour, study site, and type of institution. Overall, the median rate of caesarean delivery was 33% (quartile range 24–43); 49% were elective, 46% were intrapartum, and 5% were emergency without labour. The proportion of caesarean delivery was always higher in private hospitals (median rate 51%; 43–57) followed by social security and public institutions. Higher caesarean delivery rates in private and social security institutions were mostly due to an increase in elective caesarean delivery (figure 2). The rate of caesarean delivery among nulliparous women, or those without caesarean delivery in their previous birth, was 68% (n=22 972), ranging from 64% (n=1822) in private institutions to 69% (n=15 768) in public ones (not included in the figure).

Table 1 shows the indications for caesarean delivery. The most common indication overall was cephalopelvic disproportion/dystocia/failure to progress. Fetal distress was the second most common indication in public and social security institutions, whereas previous caesarean delivery without any complication in the current pregnancy was second in private institutions. Overall, 30% of women undergoing a caesarean delivery had a history of previous caesarean delivery. In social security institutions, pre-eclampsia or eclampsia was the third most common indication. Tubal ligation or sterilisation was the indication in 6% of the caesarean deliveries at public and social security institutions, but in 2% at private institutions. Failure of labour induction was an indication for caesarean delivery in about 4% of cases (table 1). Among women whose labour was induced, a median of 28% across hospitals (quartile range 18–40) went on to have a caesarean delivery.

Table 2 shows baseline characteristics and details of pregnancy and delivery. Furthermore, in an exploratory analysis, we stratified the results presented in table 2 by rate of caesarean delivery—eg, low, medium, or high rate, according to the tertile distribution of caesarean delivery in this sample. We noted no clear risk pattern; indeed, hospitals with a high rate of caesarean delivery tended to have demographic and clinical variables suggestive of lower pregnancy risk (though rates of previous caesarean delivery concurred with those we reported). Nevertheless, we adjusted for these baseline variables in all multiple regression models included in the tables.

Overall, also at the institutional level, maternal and perinatal outcomes were typical for moderate-risk pregnant populations. The median of the severe maternal morbidity and mortality index in these institutions was 2% (quartile range 1–4), including haemorrhage with

	Regression coefficient*	Standard error	p	% variance explained by each model†
Previous pregnancy				
Age ≤16 years	0·013	0·0302	0·68	67%
Age ≥35 years	0·011	0·0154	0·47	
<7 years of education	0·001	0·0047	0·78	
Primiparity	0·069	0·0104	<0·0001	
Caesarean delivery	0·142	0·0124	<0·0001	
Current pregnancy				
Gestational hypertension, pre-eclampsia, eclampsia	0·049	0·0196	0·01	20%
Vaginal bleeding in second half of pregnancy	0·011	0·0373	0·77	
Multiple gestation	0·239	0·1638	0·15	
Breech or other non-cephalic presentation	0·098	0·0296	0·001	
Delivery				
Referred from other institution because of pregnancy complications or for delivery	0·008	0·0037	0·03	13%
Epidural during labour	0·018	0·0048	0·0004	
Type of institution				
Institutional complexity index	0·261	0·0448	<0·0001	34%
Economic incentive for caesarean delivery	0·329	0·2365	0·17	
Public	Reference			
Social security	0·676	0·2615	0·01	
Private	0·901	0·3306	0·007	

*Obtained with multiple linear regression models with response variable defined as logit transformation of proportion of caesarean deliveries. All coefficients adjusted by other variables in subgroups. †Adjusted for number of variables in model (adjusted R^2).

Table 3: **Association between proportion of risk factors, according to institutions, and proportion of caesarean deliveries (multivariable analysis)**

	Crude regression coefficient	Standard error	p	Adjusted regression coefficient*	Standard error	p	Adjusted regression coefficient†	Standard error	P
Maternal outcome									
Severe maternal morbidity and mortality index	0·310	0·0602	<0·0001	0·316	0·0954	0·001	0·321	0·1013	0·002
Postnatal treatment with antibiotics	0·374	0·1053	0·0005	0·539	0·1896	0·005	0·591	0·2026	0·004
Perineal laceration or postpartum fistula	0·090	0·0439	0·04	0·049	0·0755	0·52	0·063	0·0796	0·4
Perinatal outcome									
Fetal death	0·110	0·0330	0·001	0·207	0·0581	0·0006	0·190	0·0623	0·003
Fetal death‡				0·214	0·0575	0·0003	0·201	0·0617	0·002
Neonatal death	0·126	0·0349	0·0004	0·088	0·0569	0·1	0·070	0·0611	0·3
Neonatal death‡				0·101	0·0530	0·06	0·089	0·0571	0·1
≥7 days on neonatal intensive or special care unit	0·310	0·0633	<0·0001	0·229	0·1097	0·04	0·143	0·1150	0·2
≥7 days on neonatal intensive or special care unit‡				0·240	0·1088	0·03	0·157	0·1146	0·2
Preterm delivery (<37 weeks' gestation)	0·219	0·0462	<0·0001	0·060	0·0743	0·4	–0·009	0·0775	0·9

*Adjusted for proportion of primiparous women, previous caesarean delivery, gestational hypertension or pre-eclampsia or eclampsia, referral from other institution for pregnancy complications or delivery, breech or other non-cephalic fetal presentation, and epidural during labour. †Adjusted for same variables as in * plus complexity index of institution and type of institution. ‡Adjusted for same variables as in previous line plus preterm delivery.

Table 4: **Association between proportion of all caesarean deliveries and maternal and perinatal outcomes at institutional level**

	Crude regression coefficient	Standard error	p	Adjusted regression coefficient*	Standard error	p	Adjusted regression coefficient†	Standard error	p
Maternal outcome									
Severe maternal morbidity and mortality index	0·284	0·0729	0·0002	0·272	0·1184	0·02	0·277	0·1148	0·02
Postnatal treatment with antibiotics	0·455	0·1217	0·0003	0·492	0·2030	0·02	0·496	0·2070	0·02
Perineal laceration or postpartum fistula	0·092	0·0512	0·08	0·082	0·0828	0·3	0·097	0·0842	0·2
Perinatal outcome									
Fetal death	0·107	0·0389	0·007	0·153	0·0652	0·02	0·163	0·0654	0·01
Fetal death‡				0·147	0·0635	0·02	0·161	0·0640	0·01
Neonatal death	0·096	0·0419	0·02	0·014	0·0704	0·8	0·010	0·0705	0·9
Neonatal death‡				–0·001	0·0595	0·99	0·005	0·0605	0·9
≥7 days on neonatal intensive or special care unit	0·289	0·0762	0·0002	0·170	0·1274	0·2	0·139	0·1233	0·3
≥7 days on neonatal intensive or special care unit‡				0·153	0·1200	0·2	0·134	0·1182	0·3
Maternal outcome	0·213	0·0552	0·0002	0·055	0·0898	0·5	0·023	0·0873	0·8

*Adjusted for proportion of primiparous women, previous caesarean delivery, and breech or other non-cephalic fetal presentation. †Adjusted for same variables as in * plus complexity index of institution and type of institution. ‡Adjusted for same variables as in previous line plus preterm delivery.

Table 5: **Association between proportion of elective caesarean deliveries and maternal and perinatal outcomes at institutional level**

blood transfusion (0·4%); hysterectomy (0·1%), maternal hospital stay of longer than 7 days (0·7%) and maternal death or admission to intensive care (0·2%). The median rate of antibiotic treatment postnatally was 33% (19–52). Third and fourth degree perineal laceration or postpartum fistula was reported in a median of 0·2% (0·0–0·6). The median rate per thousand births of intrapartum fetal death was 0·3 (0·0–0·8), for neonatal death was 4 (1–7), and of staying 7 days or longer in the neonatal intensive care unit was 19 (6–45); the rate of preterm delivery was 6% (4–9).

We undertook a multiple linear regression analysis, considering the proportion of caesarean deliveries in each institution as the dependent variable, transformed to the logit scale, while considering as independent (explanatory) variables the proportion of pregnant women in each institution with the risk factors for caesarean listed in table 2. Primiparity, previous caesarean, pre-eclampsia, breech or non-cephalic presentation, referred from other institutions, and epidural anaesthesia in labour were independently associated with an increase in caesarean deliveries. Institutions with a high complexity index, and private or social-security institutions were also associated with higher levels of caesarean delivery (table 3). Further adjustments, taking into account the number of deliveries contributed by each hospital, yielded similar results (data not shown).

We included variables significantly associated with caesarean delivery in table 3 in a final linear regression model to assess their independent effects. The only three criteria that remained positively significant were primiparity, caesarean delivery in previous pregnancy, and the institutional complexity index, explaining 72% of the variance in overall rates of caesarean delivery. We did similar analyses with intrapartum and elective caesareans

	Crude regression coefficient	Standard error	p	Adjusted regression coefficient*	Standard error	p	Adjusted regression coefficient†	Standard error	p
Maternal outcome									
Severe maternal morbidity and mortality index	0·370	0·0673	<0·0001	0·350	0·0754	<0·0001	0·355	0·0892	0·0001
Postnatal treatment with antibiotics	0·317	0·1219	0·01	0·133	0·1510	0·4	0·207	0·1788	0·5
Perineal laceration or postpartum fistula	0·088	0·0499	0·08	–0·033	0·0599	0·6	–0·016	0·0696	0·8
Perinatal outcome									
Fetal death	0·101	0·0379	0·009	0·078	0·0468	0·09	0·063	0·0554	0·3
Fetal death‡				0·080	0·0462	0·08	0·068	0·0549	0·2
Neonatal death	0·140	0·0397	0·0006	0·084	0·0439	0·06	0·072	0·0520	0·2
Neonatal death‡				0·088	0·0411	0·03	0·084	0·0488	0·09
≥7 days on neonatal intensive or special care unit	0·417	0·0686	<0·0001	0·379	0·0813	<0·0001	0·321	0·0949	0·001
≥7 days on neonatal intensive or special care unit‡				0·382	0·0809	<0·0001	0·328	0·0946	0·0007
Maternal outcome	0·271	0·0513	<0·0001	0·134	0·0564	0·02	0·080	0·0666	0·2

*Adjusted for proportion of previous caesarean delivery, gestational hypertension or pre-eclampsia, or eclampsia, induced labour, and epidural during labour. †Adjusted for same variables as in * plus complexity index of institution and type of institution. ‡Adjusted for same variables as in previous line plus preterm delivery.

Table 6: **Association between proportion of intrapartum caesarean deliveries and maternal and perinatal outcomes at institutional level**

as dependent variables. For elective caesarean, only primiparity and caesarean delivery in previous pregnancy remained significant, explaining 64% of the variation in rates; for intrapartum caesarean delivery, previous caesarean section, induction of labour, institutional complexity, and private nature of institution were retained in the final model, explaining 52% of the variance.

What was the association between caesarean delivery and pregnancy outcomes after adjustment for population risk and institutional characteristics? We used rate of caesarean delivery as the independent variable and each maternal and perinatal outcome, both transformed to the logit scale, as dependent variables in separate multiple linear regression analyses. In the crude analysis, an increase in rate of caesarean delivery was associated with a significantly higher risk for severe maternal morbidity and mortality and postnatal treatment with antibiotics (table 4). When adjusted for the set of confounding variables (case-mix) and complexity and type of institutions, caesarean delivery remained highly significantly associated with an increase in the morbidity and mortality index and in postnatal treatment with antibiotics (table 4). Rates of third or fourth degree perineal laceration or postpartum fistulae, or both, were not independently associated with rates of caesarean delivery.

Table 4 also summarises the crude and adjusted association between rate of caesarean delivery and perinatal outcomes. In the crude analysis, caesarean delivery rates were positively and significantly associated with an increase in the rate of the four negative perinatal outcomes. After adjustment for the case-mix of the populations served, the rate of caesarean delivery was positively and statistically associated with an increase in the rates of fetal death, numbers of infants admitted to the neonatal intensive care unit for 7 days or more, and borderline significant for neonatal death after adjusting for preterm delivery. Adjustment for type of hospital did not change these results, although adjustments for complexity of the institutions eliminated these neonatal negative effects, except for fetal death (table 4).

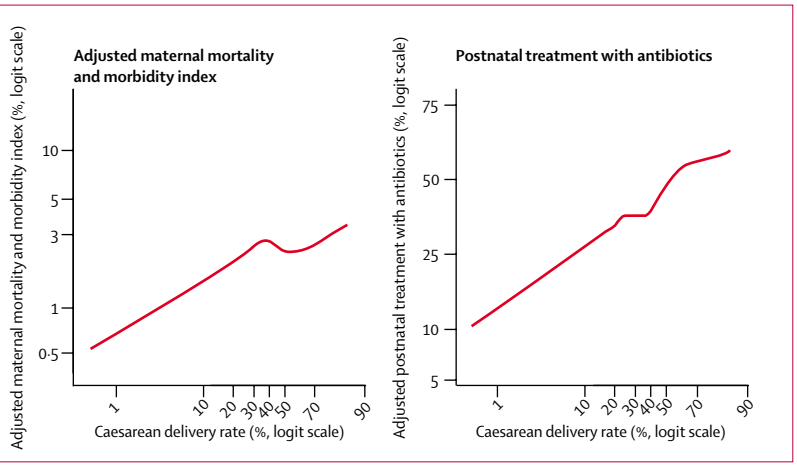

Figure 3: **Association between rate of caesarean delivery and maternal morbidity and mortality index and postnatal treatment with antibiotics**
Rates of outcomes adjusted by proportions of: primiparous women, previous caesarean delivery, gestational hypertension or pre-eclampsia or eclampsia during current pregnancy, referral from other institution for pregnancy complications or delivery, breech or other non-cephalic fetal presentation, and epidural during labour, along with complexity index for institution and type of institution in multiple linear regression analysis. Curves based on LOWESS smoothing applied to scatterplot of logit of rates of caesarean delivery versus logit of adjusted probability of each outcome.

We stratified the results presented in table 4 by elective and intrapartum caesarean delivery. The increase in elective caesareans was positively and significantly associated with the proportion of women with the severe morbidity and mortality index and postnatal antibiotic treatment after adjustment for all confounding variables, as in table 4 (table 5). Of the perinatal outcomes, only fetal death was independently associated with elective caesarean delivery rates. After adjustment for institutional type and complexity, the maternal morbidity and mortality index, postnatal treatment with antibiotics, and fetal death

remained associated with elective caesarean delivery (table 5), suggesting that the crude effect of caesarean delivery on neonatal death, rate of infants spending 7 days or more in the neonatal intensive care unit, and preterm delivery is confounded by the population characteristics and complexity of the institution.

Table 6 shows a similar analysis as in table 5, but with intrapartum caesarean delivery as the independent variable. After adjustment for the same confounding variables, the rate of intrapartum caesarean delivery was associated with an increase in the severe maternal morbidity and mortality index, neonatal death, rate of infants spending 7 days or more in the neonatal intensive care unit (even after adjustment for preterm delivery), and total preterm delivery. After adjustment for both the type of institution and institutional complexity, the severe maternal morbidity and mortality index and rate of infants spending 7 days or more in the neonatal intensive care unit remained positively and significantly associated with rate of intrapartum caesarean delivery.

Finally, we assessed whether there was a threshold rate of caesarean delivery associated with the noted increase in negative outcomes, as adjusted for the confounding variables considered in table 4. For postnatal maternal treatment with antibiotics and severe maternal morbidity and mortality index, the increase seemed linear (figure 3). Risk of preterm delivery and neonatal death rose at caesarean delivery rates of between 10% and 20% (figures 4 and 5).

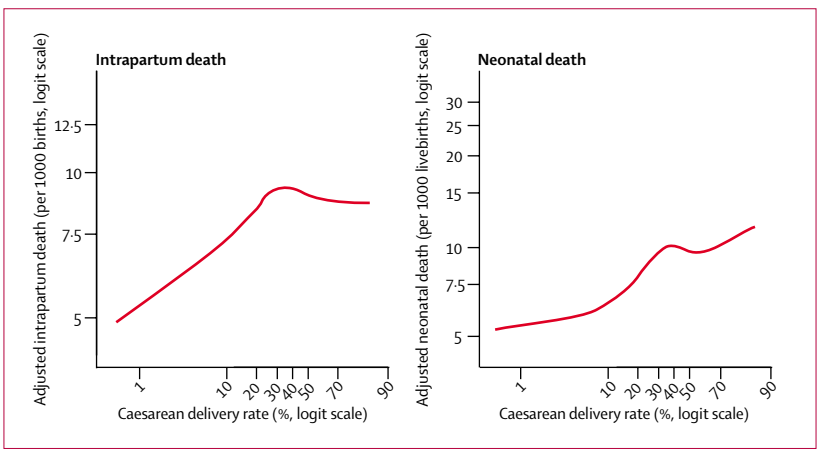

Figure 4: **Association between rate of caesarean delivery and intrapartum death (per 1000 births) and neonatal mortality (per 1000 livebirths)**
Mortality rates adjusted by proportions of: primiparous women, previous caesarean delivery, gestational hypertension or pre-eclampsia or eclampsia during current pregnancy, referral from other institution for pregnancy complications or delivery, breech or other non-cephalic fetal presentation, and epidural during labour, along with complexity index for institution and type of institution in multiple linear regression analysis.

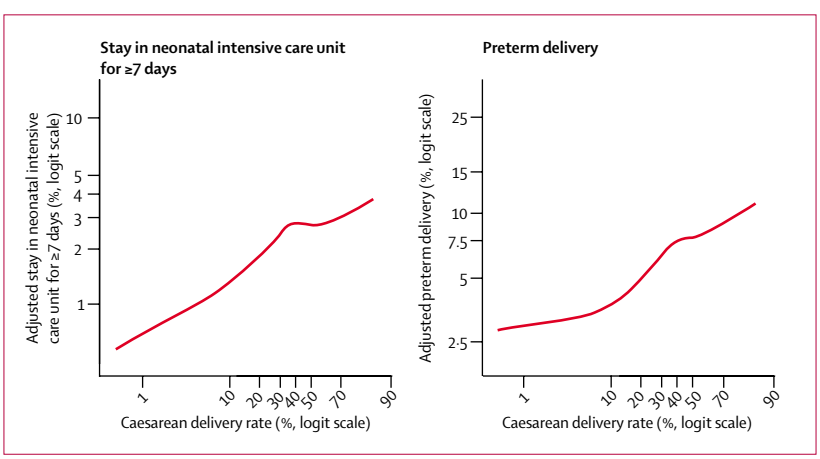

Figure 5: **Association between rate of caesarean delivery and neonatal admission to intensive care for 7 days or more and preterm delivery**
Rates of outcomes adjusted by proportions of: primiparous women, previous caesarean delivery, gestational hypertension or pre-eclampsia or eclampsia during current pregnancy, referral from other institution for pregnancy complications or delivery, breech or other non-cephalic fetal presentation, and epidural during labour, along with complexity index for institution and type of institution in multiple linear regression analysis.

Discussion

Our findings indicate that increase in rates of caesarean delivery is associated with increased use of antibiotics postpartum, greater severe maternal morbidity and mortality, and higher fetal and neonatal morbidity, even after adjustment for demographic characteristics, risk factors, general medical and pregnancy associated complications, type and complexity of institution, and proportion of referrals. The high rates of caesarean delivery and its more frequent indications were similar across countries with different health systems and perinatal outcomes.

Our study had limitations, including the possibility of selection bias. Sources could result from the inability of three of the original 11 selected countries to participate in a timely fashion, the refusal of three selected institutions to participate, and the deterministic selection of the capital cities in each country. Furthermore, the large number of health institutions involved limited standardisation of diagnoses. We therefore concentrated our analyses on a few unequivocal morbidity and mortality indicators, using data prospectively abstracted by staff from the same hospital; we discussed unclear or incomplete records directly with the attending medical staff. Additionally, our real-time, web-based data entry system and its internal consistency procedures facilitated the identification of incomplete or inconsistent data, which could then be queried within a few weeks of the event. For logistical reasons, the survey lasted only 3 months, and so did not capture possible time-related effects—eg, in the characteristics of the population or relating to training of new staff. Our analyses and inferences are based on institutional-level data, for the purpose of making institutional-level recommendations. The so-called ecological fallacy[24] does not, therefore, apply here.

Although we have made extensive statistical adjustments for many possible confounding variables, unidentified factors might have affected our noted associations. The consistent trends noted are, however, unlikely to have been affected in such a way. Finally, the very high rates of caesarean delivery observed in this survey may not be directly extrapolated to the whole country or region, but should reflect very well the situation in large institutions in

these countries. We also believe that the relationsships with outcomes we have succeeded in identifying should be generalisable beyond the participating institutions.

Independent of mothers' risk, use of epidural in labour, or type and complexity of institution, high rates of caesarean delivery were associated at the institutional level with postnatal treatment with antibiotics, in addition to the prophylactic antibiotics recommended after caesarean delivery. These findings concur with the increased level of infections associated with caesarean delivery in hospitals in developed countries.[25] Caesarean delivery rates were also independently associated with the maternal morbidity and mortality index, which included conditions such as blood transfusions in agreement with reported higher risk of caesarean delivery for severe postpartum haemorrhage[26] and the proportion of women who stayed in hospital for more than 7 days postpartum—ie, beyond the maximum stay for uncomplicated caesarean delivery. Also, rates of caesarean delivery were not associated with a protective effect on perineal lacerations, as could have been expected.

Caesarean delivery did not improve perinatal outcomes either, as suggested by data from developed countries.[27] On the contrary, an increase in fetal death was independently associated with caesarean delivery, especially elective caesarean delivery. This finding is difficult to interpret, since we did not record the precise timing of death vis-à-vis the indication for caesarean, although elective caesarean delivery is usually not indicated for stillbirths. However, similar observations have been made in high-risk women who had had a previous caesarean (the most common indication for caesarean delivery in our population)[28] and among obstetricians in the USA with high rates of caesarean delivery, who also recorded higher rates of fetal death among low birthweight infants than obstetricians with lower rates of caesarean deliveries.[27]

Our original hypothesis was that rates of caesarean delivery would show a U-shaped association with negative perinatal outcomes. We did not note such a pattern, even in the adjusted analysis, perhaps because there were only a few hospitals with low rates of caesarean delivery. We did note an increased risk of preterm delivery and neonatal mortality starting between rates of caesarean delivery of 10% and 20%. The higher rates of newborn babies spending 7 days or more in a neonatal intensive care unit among hospitals with high caesarean delivery rates could be related to an increase in respiratory distress syndrome associated with elective caesarean delivery.

Rates of caesarean delivery, especially elective caesarean delivery in private hospitals, reflect a complex social process, affected by clinical status, family and social pressures, the legal system, availability of technology, women's role models (celebrity elective caesarean delivery). Examples from private institutions show that moderate rates of caesarean delivery are not unrealistic even in affluent societies.[29] Our results also show how a medical intervention or treatment that is effective when applied to sick individuals in emergency situations can do more harm than good when applied to healthy populations.

In Latin America, about 11 million babies are born every year. An increase from 15% (as initially suggested) to the observed 35% in caesarean deliveries, represents an additional 2 million caesarean deliveries per year. The difference in cost (without any complications of caesarean delivery) between a vaginal delivery and a caesarean delivery is about US$350 for a country like Chile.[30] In a developed country, for each 1% increase in caesarean deliveries, there is an increase in cost of about US$9·5 million.[13] These large sums of money could be used to improve other areas of maternal and newborn care and to pay for needed research.

In conclusion, high rates of caesarean delivery do not necessarily indicate good quality care or services. Indeed institutions that deliver a lot of babies by caesarean should initiate a detailed and rigorous assessment of the factors related to their obstetric care and the perinatal outcomes achieved vis-à-vis the case mix of the population they serve; at present their services might cause (iatrogenic) harm.

Contributors

J Villar, G Carroli, A Faundes, A Donner, L Bakketeig, and A Shah were responsible for the idea and conception of the survey. J Villar, A Shah, G Carroli, and A Donner prepared the protocol. L Campodónico, G Carroli, J Villar, and A Shah supervised and coordinated the survey's overall undertaking in Latin America. D Wojdyla, L Campodónico, A Donner, D Giordano, and M Kublickas were responsible for data management and analysis in collaboration with J Villar. E Valladares, N Zavaleta, A Velazco, V Bataglia, A Langer, A Narváez, M Romero, S Reynoso, K Simônia de Pádua, and A Acosta collaborated in the preparation of the protocol and the survey and implemented it in their respective countries. They actively contributed to the overall undertaking of the trial. J Villar, G Carroli, A Donner, and A Faundes wrote the report with input from all investigators. All investigators read the report and made substantive suggestions on its content.

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Conflict of interest statement

We declare that we have no conflict of interest.

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