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Intervention using the Robson classification as a tool to reduce cesarean section rates in six public hospitals in Brazil

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Abstract

Objectives: To analyze the effectiveness and safety of a multifaceted intervention to reduce cesarean section (CS) rates.

Methods: This interrupted time series study involved six public hospitals with pre-intervention CS rates>35 %. We collected monthly data on overall and Robson group CS rates of 37,031 women who gave birth at the six hospitals during 30 months in the pre-intervention (12 months, n=14,836 women), intervention (6 months, n=6,431 women), and post-intervention (12 months, n=15,764 women) study periods. The intervention bundle included six components: audit and feedback using the Robson classification, goal setting for overall CS rate, distribution of evidence-based guidelines, informative meetings with hospital coordinators, newsletters, and inter-hospital mentoring.

Results: There were no significant changes in mean overall CS rates between the three periods. However, five of the six hospitals had a significant decrease in CS rates in at least one Robson group during the study period: groups 1 and 5a (2 hospitals), group 2a (1 hospital), groups 4 and 4a (1 hospital), and group 5b (1 hospital). There were no significant increases in adverse events (maternal and perinatal mortality, neonatal asphyxia) in any of the hospitals with reductions in CS rates.

Conclusions: The multifaceted intervention did not significantly reduce the overall CS rate in the participating hospitals. However, five of the six hospitals had significant reductions in CS rates in at least one Robson group, without increasing adverse maternal or perinatal outcomes.

Keywords: cesarean section; Robson classification; clinical audit; maternal mortality; perinatal mortality; Health Services Administration

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Introduction

Births by cesarean section (CS) have increased worldwide over the last decades, and Brazil stands out as one of the top five countries with the CS highest rates [1]. Several non-clinical factors contribute to rising CS rates, including convenience, fear of litigation, financial incentives, and popular misconceptions about the safety of CS and the risks of vaginal deliveries [2–5]. A considerable proportion of contemporary women have "unnecessary" CS, defined as cesareans performed without any medical indication [6]. However, a cesarean, as any major surgery, exposes women to short- and long-term risks, as well as complications in future pregnancies [7–9]. Children delivered by CS may also be at risk for immediate and long-term complications [10–12].

The worldwide increase in CS rates and its associated risks, especially in low resource settings [13, 14], has triggered efforts to reduce unnecessary cesareans, thus reducing overall CS rates. However, "overall" CS rate

provides limited information because they may be influenced by several factors, including differences in population characteristics and obstetric practice. The Robson classification (Supplementary Table S1) addresses the issue of obstetric population characteristics by categorizing all pregnant women admitted for delivery into one of 10 unique groups based on their parity, gestational age, fetal presentation, number of fetuses, and onset of labor [15]. Since 2015, the World Health Organization (WHO) recommends the use of the Robson classification to monitor and compare CS rates over time and between different institutions, cities, or countries [15]. Many clinical and non-clinical interventions to reduce CS rates have been described and tested, with variable results [16–18]. However, relatively few studies describe the use of the Robson classification as an audit and feedback tool in interventions to reduce CS rates [19–22].

The aim of this study was to analyze the effectiveness and safety of a multifaceted intervention, which included audit and feedback using the Robson classification, to reduce CS rates in six public hospitals in a large Brazilian city.

Subjects and methods

This longitudinal interrupted time series intervention study involving six public hospitals was conducted over a 30- month period (July 2015–December 2017) divided into three periods: pre-intervention (12 months), intervention (6 months), and post-intervention (12 months). The study was approved by the Ethics Committee of Federal University of São Paulo (1.814.4.257). Informed consent was waived because all data were at population level.

Participants

To select the hospitals, we analyzed official birth statistics of the 37 hospitals managed by the municipal health department in 2014 and ranked the hospitals according to their overall CS rates. The first six hospitals with the highest CS rates were selected to participate in the study. All had CS rates >35 % in 2014, and were not planning to start any interventions to reduce CS rates.

Intervention

The intervention bundle included six components implemented at the same time in all hospitals (Table 1). The components were selected based on the literature available at the time, personal experience of the investigators, feasibility, and availability of human resources.

Outcomes

The primary outcomes were changes in a) overall CS rates, b) Robson groups 1, 2, 3, 4, and 5 CS rates, and c) 5-min Apgar scores <7, in each of the six hospitals between the study periods. The secondary outcomes were changes in maternal mortality ratio (in-hospital), and perinatal mortality rates (stillbirths ≥500 g and in-hospital neonatal death up to 7 days of life). All data were collected from the municipal live birth information system (SINASC/CEInfo/SMS-SP) which extracts information from the birth certificates, the municipal maternal mortality committee, and the city mortality information system (SIM).

Statistical analysis

We analyzed each hospital´s monthly overall CS rates, CS rates in each of the Robson groups, and rates of 5-min Apgar <7. Data were collected for 30 time points, divided into three periods: pre-intervention (12 points), intervention (6 points), and post-intervention (12 points). The interrupted time series method was used to assess changes in the trends and levels between the three periods for monthly CS rates. The Pearson Chi-squared (χ^2) test was used to compare changes in overall rates of asphyxia, maternal mortality, and perinatal mortality between the three periods. Results were considered significant at $p<0.05$. The R program was used for all analyses.

Results

Hospital characteristics

Three institutions (H1, H2, and H6) were tertiary referral hospitals for high-risk pregnancies, three had an obstetrics-gynecology residency program (H2, H5 and H6), two had training programs for nursing students (H2 and H5), and one had a training program for medical students (H6) (Table 2).

Changes in cesarean section rates

We collected monthly data on overall and Robson group CS rates for 37,031 women who gave birth at the six hospitals in the pre-intervention (12-months, n=14,836 women),

Table 1: Multifaceted intervention components.

Component	Target	Details
Audit and feedback using the Robson classification	Hospital directors & obstetric coordinators[a]	During the intervention period, hospitals received monthly emails with progress report tables containing data on their CS rates (overall and per Robson group), and 5-min Apgar scores <7 for that month, and changes compared to previous months
Goal setting	Obstetric coordinators	The main goal was to reduce the overall hospital CS rate to <35 % without increasing perinatal asphyxia
Evidence-based practice guidelines	Obstetric coordinators & healthcare providers	At the first presential meeting, obstetric unit coordinators received printed practice guidelines on evidence-based obstetric care, prepared by one of the model hospitals. The guidelines had recommendations on management of spontaneous labor, partograph use/interpretation, intrapartum cardiotocography, labor induction, and vaginal delivery after CS. Coordinators were advised to make these guidelines available in the labor ward and to discuss and encourage their use by their obstetric teams
Informative meetings	Obstetric coordinators	Obstetric coordinators participated in four presential 90-min meetings at the municipal health department (once every two months). At the first meeting (1 week before implementation of the intervention), the investigators presented the Robson classification, each hospital´s data on CS and asphyxia rates in 2015, the project objectives, and the intervention bundle. In the first part of each subsequent meeting, the investigators presented the latest data on CS and asphyxia rates for each hospital, and the same data for the three "model" hospitals. In the second part of the meeting, participants had small group discussions to share experiences, successes, and difficulties to reduce CS rates in their hospitals over the last two months
Newsletters	Obstetric coordinators	Every two months, hospitals received an electronic newsletter with comments on the progress of the six hospitals and information on safe reduction of CS rates. Obstetric coordinators were encouraged to share the newsletter with the labor and delivery ward teams
Mentoring between hospitals	Obstetric coordinators	Three public municipal hospitals with CS rates <35 % and good maternal and perinatal outcomes in 2014–2015 were selected by the health department to serve as "models" for the six hospitals with higher CS rates. The obstetric coordinators of the model hospitals were asked to act as mentors for the six hospitals with higher CS rates. Each model hospital was matched to two study hospitals. Mentors participated in all informative meetings to support the six study hospitals and share their experience

CS, cesarean section. [a]Obstetric coordinators: head obstetrician and head obstetric nurse of the labor and delivery ward.

Table 2: Main characteristics and overall CS rates of the six study hospitals.

Hospital characteristics	H1	H2	H3	H4	H5	H6
Geographical location	West	South	Southeast	North	East	North
Tertiary referral hospital	Yes	Yes	No	No	No	Yes
Public health units referring patients, n	28	27	4	10	12	12
OB-GYN residency program	No	Yes	No	No	Yes	Yes
Training program for nursing students	No	Yes	No	No	Yes	No
Training program for medical students	No	No	No	No	No	Yes
Pre-intervention period (12 months)						
Deliveries, n	2,388	4,751	1,043	1,360	2,927	2,367
CS, n	1,029	1,755	386	507	1,116	983
Overall CS rate, %	43.1	36.9	37.0	37.3	38.1	41.5
Intervention period (6 months)						
Deliveries, n	1,125	1,812	405	683	1,395	1,011
CS, n	447	739	173	235	533	411
Overall CS rate, %	39.7	40.8	42.7	34.4	38.2	40.7
Post-intervention period (12 months)						
Deliveries, n	2,400	4,747	1,320	1,367	3,291	2,639
CS, n	981	1,819	485	449	1,280	1,020
Overall CS rate, %	40.9	38.3	36.7	32.8	38.9	38.7

CS, cesarean section; n, number; OB-GYN, obstetrics and gynecology.

intervention (6-months, n=6,431), and post-intervention (12-months, n=15,764) periods. There were no statistically significant changes in mean overall CS rates or trends between the three periods in any hospital (Table 2, Supplementary Figure S1). During the intervention and post-intervention periods, one of the six hospitals (H4) reached the <35 % overall CS rate goal, but this decrease was not statistically significant (Table 2, Supplementary Figure S1). There were changes in the CS rates of Robson groups 1 to 5 in several hospitals during the study period (Table 3, Supplementary Tables S2–S7). In the linear multiple regression analyses, five of the six hospitals (H1, H3, H4, H5 and H6) had significant decreases in CS trends and or rates in at least one of the five Robson groups (Table 3, Supplementary Figure S2, Supplementary Tables S2–S7). In H1, there was a significant decrease in CS trends and rates in Robson group 1 (26.6 vs. 24.2 %, pre-intervention vs. post-intervention), and in CS trends and rates in group 5a (68.3 vs. 59.6 %, pre-intervention vs. intervention) (Supplementary Figure S2A–B, Supplementary Table S2). In H2, there were no significant changes in CS rates between the three periods in any Robson group (Supplementary Table S3). Hospital H3 had a significant decrease in CS trends and rates in group 1 (22.5 vs. 20.6 %, pre-intervention vs. post-intervention) (Supplementary Figure S2C, Supplementary Table S4).

Table 3: Rates of cesarean sections in Robson groups 1 to 5 in the six hospitals in the pre-intervention, intervention, and post-intervention periods.

Robson group	Hospital					
	H1	H2	H3	H4	H5	H6
Pre-intervention period (12 months)						
Group 1	26.6[a,b]	31.7	22.5[a,b]	20.2	11.3	26.1
Group 2	65.7	36.7	53.3	68.5	43.2	43.4
Group 2a	54.4	6.8	36.9	57.1	25.1	35.3
Group 3	7.7	13.0	3.2	5.8	2.7	8.3
Group 4	23.9[a,b]	23.1	24.4	56.9[f]	16.8	24.2
Group 4a	14.6[a,b]	5.3	15.6	32.4[f]	7.5	15.6
Group 5	77.0	68.2	74.5	69.7	68.2	63.6
Group 5a	68.3[d,e]	60.0	65.2	57.4[a,b]	57.2	53.5
Group 5b	99.3	96.8	96.6	97.9[g]	92.9	97.2
Intervention period (6 months)						
Group 1	24.9	23.7	19.1	23.4	17.8	17.7
Group 2	61.1[c]	63.7	75.0	66.7	64.2	53.0
Group 2a	50.5	41.2	54.2	54.4	48.9[h]	41.0
Group 3	9.2	9.3	6.5	3.3	6.8	6.5
Group 4	25.4	52.3	32.3	21.7	39.4	39.7
Group 4a	10.2	26.8	27.6	5.3	20.5	30.0
Group 5	70.4	73.9	81.5	67.7	70.6	70.1
Group 5a	59.6 [d,e]	66.4	74.0	51.1	59.5	60.8
Group 5b	100.0	97.6	100.0	100.0	96.7	94.8
Post-intervention period (12 months)						
Group 1	24.2[a,b]	14.4	20.6[a,b]	18.5	23.3	20.0
Group 2	68.0[c]	71.0	59.9	61.1	60.8	55.3
Group 2a	56.6	42.0	48.6	48.0	44.4[h]	45.7
Group 3	6.6	3.9	5.6	4.7	7.5	6.1
Group 4	50.9[a,b]	48.5	26.9	23.3[f]	28.6	32.5
Group 4a	36.8[a,b]	19.7	15.5	14.8[f]	15.3	21.9
Group 5	71.3	70.1	72.0	65.3	69.0	67.0
Group 5a	59.6	60.7	63.5	49.8[a,b]	58.3	56.6
Group 5b	98.8	96.7	100.0	99.0[g]	97.0	98.6

All numbers represent percentages. [a]Statistically significant change in mean CS rate between periods. [b]Statistically significant change in CS rate trend between periods. [c]Statistically significant change in mean CS rate between periods. [d]Statistically significant change in mean CS rate between periods. [e]Statistically significant change in CS rate trend between periods. [f]Statistically significant change in CS rate trend between periods. [g]Statistically significant change in CS rate trend between periods. [h]Statistically significant change in mean CS rate between periods.

Hospital H4 had significant decreases in CS rate trends between the pre-intervention and post intervention periods in groups 4, 4a and 5a, and in CS rates in group 5a (Supplementary Figure S2D–F, Supplementary Table S5). Hospital H5 had a significant decrease in CS rates in group 2a (48.9 vs. 44.4 %, intervention vs. post-intervention) (Supplementary Figure S2G, Supplementary Table S6), and hospital H6 a significant decrease in CS trends and rates in group 5b (97.2 vs. 94.8 %, pre-intervention vs. intervention) (Supplementary Figure S2H, Supplementary Table S7).

Two hospitals had significant increases in CS rates in some Robson groups. In H1, there was a significant increase in CS rates in Group 2 (intervention vs. post-intervention), and a significant increase in CS trends and rates in groups 4 and 4a (pre-intervention vs. post-intervention) (Table 3, Supplementary Table S2). Hospital H4 had a significant increase in CS trends in group 5b (pre-intervention vs. post-intervention) (Table 3, Supplementary Table S5). Hospitals H3 and H5 had transient increases in CS trends and rates between the pre-intervention and intervention periods, followed by decreases in CS trends and rates between the intervention and post-intervention periods. In H3, this occurred in Robson groups 2 and 2a (Supplementary Table S4); in H5, this occurred in group 4a (Supplementary Table S6).

Change in neonatal asphyxia, maternal mortality, and perinatal mortality

There were no significant changes in the rates of asphyxia between the three study periods in five of the six hospitals (Table 4). Hospital H2 had a significant increase in the rate of asphyxia between the pre-intervention and post-intervention periods (2.1 vs. 2.9 %, p=0.015), however, this was the only hospital that did not have significant reduction in CS rates in any of the Robson groups analyzed (Table 5). There were no significant changes in maternal mortality ratio during the study period in any of the hospitals. Perinatal mortality remained similar in five of the six hospitals and decreased significantly in one hospital (H6) between the intervention and post-intervention periods (Table 4). The summary of the changes in CS rates and adverse maternal and perinatal outcomes in each of the six hospitals is presented in Table 5.

Discussion

Although the intervention did not reduce overall CS rates in any hospital, in five hospitals it was associated with significant reductions in CS rates in at least one of the Robson groups, without significant increases in adverse maternal and perinatal outcomes.

Similar studies that used the Robson classification as an audit and feedback tool to reduce CS rates also reported the safety of this intervention on perinatal outcomes [21–27]. We did not identify any similar study that assessed maternal mortality. Several studies that implemented interventions to reduce CS rates using audit and feedback with the Robson classification reported significant reductions in overall CS rates and/or in CS rates in specific Robson groups. However,

Table 4: Changes in asphyxia, maternal mortality and perinatal mortality in the six hospitals during the study period.

Phase	All hospitals		H1		H2		H3		H4		H5		H6	
Asphyxia rate														
	n/N[a]	%	n/N	%	n/N	%	n/N	%	n/N	%	n/N	%	n/N	%
Pre-intervention	375/14,836	2.5	97/2,388	4.1	101/4,751	2.1[e]	20/1,043	1.9	40/1,360	2.9	63/2,927	2.2	54/2,367	2.3
Intervention	153/6,431	2.4	35/1,125	3.1	42/1812	2.3	5/405	1.2	15/683	2.2	30/1,395	2.2	26/1,011	2.6
Post-intervention	403/14,764	2.7	68/2,400	2.8	138/4,747	2.9[e]	21/1,320	1.6	41/1,367	3.0	59/3,291	1.8	76/2,639	2.9
p-value[d]	0.286		0.054		0.044		0.634		0.548		0.540		0.412	
Maternal mortality rate														
	n/N[b]	‰oo	n/N	‰oo	n/N	‰oo	n/N	‰oo	n/N	‰oo	n/N	‰oo	n/N	‰oo
Pre-intervention	6/14,836	40.4	0/2,388	–	1/4,751	21.0	1/1,043	95.9	1/1,360	73.5	2/2,927	68.3	1/2,367	42.2
Intervention	1/6,431	15.5	0/1,125	–	1/1812	55.2	0/405	–	0/683	–	0/1,395	–	0/1,011	–
Post-intervention	8/14,764	54.2	0/2,400	–	5/4,747	105.3	0/1,320	–	0/1,367	–	2/3,291	60.8	1/2,639	37.9
p-value[d]	0.446		N/A	–	0.254		0.437		0.471		0.633		0.814	
Perinatal mortality rate														
	n/N[c]	‰	n/N	‰	n/N	‰	n/N	‰	n/N	‰	n/N	‰	n/N	‰
Pre-intervention	240/14,836	16.3	32/2,388	13.4	90/4,751	18.9	16/1,043	15.3	20/1,360	14.7	39/2,927	13.3	43/2,367	18.2
Intervention	112/6,431	17.4	13/1,125	11.6	36/1812	19.9	3/405	7.4	9/683	13.2	24/1,395	17.2	27/1,011	19.4[f]
Post-intervention	229/14,764	15.5	25/2,400	10.4	96/4,747	20.2	10/1,320	7.6	15/1,367	11.0	48/3,291	14.6	35/2,639	13.3 [f]
p-value[d]	0.592		0.631		0.901		0.148		0.687		0.709		0.020	

Asphyxia rate: % of liveborn infants with 5-min Apgar score <7. Maternal mortality rate: (number of direct and indirect maternal deaths/number of live births) × 100,000. ‰Perinatal Mortality Rate (number of fetal deaths + number of early neonatal deaths)/(number of live births + stillbirths) × 1,000. [a]n=number of newborns with 5-min Apgar score<7, N=total number of live births. [b]n=number of maternal deaths. N=number of live births. [c]n=number of perinatal deaths. N=total number of births (live births + stillbirths). [d]Pearson's Chi-square test evaluating differences between periods (pre-intervention, intervention, post-intervention) in the same hospital. [e]Pre-intervention vs. post-intervention: p=0.0151. [f]Intervention vs. post-intervention: p=0.0049.

Table 5: Summary of the effectiveness and safety of an intervention to reduce cesarean sections rates in six public hospitals.

Hospital outcome	H1[a] Baseline CS rate 43.1 %	H2[a] Baseline CS rate 36.9 %	H3 Baseline CS rate 37.0 %	H4 Baseline CS rate 37.3 %	H5 Baseline CS rate 38.1 %	H6[a] Baseline CS rate 41.5 %
Change in overall CS rate[b]	NS	NS	NS	NS	NS	NS
Changes in overall CS rate tendency	NS	NS	NS	NS	NS	NS
Changes in Robson 1 CS rate	Decrease pre vs. post[c,d]	NS	Decrease pre vs. post[c,d]	NS	NS	NS
Changes in Robson 2 CS rate	Increase interv vs. post[c]		Increase pre vs. interv[c,d] Decrease interv vs. post[c,d]	NS	NS	NS
Changes in Robson 2a CS rate	NS	NS	Increase pre vs. interv[c,d] Decrease interv vs. post[c,d]	NS	Decrease interv vs. post[c]	NS
Changes in Robson 3 CS rate	NS	NS	NS	NS	NS	NS
Changes in Robson 4 CS rate	Increase pre vs. post[c,d]			Decrease pre vs. post[d]		
Changes in Robson 4a CS rate	Increase pre vs. post[c,d]	NS	NS	Decrease pre vs. post[d]	Increase pre vs. interv[c,d] Decrease interv vs. post[c,d]	NS

Table 5: (continued)

Hospital outcome	H1[a] Baseline CS rate 43.1 %	H2[a] Baseline CS rate 36.9 %	H3 Baseline CS rate 37.0 %	H4 Baseline CS rate 37.3 %	H5 Baseline CS rate 38.1 %	H6[a] Baseline CS rate 41.5 %
Changes in Robson 5 CS rate	NS		NS	NS	NS	NS
Changes in Robson 5a CS rate	Decrease pre vs. interv[c,d]	NS	NS	Decrease pre vs. post[c,d]	NS	NS
Changes in Robson 5b CS rate	NS	NS	NS	Increase pre vs. post[d]	NS	Decrease pre vs. interv[c,d]
Changes in rate of 5-min Apgar score <7	NS	Increase pre vs. post[e]	NS	NS	NS	NS
Change in maternal mortality ratio	NS	NS	NS	NS	NS	NS
Changes in perinatal mortality	NS	NS	NS	NS	NS	Decrease interv vs. post[e]

CS, cesarean section; Interv, intervention; NS, non-significant. [a]Tertiary referral hospital. [b]Overall CS rate: total number of CS/total number of deliveries. [c]Statistically significant change in mean CS rate between periods. [d]Statistically significant change in CS rate trend between periods. [e]Statistically significant change.

it is difficult to compare our results with these studies because of differences in the number of hospitals involved, level of care provided by these institutions, duration and number of components of the interventions, and the Robson groups targeted by the researchers.

While our study included six (three tertiary and three non-tertiary) hospitals, most similar studies included only one hospital and several did not provide information about its level of care [20–24, 26–28]. In theory, concentrating efforts to reduce CS rates in only one hospital could be more effective. Piffer et al. [25] described the use of the Robson classification for audit and feedback in seven Italian maternity hospitals, but did not provide information on the type of population managed in these institutions. This information is important because the hospital's level of care is one of the factors that influence CS rates in Robson groups 1 and 3, and could explain the variability in overall CS rates between different hospitals [29]. Indeed, in the pre-intervention period, our three tertiary hospitals (H1, H2, H6) had the highest CS rates in Robson groups 1 and 3, and two of these hospitals (H1, H6) also had the highest overall CS rates in this period. Although several studies used the Robson classification for audit and feedback to reduce CS rates [23–28], the interventions differed substantially. Differently from our study, most similar studies created bundles mainly targeted at doctors and midwives directly involved in intrapartum care [20–28]. While our study tested an intervention with six components, one of which was audit and feedback using the Robsons classification, some studies included only the Robson audit and feedback component [24, 27], several studies included two to five components [20–22, 28], and three studies included seven or more components [23, 25, 26]. The duration of our intervention (six months) was shorter than most similar studies [21, 22, 24–28]. We monitored the effects of the intervention on overall CS rates and on CS rates in Robson groups 1, 2, 3, 4, and 5, as these five groups represent over 70 % of the obstetric population managed in all maternity hospitals [30]. Several studies [21, 22, 24, 25, 28] evaluated the effects of their interventions on overall CS rates, while others monitored only Robson groups 1 and/or 2 [20, 26, 27], and one study (23) monitored Robson groups 1, 2, 3 and 4 combined.

Several factors could explain why overall CS rates did not decrease significantly in our six hospitals. First, the selection of the participating hospitals, design of the intervention, and decision to implement it were made by the investigators and municipal health department authorities, without the involvement of the hospital directors and obstetric coordinators. Moreover, we did not conduct prior formative research in each hospital. Formative research before designing interventions to reduce CS rates allows local adaptation/modification of the components of the intervention according to the unique characteristics and workplace culture of each hospital [6]. It is well known that health professionals may not understand the value of proposed interventions, and be reluctant to change obstetric practices [6]. Lack of training, skills, or experience are the main barriers to changing health professionals' behavior to reduce CS rates [31]. The selection of intervention components may also have contributed to its limited success. Finally, it is probable that the relatively short duration of the intervention (six months) may also have contributed to the study results. The duration of interventions in studies reporting significant reductions in CS overall rates ranged from nine months [24] to 10 years [26].

This was the first study involving several public hospitals in a large Brazilian city to test the Robson classification as an

audit and feedback tool in an intervention to reduce CS rates. A strength of the study was the use methodology recommended for interrupted time series, including analyses of CS rates at 30 time points. This type of analysis is appropriate for evaluating the effect of interventions in non-experimental longitudinal studies [32]. It is being increasingly used in evaluating public health studies because it is adequate to assess interventions used for clearly defined periods of time that assess health outcomes at the population level [33].

The main study limitations were the lack of formative research, short duration of the intervention, lack of patient level data (such as CS indications), and lack of monitoring of the adherence of hospitals to the clinical guidelines provided, and to the mentoring process. Additionally, since all components of the multifaceted intervention were implemented simultaneously, we could not assess the impact of each component on the outcomes. Finally, despite acknowledging the importance of this information [34], we did not use the Robson classification to identify the groups that contributed the most to the overall CS rate in each hospital and create interventions targeting these specific groups. This decision was taken because of the lack resources to create and implement different intervention bundles for each of the hospitals.

Future studies should address the aforementioned limitations and consider the possibility of including specific clinical interventions to improve the management of labor and safely reduce CS rates such as the use of intrapartum ultrasound [35], and training healthcare providers on the physiological interpretation of intrapartum cardiotocography [36].

Conclusions

A multifaceted intervention including the Robson classification as an audit and feedback tool did not significantly reduce overall CS rates in six public hospitals. However, five of the six hospitals had significant reductions in CS rates in at least one of the Robson groups without increasing adverse maternal or perinatal outcomes.

Research ethics: Our investigations were carried out following the rules of the Declaration of Helsinki of 1975, revised in 2013. This study was approved by the Ethics Committee for Research of Federal University of São Paulo (1.814.4.257).

Informed consent: All women were informed about the study and signed the Informed Consent Form.

Author contributions: Conceptualization, MRT, AKA; methodology, EB; validation, ERC, MF; formal analysis, EAJ; investigation, MNO; resources, NS; data curation, AJSG; writing—original draft preparation, AJSG; writing—review and editing, EAJ and MRT; visualization, MRT, AKA, EB, ERC, MF, EAJ, MNO, NS, AJSG; supervision, NS; project administration, MRT. All authors have read and agreed to the published version of the manuscript.

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References

1. Betran AP, Ye J, Moller AB, Souza JP, Zhang J. Trends and projections of caesarean section rates: global and regional estimates. BMJ Glob Health 2021;6:e005671.
2. Stoll K, Edmonds JK, Hall WA. Fear of childbirth and preference for cesarean delivery among young American women before childbirth: a survey study. Birth 2015;42:270–6.
3. Gamble JA, Creedy DK. Women's preference for a cesarean section: incidence and associated factors. Birth 2001;28:101–10.
4. Faisal-Cury A, Menezes PR. Factors associated with preference for cesarean delivery. Rev Saude Publica 2006;40:226–32.
5. Elaraby S, Altieri E, Downe S, Erdman J, Mannava S, Moncrieff G, et al. Behavioural factors associated with fear of litigation as a driver for the increased use of caesarean sections: a scoping review. BMJ Open 2023; 13:e070454.
6. World Health Organization. WHO recommendations on non-clinical interventions to reduce unnecessary caesarean sections [Internet]. Geneva: World Health Organization; 2018. Available from: https://www.ncbi.nlm.nih.gov/books/NBK532672/pdf/Bookshelf_NBK532672.pdf [cited Sep 27 2021].
7. Victora CG, Barros FC. Beware: unnecessary caesarean sections may be hazardous. Lancet 2006;367:1796–7.
8. Souza JP, Gulmezoglu A, Lumbiganon P, Laopaiboon M, Carroli G, Fawole B, et al. Caesarean section without medical indications is associated with an increased risk of adverse short-term maternal outcomes: the 2004–2008 WHO Global Survey on Maternal and Perinatal Health. BMC Med 2010;8:71.
9. Keag OE, Norman JE, Stock SJ. Long-term risks and benefits associated with cesarean delivery for mother, baby, and subsequent pregnancies: systematic review and meta-analysis. PLoS Med 2018; 15:e1002494.
10. Papathoma E, Triga M, Fouzas S, Dimitriou G. Cesarean section delivery and development of food allergy and atopic dermatitis in early childhood. Pediatr Allergy Immunol 2016;27:419–24.
11. Lumbiganon P, Laopaiboon M, Gulmezoglu AM, Souza JP, Taneepanichskul S, Ruyan P, et al. Method of delivery and pregnancy outcomes in Asia: the WHO global survey on maternal and perinatal health 2007–08. Lancet 2010;375:490–9.
12. Kuhle S, Tong OS, Woolcott CG. Association between caesarean section and childhood obesity: a systematic review and meta-analysis. Obes Rev 2015;16:295–303.
13. Sobhy S, Arroyo-Manzano D, Murugesu N, Karthikeyan G, Kumar V, Kaur I, et al. Maternal and perinatal mortality and complications associated with

caesarean section in low-income and middle-income countries: a systematic review and meta-analysis. Lancet 2019;393:1973–82.
14. Torjesen I. Caesarean section is highly risky for mothers and babies in low and middle income countries. BMJ 2019;364:l1499.
15. World Health Organization. WHO statement on caesarean section rates [Internet]. Geneva: World Health Organization; 2015. Available from: http://apps.who.int/iris/bitstream/handle/10665/161442/WHO_RHR_15.02_eng.pdf?sequence=1 [cited Sep 27 2021].
16. Brown HC, Paranjothy S, Dowswell T, Thomas J. Package of care for active management in labour for reducing caesarean section rates in low-risk women. Cochrane Database Syst Rev 2013;2013: CD004907.
17. Chen I, Opiyo N, Tavender E, Mortazhejri S, Rader T, Petkovic J, et al. Non-clinical interventions for reducing unnecessary caesarean section. Cochrane Database Syst Rev 2018;9:CD005528.
18. Chaillet N, Dumont A. Evidence-based strategies for reducing cesarean section rates: a meta-analysis. Birth 2007;34:53–64.
19. Boatin AA, Cullinane F, Torloni MR, Betran AP. Audit and feedback using the Robson classification to reduce caesarean section rates: a systematic review. BJOG 2018;125:36–42.
20. Crosby DA, Vallejo N, Lachman P, Mullally A, Sheehan S. Reducing the caesarean section rate in nulliparous spontaneous labour: a multidisciplinary institutional approach. Eur J Obstet Gynecol Reprod Biol 2020;244:207–8.
21. Kempe P, Vikstrom-Bolin M. The continuous audit of events and outcomes of labour and birth using the Ten Group Classification System and its role in quality improvement. Eur J Obstet Gynecol Reprod Biol 2019;237:181–8.
22. Pinto P, Crispin-Milart PH, Rojo E, Adiego B. Impact of clinical audits on cesarean section rate in a Spanish hospital: analysis of 6 year data according to the Robson classification. Eur J Obstet Gynecol Reprod Biol 2020;254:308–14.
23. Svelato A, Meroni MG, Poli M, Perino A, Spinoso R, Ragusa A. How to reduce caesarean sections in first four Robson's classes [abstract]. BJOG 2014;121:91.
24. Scarella A, Chamy V, Sepulveda M, Belizan JM. Medical audit using the Ten Group Classification System and its impact on the cesarean section rate. Eur J Obstet Gynecol Reprod Biol 2011;154:136–40.
25. Piffer SPF, Tenaglia F, Paoli A, Nicolodi F, Luewink A. The Robson ten group classification of cesarean section in 7 alpine maternity units in an homogenous area. Eur J Epidemiol 2012;27:S122–3.
26. Blomberg M. Avoiding the first cesarean section–results of structured organizational and cultural changes. Acta Obstet Gynecol Scand 2016; 95:580–6.
27. Aguiar RA, Gaspar J, Reis ZS, Santos Junior MR, Corrêa Junior MD. Implementation of the caesarean births review using the ten group Robson's Classification and its immediate effects on the rate of caesareans, at a university hospital. In: Poster presented at: the international congress birth: clinical challenges in labor and delivery. Fortaleza: Fortaleza; 2015.
28. Maneschi F, Algieri M, Perrone S, Nale R, Sarno M. Cesarean 10-group classification: a tool for clinical management of the delivery ward. Minerva Ginecol 2015;67:389–95.
29. Gerli S, Favilli A, Franchini D, De Giorgi M, Casucci P, Parazzini F. Is the Robson's classification system burdened by obstetric pathologies, maternal characteristics and assistential levels in comparing hospitals cesarean rates? A regional analysis of class 1 and 3. J Matern Fetal Neonatal Med 2018;31:173–7.
30. World Health Organization. Robson classification: implementation manual [Internet]. Geneva: World Health Organization; 2017. Available from: https://www.who.int/reproductivehealth/publications/maternal_perinatal_health/robson-classification/en/ [cited Sep 27 2021].
31. Kingdon C, Downe S, Betran AP. Interventions targeted at health professionals to reduce unnecessary caesarean sections: a qualitative evidence synthesis. BMJ Open 2018;8:e025073.
32. Penfold RB, Zhang F. Use of interrupted time series analysis in evaluating health care quality improvements. Acad Pediatr 2013;13: S38–44.
33. Bernal JL, Cummins S, Gasparrini A. Interrupted time series regression for the evaluation of public health interventions: a tutorial. Int J Epidemiol 2017;46:348–55.
34. Triunfo S, Ferrazzani S, Lanzone A, Scambia G. Identification of obstetric targets for reducing cesarean section rate using the Robson Ten Group Classification in a tertiary level hospital. Eur J Obstet Gynecol Reprod Biol 2015;189:91–5.
35. Rizzo G, Ghi T, Henrich W, Tutschek B, Kamel R, Lees CC, et al. Ultrasound in labor: clinical practice guideline and recommendation by the WAPM-World Association of Perinatal Medicine and the PMF-Perinatal Medicine Foundation. J Perinat Med 2022;50:1007–29.
36. Chandraharan E, Pereira S, Ghi T, Gracia Perez-Bonfils A, Fieni S, Jia YJ, et al. International expert consensus statement on physiological interpretation of cardiotocograph (CTG): first revision (2024). Eur J Obstet Gynecol Reprod Biol 2024;302:346–55.

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