ORIGINAL ARTICLE

Impact of the COVID-19 Pandemic on Overall Cesarean Section Rate as Classified by the Robson Classification

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Objective: To evaluate the impact of the COVID-19 pandemic on cesarean section (CS) rates, using the Robson classification between pre-pandemic and pandemic periods at a university hospital in Thailand.

Materials and Methods: This retrospective comparative study was conducted at the Faculty of Medicine Vajira Hospital, Navamindradhiraj University, Bangkok, Thailand. Data were collected from pregnant women who delivered during the pre-COVID-19 period (October 2018 to September 2019) and the COVID-19 period (October 2020 to September 2021). Pregnant women were classified into 10 groups according to the Robson classification. Maternal demographics, obstetric data, and neonatal outcomes were extracted from electronic medical records. Chi-squared and t-tests were used for statistical comparisons, with a $p<0.05$ considered significant.

Results: The present study included 3,649 women, 2,002 in the pre-pandemic group and 1,647 in the pandemic group. The overall CS rate remained stable (37.56% vs. 36.49%, p=0.505). Robson groups 5a, 1, 2b remained the most prevalent group contributing to the overall CS rate, and groups 2b, 4b, 5b, and 9 had 100% CS rates in both periods. However, significant shifts in the onset of labor were observed: spontaneous labor decreased (78.7% vs. 72.6%, p<0.0001), while induced labor (5.0% vs. 8.2%, p=0.0001) and pre-labor CS (16.3% vs. 19.2%, p=0.0235) increased during the pandemic.

Conclusion: While the COVID-19 pandemic did not significantly impact overall CS rates, which remained above WHO recommendations and with a relatively stable distribution of cases within the Robson classification groups, it was associated with significant shifts in labor onset. Notably, spontaneous labor decreased while induced and pre-labor CS increased.

Keywords: COVID-19; Cesarean section; Robson classification; Onset of labor; Pandemic; Pregnancy; Thailand

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Cesarean section (CS) is a crucial obstetric procedure which could reduce maternal and fetal morbidity and mortality in many situations, such as prolonged labor, fetal distress, placenta previa, etc[1]. Although it can be life-saving under certain circumstances, it is important to avoid overuse of the procedure. Unnecessary CS can increase the risks for mothers and babies, including complications during the procedure, longer recovery times, and potential issues in subsequent pregnancies[2-4]. Despite its potential risks, there has been a significant increase in the CS rates across many developed and developing countries worldwide. Because of the potential implications for maternal and neonatal health, this trend has raised concerns among healthcare professionals, policy makers, and public health experts.

In 1985, the World Health Organization (WHO) convened a conference and recommended that the optimal rate for CS should be between 10% and 15%. The organization recommended using the Robson classification system to compare CS rates. This system categorizes pregnant women into 10 groups based on six key parameters: parity, previous CS, onset of labor, number of fetuses, gestational age, and fetal lie and presentation[5]. A study conducted in 2020 in Thailand reported an overall CS rate of 48.86%. By using the Robson classification; group 5, group 1, and group 2 were the top three contributors to overall cesarean deliveries (28.91%, 23.71%, 17.65%, respectively[6]. This high incidence of CS suggested a significant overuse of the procedure in Thailand, which could have implications for maternal and neonatal health outcomes, healthcare costs, and healthcare system resources.

The emergence of the COVID-19 pandemic brought significant challenges to healthcare systems worldwide,

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including obstetric care. Pregnant women, like the general population, faced the risk of COVID-19 infection and its potential complications[7]. Studies on COVID-19 infections in pregnant women have indicated that most cases were either asymptomatic or presented with mild symptoms[8]. Several studies[9] reported a higher rate of CS among pregnant women with COVID-19 compared with uninfected pregnancies. However, the reasons behind this higher rate have not been thoroughly explored, whether it is directly related to obstetric factors influenced by the infection or related to other factors.

To address this gap in knowledge, we conducted this study with the aim to compare overall CS rates and CS rate as classified by Robson classification before and during the COVID-19 pandemic. This approach allowed us to analyze CS rates across different Robson groups, thereby identifying variations in CS utilization based on various obstetric characteristics such as parity, previous CS, onset of labor, and fetal presentation.

Materials and Methods

This was a retrospective study conducted at the Faculty of Medicine Vajira Hospital, Navamindradhiraj University, Bangkok, Thailand. The institutional review board approved the study (No. 043/2565), and the study adhered to the principles outlined in the Declaration of Helsinki.

The study population included pregnant women who delivered at the authors' institution during two distinct periods: the pre-COVID-19 period (October 2018 to September 2019) and the COVID-19 period (October 2020 to September 2021).

The sample size for comparing proportions was calculated using the following formula:

$$n = (Z\alpha/2+Z\beta)^2 * (p1(1-p1)+p2(1-p2)) / (p1-p2)^2$$

To estimate with a level of significance of 0.05 and power of 90% where the CS rates were based on the pilot investigation of 200 women who delivered from October to November 2017 (pre-COVID-19 pandemic) and 200 women who delivered from October to November 2020 (during the COVID-19 pandemic), showing CS rates of 31% and 40%, respectively, the required sample size were at least 589 for each group. To capture the full spectrum of seasonal variations and potential fluctuations in cesarean section rates throughout the year, data collection was extended to include all births within a 12-month period.

Data comprising maternal demographic characteristics, history of COVID-19 infection, obstetric details (including the mode of delivery and indication for cesarean section [CS]), and neonatal outcomes were extracted from the electronic medical records. Pregnant women were categorized into 10 groups according to the Robson classification (Table 1). The outcome measures were the overall CS rates before and during the COVID-19 pandemic, and the CS rates for each Robson group, elucidating their respective contributions to the overall CS rate.

Qualitative data were reported as frequencies and percentages. Quantitative data were reported as means and standard deviations or medians and interquartile ranges. Chi-squared test and t-tests were used for statistical comparison. All statistical tests were performed at a significance $p<0.05$. Data were analyzed using IBM SPSS® Statistics for Windows 28 (IBM Corp. Released 2021. IBM SPSS Statistics for Windows, version 28.0. Armonk, NY: IBM Corp).

Table 1. Robson Classification with subdivisions

Group	Obstetric Population
1	Nulliparous women with a single cephalic pregnancy, ≥37 weeks gestation in spontaneous labour
2	Nulliparous women with a single cephalic pregnancy, ≥37 weeks gestation who had labour induced or were delivered by CS before labour
2a	Labour induced
2b	Pre-labour CS
3	Multiparous women without a previous CS, with a single cephalic pregnancy, ≥37 weeks gestation in spontaneous labour
4	Multiparous women without a previous CS, with a single cephalic pregnancy, ≥37 weeks gestation who had labour induced or were delivered by CS before labour
4a	Labour induced
4b	Pre-labour CS
5	All multiparous women with at least one previous CS, with a single cephalic pregnancy, ≥37 weeks gestation
5a	With one previous CS
5b	With two or more previous CSs
6	All nulliparous women with a single breech pregnancy
7	All multiparous women with a single breech pregnancy including women with previous CS(s)
8	All women with multiple pregnancies including women with previous CS(s)
9	All women with a single pregnancy with a transverse or oblique lie, including women with previous CS(s)
10	All women with a single cephalic pregnancy < 37 weeks gestation, including women with previous CS(s)

Results

During the study period, deliveries from 3,733 pregnant women were recorded at the authors' institution. Of these, 84 were excluded due to incomplete medical records. Consequently, 3,649 women were included in the present study, with 2,002 in the pre-COVID-19 pandemic group and 1,647 in the COVID-19 pandemic group. The cesarean section (CS) rates were 37.56% (95% CI: 35.49, 39.63) before the pandemic and 36.49% (95% CI: 34.16, 38.82) during the pandemic. The difference in CS rates between the pre-pandemic and pandemic periods was 1.07% (95% CI: -2.08, 4.22; p=0.505).

According to the Robson classification (Table 2), most pregnant women before the COVID-19 pandemic belonged to group 3 (33.87%), group 1 (31.77%), and group 10 (9.24%), respectively. The top three groups contributing to the overall CS rate before the COVID-19 pandemic were classified as group 5a (23.40%), group 1 (21.81%), and group 2b (9.57%).

While during the COVID-19 pandemic, group 3 had the highest proportion of pregnant women (32.91%), followed by groups 1 (28.17%) and 10 (9.11%). Also, the top three Robson groups contributing to the overall CS rate were group 5a (22.13%), group 1 (18.64%), and group 2b (16.64%), which correspond to the trends before the COVID-19 pandemic.

In addition, group 2b, 4b, 5b, and 9 comprised the highest CS rates (100%) in both periods. Analysis of characteristics based on Robson classification revealed statistically significant shifts in the onset of labor between the non-COVID-19 and COVID-19 periods. Notably, the proportion of spontaneous labor decreased significantly during the pandemic to 72.6%, from 78.7% before the pandemic, representing a difference of 6.1% (95% CI: 3.3, 8.9; p<0.0001). Conversely, rates of both induced labor and pre-labor cesarean sections (no labor) increased significantly during the pandemic. Induced labor rose from 5.0% to 8.2% (difference: 3.2%; 95% CI: 1.6, 4.8; p=0.0001), while pre-labor cesarean sections increased from 16.3% to 19.2% (difference: 2.9%; 95% CI: 0.4, 5.4; p=0.0235) (Table 3). Furthermore, examination of subgroups revealed that within the vaginal delivery group, the rate of induced labor was also significant higher during the pandemic (difference: 4.4%; 95% CI: 2.3, 6.5; p<0.0001). Also, the cesarean delivery group exhibited a significant higher rate of no labor (pre-labor CS) during the pandemic compared to the pre-pandemic period (difference: 9.0%; 95% CI: 3.7, 14.3; p=0.001). There were no statistically significant difference in parity, rate of previous CS, number of fetuses, gestational age, and fetal lie and presentation between the two groups.

Maternal characteristics between pre-pandemic (non-COVID-19) and pandemic (COVID-19) periods

Table 2. Cesarean section rate before and during the COVID-19 pandemic period classified by Robson classification

Group	Number of CS in group		Number of women in group		Group size (%)		Group CS rate (%)		Absolute group contribution to overall CS rate (%)		Relative contribution of group to overall CS rate (%)	
	Before COVID-19	During COVID-19	Before COVID-19	During COVID-19	Before COVID-19	During COVID-19	Before COVID-19	During COVID-19	Before COVID-19	During COVID-19	Before COVID-19	During COVID-19
1	164	112	636	464	31.77	28.17	25.79	24.14	8.19	6.80	21.81	18.64
2a	25	31	51	68	2.55	4.13	49.02	45.59	1.25	1.88	3.32	5.16
2b	72	100	72	100	3.60	6.07	100.00	100.00	3.60	6.07	9.57	16.64
3	71	40	678	542	33.87	32.91	10.47	7.38	3.55	2.43	9.44	6.66
4a	13	4	38	55	1.90	3.34	34.21	7.27	0.65	0.24	1.73	0.67
4b	41	19	41	19	2.05	1.15	100.00	100.00	2.05	1.15	5.45	3.16
5a	176	133	178	135	8.89	8.20	98.88	98.52	8.79	8.08	23.40	22.13
5b	30	24	30	24	1.50	1.46	100.00	100.00	1.50	1.46	3.99	3.99
6	31	26	32	26	1.60	1.58	96.88	100.00	1.55	1.58	4.12	4.33
7	25	26	26	26	1.30	1.58	96.15	100.00	1.25	1.58	3.32	4.33
8	21	21	23	24	1.15	1.46	91.30	87.50	1.05	1.28	2.79	3.49
9	12	14	12	14	0.60	0.85	100.00	100.00	0.60	0.85	1.60	2.33
10	71	51	185	150	9.24	9.11	38.38	34.00	3.55	3.10	9.44	8.49
Total	752	601	2002	1647	100.0	100.0			37.56	36.49	100.00	100.00

Table 3. Characteristics based on Robson classification

Characteristics	Total					Vaginal delivery					Cesarean delivery				
	Before COVID-19 pandemic		COVID-19 pandemic		p-value	Before COVID-19 pandemic		COVID-19 pandemic		p-value	Before COVID-19 pandemic		COVID-19 pandemic		p-value
	n	(%)	n	(%)		n	(%)	n	(%)		n	(%)	n	(%)	
Parity															
Nullipara	884	(44.2)	747	(45.4)	0.468	558	(44.6)	443	(42.4)	0.271	326	(43.4)	304	(50.6)	0.008
Multipara	1,118	(55.8)	900	(54.6)		692	(55.4)	603	(57.6)		426	(56.6)	297	(49.4)	
Previous CS															
Yes	261	(13.0)	190	(11.5)	0.170	3	(0.2)	3	(0.3)	1.000	258	(34.3)	187	(31.1)	0.214
No	1,741	(87.0)	1,457	(88.5)		1,247	(99.8)	1,043	(99.7)		494	(65.7)	414	(68.9)	
Onset of labor															
Spontaneous	1,577	(78.8)	1,198	(72.7)	<0.001	1,189	(95.1)	949	(90.7)	<0.001	388	(51.6)	249	(41.4)	<0.001
Induced	100	(5.0)	135	(8.2)		61	(4.9)	97	(9.3)		39	(5.2)	38	(6.3)	
No labor (pre-labor CS)	325	(16.2)	314	(19.1)		0	(0.0)	0	(0.0)		325	(43.2)	314	(52.2)	
Number of fetuses															
Singleton	1,983	(99.1)	1,623	(98.5)	0.157	1,248	(99.8)	1,043	(99.7)	0.665	735	(97.7)	580	(96.5)	0.172
Multiple	19	(0.9)	24	(1.5)		2	(0.2)	3	(0.3)		17	(2.3)	21	(3.5)	
Gestational age															
Preterm (<37 weeks)	244	(12.2)	195	(11.8)	0.748	133	(10.6)	108	(10.3)	0.806	111	(14.8)	87	(14.5)	0.883
Term (37 weeks or more)	1,758	(87.8)	1,452	(88.2)		1,117	(89.4)	938	(89.7)		641	(85.2)	514	(85.5)	
Fetal lie and presentation															
Cephalic	1,920	(95.9)	1,571	(95.4)	0.606	1,242	(99.4)	1,044	(99.8)	0.122	678	(90.2)	527	(87.7)	0.319
Breech	70	(3.5)	62	(3.8)		8	(0.6)	2	(0.2)		62	(8.2)	60	(10.0)	
Transverse lie	12	(0.6)	14	(0.9)		0	(0.0)	0	(0.0)		12	(1.6)	14	(2.3)	

Table 4. Baseline characteristics and detailed analysis of pregnant women before and during the COVID-19 period

Characteristics	Total		Vaginal delivery		Cesarean delivery	
	Before COVID-19	During COVID-19	Before COVID-19	During COVID-19	Before COVID-19	During COVID-19
	n=2,002	n=1,647	n=1,250	n=1,046	n=752	n=601
Age (year)	27.33±6.89	28.05±6.24	26.09±6.64	27.07±6.20	29.38±6.81	29.76±5.93
<20	278 (13.9)	146 (8.9)	217 (17.4)	115 (11.0)	61 (8.1)	31 (5.2)
20 to 34	1,375 (68.7)	1,216 (73.8)	879 (70.3)	781 (74.7)	496 (66.0)	435 (72.4)
>34	349 (17.4)	285 (17.3)	154 (12.3)	150 (14.3)	195 (25.9)	135 (22.5)
BMI (kg/m^2)	27.44±5.06	27.96±5.02	26.80±4.73	27.28±4.77	28.50±5.42	29.14±5.22
<25	685 (34.2)	497 (30.2)	489 (39.1)	370 (35.4)	196 (26.1)	127 (21.1)
25 to 29	784 (39.2)	647 (39.3)	478 (38.2)	411 (39.3)	306 (40.7)	236 (39.3)
30 to 34	379 (18.9)	364 (22.1)	214 (17.1)	199 (19)	165 (21.9)	165 (27.5)
35 to 39	109 (5.4)	98 (6.0)	52 (4.2)	49 (4.7)	57 (7.6)	49 (8.2)
>40	45 (2.2)	41 (2.5)	17 (1.4)	17 (1.6)	28 (3.7)	24 (4.0)
Covid-19 infection						
Non-covid infection	-	1,615 (98.1)	-	1,038 (99.2)	-	577 (96.0)
Infection with no symptom	-	22 (1.3)	-	8 (0.8)	-	14 (2.3)
Infection with mild symptom	-	4 (0.2)	-	0 (0.0)	-	4 (0.7)
Infection with pneumonia	-	6 (0.4)	-	0 (0.0)	-	6 (1.0)
Maternal condition						
Pregnancy induced hypertension	9 (0.4)	35 (2.1)	4 (0.3)	23 (2.2)	5 (0.7)	12 (2.0)
Preeclampsia	90 (4.5)	53 (4.5)	44 (3.5)	22 (2.1)	46 (6.1)	31 (5.2)
Gestational diabetes mellitus	210 (10.5)	163 (9.9)	101 (8.1)	88 (8.4)	109 (14.5)	75 (12.5)
Overt DM	7 (0.3)	6 (0.4)	1 (0.1)	1 (0.1)	6 (0.8)	5 (0.8)
Other medical conditions	38 (1.9)	52 (3.2)	23 (1.8)	36 (3.4)	15 (2.0)	16 (2.7)
More than 1	16 (0.8)	27 (1.6)	4 (0.3)	11 (1.1)	12 (1.6)	16 (2.7)
Indication for CS						
Cephalopelvic disproportion	191 (9.5)	151 (9.2)	-	-	191 (25.4)	151 (25.1)
Fetal non-reassuring status	114 (5.7)	50 (3)	-	-	114 (15.2)	50 (8.3)
Previous cs	261 (13)	176 (10.7)	-	-	261 (34.7)	176 (29.3)
Maternal request	35 (1.7)	41 (2.5)	-	-	35 (4.7)	41 (6.8)
Twin	14 (0.7)	17 (1)	-	-	14 (1.9)	17 (2.8)
Breech	42 (2.1)	51 (3.1)	-	-	42 (5.6)	51 (8.5)
Others/not specified	87 (4.3)	88 (5.3)	-	-	87 (11.6)	88 (14.6)
COVID-19 infection	-	24 (1.5)	-	-	-	24 (4.0)
Postpartum hemorrhage	40 (2.0)	33 (2.0)	9 (0.7)	5 (0.5)	31 (4.1)	28 (4.1)

were presented in Table 4. In both the pre-pandemic and pandemic periods, women undergoing cesarean delivery were significantly older (non-COVID-19: 29.38±6.81 vs. 26.09±6.64 years, p<0.001; COVID-19: 29.78±5.99 vs. 27.12±6.07 years, p<0.001) and had higher BMIs (non-COVID-19: 28.51±5.42 vs. 26.80±4.73 kg/m^2, p<0.001; COVID-19: 29.05±5.06 vs. 27.27±4.82 kg/m^2, p<0.001) compared to those delivering vaginally.

Maternal conditions such as preeclampsia (non-COVID-19: 6.1% vs. 3.5%, p=0.003; COVID-19: 5.2% vs. 2.1%, p<0.001), gestational diabetes, overt diabetes mellitus, and multiple comorbidities were significantly more prevalent in the cesarean delivery subgroup in both periods. Notably, the overall prevalence of preeclampsia decreased significantly during the COVID-19 pandemic compared to the pre-pandemic period (3.2% vs. 4.5%, p=0.041).

In both periods, the most common indication for cesarean delivery was previous cesarean section (pre-pandemic: 34.7%; COVID-19: 29.3%), followed by cephalopelvic disproportion (pre-pandemic: 25.4%; COVID-19: 25.1%).

During the COVID-19 pandemic period, 32 (1.9%) of the 1647 pregnant women were reported as infected with COVID-19. Among those who underwent cesarean delivery, COVID-19 infection was listed as an indication for the procedure in 24 cases (4.0% of all CS). Of these, 14 were asymptomatic carriers (2.3% of all CS) and 10 had symptomatic infection (1.7% of all CS).

Table 5. Neonatal outcome

Characteristics	Total			Vaginal delivery			Cesarean delivery		
	Before COVID-19 pandemic	During COVID-19 pandemic	p-value	Before COVID-19 pandemic	COVID-19 pandemic	p-value	Before COVID-19 pandemic	COVID-19 pandemic	p-value
	n (%)	n (%)		n (%)	n (%)		n (%)	n (%)	
Fetal birth weight (gram)									
<2,000	88 (4.4)	72 (4.3)	0.701	41 (3.3)	31 (3.0)	0.326	47 (6.1)	41 (6.6)	0.357
2,000 to 2,499	153 (7.6)	148 (8.9)		89 (7.1)	84 (8.0)		64 (8.3)	64 (10.3)	
2,500 to 2,999	734 (36.4)	592 (35.4)		476 (38.0)	383 (36.5)		258 (33.6)	209 (33.6)	
3,000 to 3,499	785 (38.9)	640 (38.3)		512 (40.9)	412 (39.3)		273 (35.6)	228 (36.7)	
>3,500	259 (12.8)	219 (13.1)		134 (10.7)	139 (13.3)		125 (16.3)	80 (12.9)	
Fetal APGAR score									
At 1 min									
<7	98 (4.9)	65 (3.9)	0.156	36 (2.9)	27 (2.6)	0.659	62 (8.1)	38 (6.1)	0.157
7 to 10	1,921 (95.1)	1,606 (96.1)		1,216 (97.1)	1,022 (97.4)		705 (91.9)	584 (93.9)	
At 5 min									
<7	25 (1.2)	23 (1.4)	0.712	17 (1.4)	12 (1.1)	0.647	8 (1.0)	11 (1.8)	0.247
7 to 10	1,994 (98.8)	1,648 (98.6)		1,235 (98.6)	1,037 (98.9)		759 (99)	611 (98.2)	
Fetal complication									
Birth asphyxia	87 (4.3)	58 (3.5)	0.011	29 (2.3)	20 (1.9)	0.178	58 (7.6)	38 (6.1)	0.019
Birth trauma	17 (0.8)	7 (0.4)		17 (1.4)	7 (0.7)		0 (0.0)	0 (0.0)	
Stillbirth	12 (0.6)	11 (0.7)		11 (0.9)	9 (0.9)		1 (0.1)	2 (0.3)	
Others/not specified	20 (1.0)	37 (2.2)		18 (1.4)	26 (2.5)		2 (0.3)	11 (1.8)	
ICU admission	69 (3.4)	43 (2.6)	0.137	30 (2.4)	14 (1.3)	0.064	39 (5.1)	29 (4.7)	0.717

Analysis of neonatal outcomes revealed minimal statistically significant differences between the non-COVID-19 and COVID-19 periods (Table 5). Significant differences were observed when comparing vaginal and cesarean deliveries within each period. In both the non-COVID-19 and COVID-19 periods, cesarean delivery was associated with a significantly higher proportion of infants with birth weight <2,000g and 2,000 to 2,499 g, lower Apgar scores at 1 minute, and higher rates of birth asphyxia and ICU admission ($p<0.001$).

Discussion

This retrospective study, conducted at the Faculty of Medicine of Vajira Hospital, Navamindradhiraj University, aimed to evaluate the impact of the COVID-19 pandemic on cesarean section (CS) rates, maternal characteristics, and neonatal outcomes. By comparing data from a pre-pandemic period (October 2018 to September 2019) to a period during the pandemic (October 2020 to September 2021), we found that while the overall CS rate remained relatively stable (37.56% vs. 36.49%, $p=0.505$), significant shifts occurred in the onset of labor and indications for CS, along with subtle changes in maternal characteristics. These rates are notably higher than those reported in previous studies conducted before the COVID-19 pandemic in Malaysian tertiary hospitals, a tertiary hospital in Portugal, and a University Hospital in Spain, where overall CS rates were 19%, 25%, and 25% respectively[10-12], and they are approximately three times higher than the optimal rate of 10 to 15% recommended by the WHO. This aligns with a concerning trend of increasing CS rates in Thailand, which rose from 23.2% in 2009 to 32.5% in 2017 and is projected to potentially reach 59.1% by 2030 if the trend continues[13]. These findings emphasize the importance of carefully planning and choosing the most appropriate delivery route, as CS, when not medically indicated, can increase the risk of maternal complications, including surgical wound infection, increased blood loss, surgical and anesthetic complications, hysterectomy, and even maternal death, as well as a significantly increased risk of newborn death[14-17].

Consistent with previous reports, the most prevalent Robson classification groups in both periods were Group 3 (multiparous, single cephalic, ≥37 weeks, spontaneous labor), Group 1 (nulliparous, single cephalic, ≥37 weeks, spontaneous labor), and Group 10 (all preterm single cephalic <37 weeks). Similarly, Groups 5a (multipara with at least one previous CS, single cephalic, ≥37 weeks), Group 1, and Group 2b (nulliparous, single cephalic, ≥37 weeks, induced labor or pre-labor CS, one or more previous CS) consistently contributed the most to the overall CS rate, which is consistent with other studies in the pre-COVID-19 era that have shown that the CS rate is rising, largely

attributed to groups 5 and 1[18]. These findings highlight the enduring importance of previous CS, fetal presentation, and parity as major factors influencing CS rates, irrespective of the pandemic. Also, the highest CS rate are from the group with specific indications for CS (previous CS, breech, etc.) in both periods.

The present study notably revealed the significant change in the onset of labor during the pandemic. The proportion of spontaneous labor decreased significantly, while induced labor and pre-labor CS rates increased. This change was also evident within the vaginal and cesarean delivery subgroups. Specifically, the vaginal delivery group experienced a higher rate of induced labor, and the cesarean delivery group had a higher rate of pre-labor CS during the pandemic. These changes may reflect a shift in clinical practice during the pandemic, potentially driven by a desire to control the timing of delivery, minimize hospital stays, or mitigate perceived risks associated with prolonged labor in the context of COVID-19, especially considering the hospital's policy consideration of induction of labor in pregnant women with a gestation of 38 weeks or more to reduce the number of patients requiring emergency delivery. However, further investigation is needed to clarify the specific factors contributing to these trends. The lack of statistically significant differences in other characteristics such as parity, previous CS, number of fetuses, gestational age and fetal presentation between two groups suggests that the observed changes in the onset of labor are unlikely to be attributed to the baseline difference in the characteristic of the population.

Analysis of maternal characteristics revealed that women undergoing cesarean delivery were significantly older and had higher BMIs than those delivering vaginally, a finding consistent across both periods. This aligns with established risk factors for CS. Interestingly, while the overall prevalence of preeclampsia decreased during the pandemic, it remained significantly more prevalent in the cesarean delivery subgroup, as did gestational diabetes, overt diabetes, and multiple comorbidities. The lower rate of preeclampsia during the pandemic could be attributed to changes in healthcare access, antenatal care practices, or even diagnostic criteria during this period.

In both periods, the most recorded indications for CS were previous CS and cephalopelvic disproportion, reflecting common obstetrical challenges. The high prevalence of previous CS as an indication (34.7% pre-pandemic and 29.3% during the pandemic) further emphasizes the need for strategies to reduce primary CS rates especially in terms of appropriate antepartum and intrapartum planning. Notably, during the pandemic, 1.9% of pregnant women were infected with COVID-19, and in 4.0% of all CS, COVID-19 infection was listed as an indication, with a mix of asymptomatic and symptomatic cases. Although the hospital's policy during the COVID-19 pandemic that encouraged CSs in infected pregnant women, the overall CS rate remained the same. The impact of COVID-19 infection on maternal and neonatal outcomes requires further investigation, particularly regarding the severity of infection, gestational age at infection, and long-term effects. While some studies suggest that the mode of delivery for pregnant women infected with COVID-19 should be based on obstetric conditions[19], concerns about potential vertical transmission of COVID-19 during vaginal delivery may influence healthcare providers to prefer CS in some cases[20]. The decision should be made on a case-by-case basis, weighing the individual risks and benefits.

Analysis of neonatal outcomes revealed minimal statistically significant differences between the two periods. As expected, cesarean delivery was associated with a higher proportion of infants with lower birth weight, lower Apgar scores, and higher rates of birth asphyxia and ICU admission compared to vaginal delivery, irrespective of the pandemic. These differences likely reflect the underlying indications for CS and the inherent risks associated with the procedure.

Strengths and limitations

The present study benefited from a relatively large sample size, enhancing the statistical power and generalizability of the findings. The use of the Robson classification system provided a standardized and detailed framework for analyzing cesarean section indications, allowing for a more nuanced understanding of the factors contributing to CS rates. Furthermore, the comparison of data from two distinct periods, pre-pandemic and during the pandemic, enabled a unique assessment of the impact of COVID-19 on delivery practices and outcomes. It is also worth noting that the data from both the pre-COVID-19 and COVID-19 groups were collected during the same months (October to September) but in different years, controlling for potential seasonal variations in delivery practices and outcomes. However, the retrospective design of this study, relying on data extracted from medical records, inherently limits the ability to establish causality between the observed changes and the COVID-19 pandemic. Additionally, the data may be subject to inaccuracies or incomplete information. The limited information available on the severity of COVID-19 infection, gestational age at infection, and specific management protocols for infected pregnant women hindered a more in-depth analysis of the impact of COVID-19 on pregnancy and delivery. Moreover, the single-center nature of the study, conducted at a specific institution in Thailand, may restrict the generalizability of the findings to other populations and healthcare settings.

Conclusion

The present study found that while the overall cesarean section (CS) rate remained stable during the COVID-19 pandemic compared to the pre-pandemic period, there were significant shifts in the onset of labor, with a decrease in spontaneous labor and an increase in induced labor and pre-labor CS. These changes were also observed within vaginal and cesarean delivery subgroups. Further analysis using the Robson classification revealed that the distribution of cases within specific Robson groups remained relatively consistent, with Groups 1, 3, and 5a continuing to be the most prevalent. Maternal characteristics such as older age and higher BMI continued to be associated with CS delivery, and preeclampsia remained more prevalent in the CS subgroup, although its overall prevalence decreased during the pandemic. The most common indications for CS remained consistent, with previous CS and cephalopelvic disproportion being the most frequent. While neonatal outcomes were largely similar between the two periods, a higher rate of "Other/Not Specified" fetal complications and a lower rate of ICU admissions in the vaginal delivery subgroup during the pandemic warrant further investigation. Overall, the study suggests that the COVID-19 pandemic was associated with alterations in labor and delivery practices, potentially driven by a desire to control the timing of delivery and manage perceived risks, even though the distribution of cases according to the Robson classification did not show major shifts.

What is already known on this topic?

While the World Health Organization recommends an optimal cesarean section (CS) rate between 10 to 15%, rates are rising globally. The COVID-19 pandemic has further complicated this trend, with studies showing mixed results on its impact on overall CS rates. Some evidence suggests a tendency for pregnant individuals with COVID-19 infections to undergo cesarean sections without proper indication, potentially driven by concerns about viral transmission and altered hospital policies. However, limited evidence exists on the pandemic's impact on specific indications for CS, particularly using standardized systems like the Robson classification. Furthermore, while COVID-19 infection during pregnancy may be linked to adverse outcomes, the magnitude and nature of these risks remain under investigation.

What this study adds?

This study contributes novel insights into the impact of the COVID-19 pandemic on labor and delivery practices, specifically examining shifts in the onset of labor and indications for cesarean section (CS). By employing the Robson classification, the study quantifies changes in the distribution of CS cases across different groups during the pandemic, revealing a significant decrease in spontaneous labor and a concurrent increase in induced labor and pre-labor CS. These findings suggest that the pandemic may have prompted alterations in clinical decision-making, potentially driven by a desire to control the timing of delivery and manage perceived risks associated with COVID-19. Furthermore, the study provides valuable baseline data on CS rates and indications during the pandemic in a specific setting, which can be used for comparison with future studies investigating the ongoing impact of COVID-19 and other emerging infectious diseases on maternal and neonatal health.

Future research should explore the reasons behind the increase in induced labor and pre-labor CS during the pandemic. Collecting more detailed data on COVID-19 infection severity, gestational age at infection, treatment protocols, and long-term maternal and neonatal outcomes is crucial. Finally, multi-center studies with long-term follow-up are needed to enhance generalizability and assess the lasting impact of pandemic-related changes in delivery practices.

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Conflicts of interest

The authors declare no conflict of interest.

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