Original Article

DOI: 10.4274/anajog.galenos.2024.41861

Anat J Obstet Gynecol Res

What is an Ideal Cesarean Birth Rate? The Use of the C-Model and the Further Interpretation with the Robson Classification System, A Retrospective Analysis

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ABSTRACT

Purpose: Our aim was to evaluate the clinical implementation of the World Health Organization (WHO) recommended an optimal cesarean sections (CS) rate of 10-15%. However, this recommendation has been increasingly challeng WHO C-Model in combination with the Ten-Group Classification System (TGCS).

Methods: The data of women who gave birth between December 2019 and February 2020 was retrospectively analyzed. The over- or under-use of CS was assessed by comparing the observed CS rate and the mean estimated CS rate obtained by C-Model for each TGCS group and for the study cohort. The standardized CS ratio was calculated by the ratios between the observed CS rate and the mean estimated CS rate and between the observed CS rate and the estimated CS rate using the determined cut-off.

Results: One thousand two hundred thirty-two women were included in the study. The observed CS rate was 37.42% (n=461). The area under curve for the C- Model to predict CS was 0.952 [95% confidence interval (CI)=0.940-0.965]. The diagnostic odds ratio of the C-Model (determined based on a cut-off point of 19.6%) was 75.9 (95% CI=52.1 to 110.5, Z=22.56, p<0.0001). The standardized CS ratios between the observed CS rate (37.42%) and the estimated CS rate using the determined cut-off value (38.9%) and the mean estimated CS rate (30.5%) were 0.96 and 1.23, respectively.

Conclusion: The C-Model is a promising tool for initially assessing the balance between observed and estimated CS rates pragmatically. Combining the use of the C-Model with detailed TGCS interpretation can be helpful in dedicated clinical settings to achieve the desired CS rates that might eventually improve neonatal and maternal morbidity and mortality.

Keywords: Cesarean section rate, C-Model, Robson classification, ten-group

INTRODUCTION

Cesarean section (CS) is a life-saving operation for the mother and the baby when performed within medical indications.[1] However, its overuse can increase maternal-neonatal morbidity and mortality[2] or at least does not reduce the adverse outcomes beyond certain limits.[3] CS rates have long been a subject of global debate due to the varying outcomes associated with their overuse and underuse. In 1985, the World Health Organization (WHO) recommended an optimal CS rate of 10-15%.[4] However, this recommendation has been increasingly challenged due to differing socioeconomic contexts and evolving obstetric practices.[5,6]

The worldwide CS target rate's generalizability has already been questioned.[7,8] The optimal CS rate in large, global studies can vary based on the time frame and the socioeconomic features of included countries.[9] Institutional optimal CS rate can directly be influenced by the maternity unit's infrastructure, which includes qualifications (such as a reference center for complex cases), adequate resources, obstetric protocols, and availability of services (such as external cephalic version, vaginal birth after CS). In addition, the common obstetric profile of the targeted population including maternal age, parity, obstetric characteristics, and accompanying morbidities can affect the desired population-based CS rate. Patient safety should be the paramount goal when aiming to reduce the

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Received: 13.08.2024 **Accepted:** 25.08.2024

overuse of CS at an appropriate level.[7,8] Therefore, it is wise to keep the CS rate at a certain level with an optimal balance of maternal and perinatal outcomes.[10]

The C-Model was developed in a multi-country cross-sectional study by the WHO to provide more tailored CS rate benchmarks.[11] It utilizes the Ten-Group Classification System (TGCS) as its basis to incorporate specific maternal and fetal characteristics, as well as healthcare settings.[11,12] This approach addresses the variability in global CS rates and focuses on optimizing outcomes based on institutional and demographic factors. The use of C-Model was previously tested in a limited number of studies and was found as a valid tool in obtaining optimal CS rates for their settings.[13]

The aim of the present study was to evaluate the C-Model predictivity and clinical implementation of C-Model in combining with TGCS in a tertiary hospital.

METHODS

This retrospective observational study was conducted in a tertiary training and research hospital. The data of women who were admitted for delivery to the inpatient clinic of the maternity ward and who gave birth during three months-period between December 2019 and February 2020 were analyzed. Those who gave birth at less than 22 weeks of gestational age and those whose newborns weighed less than 500 grams at birth were excluded. Data on maternal and obstetric characteristics and outcomes were extracted from electronic medical files. The University of Health Sciences Turkey, Sancaktepe Şehit Prof. Dr. İlhan Varank Training and Research Hospital, Scientific Research Ethics Committee has approved the study (approval number: 2020/57, date: 16.12.2020). This study was conducted in accordance with the principles of the Declaration of Helsinki.

The perinatal events and outcomes were analyzed from the extracted data and the CS rates were analyzed using TGCS. The TGCS group details were reproduced with the utilization of the Robson Classification Implementation Manual[14] and therefore, the previously recorded TGCS data was not used for this study to increase the data quality and lower the missing information. The probability of delivery by CS was calculated for each woman using the WHO's C-Model online calculator (https://cmodel.fmrp.usp.br/). The over-or under-use of CS rate was assessed by comparing the observed CS rate and the mean estimated CS rate obtained by C-Model for each TGCS group.

The C-Model calculates the CS probability using some specific maternal conditions including obstetric characteristics, demographics and severity, and maternal complications domains. The relevant data for obstetric characteristics include parity, previous CS, multiple pregnancy, provider-initiated childbirth (spontaneous labor, induced or CS before labor), fetal head presentation and week of gestation. The data for demographics include maternal age, while data for severity encompass conditions requiring intensive care unit (ICU) admission or those involving significant organ dysfunction. The data for maternal complications include placenta previa, placental abruption, chronic hypertension, preeclampsia, renal disease, and human immunodeficiency virus.

The sample size was calculated using OpenEpi version 3 (www.openepi.com/SampleSize/SSPropor.htm), on the basis of the following formula: n=(DEFFxNp [1-p])/(d2/Z2 1-α/2x[N-1]+px[1-p]). The total number of deliveries (N) per year at the study hospital was 4,500, and the cesarean delivery (CD) rate (estimated proportion, p) was 38%. With a level of precision (d) of 5%, a Z-score (Z) of 1.96 (value from the standard normal distribution corresponding to the desired confidence level of 95%), and a design effect (DEFF) of 1 (assuming simple random sampling), the sample size needed was 336.

Statistical Analysis

SPSS for Windows version 22.0 (SPSS, Chicago, IL, USA) was used for statistical analysis. The proportion of variables examined by descriptive statistical tests and was specified as numbers and percentages. Quantitative data were expressed as mean ± standard deviation and median [interquartile range (IQR)] according to distribution characteristics. The observed CS rate, group size, the contribution of the group, and the estimated CS rate based on mean values of C-Model results were calculated for each TGCS group. In addition, the Receiver Operator

Characteristic (ROC) curve analysis was used to obtain the optimal cut-off value of C-Model predicting the probability of CS regarding the entire study population. Overall estimation of CS rate was also calculated using the determined cut-off value. The standardized CS ratio was calculated twice for good measure: once as the ratio between the observed CS rate and the mean estimated CS rate, and again as the ratio between the observed CS rate and the estimated CS rate using the specified cut-off.

RESULTS

One thousand two hundred thirty-two women gave birth and data of them were analyzed in the present study. Maternal and obstetric characteristics are presented in Table 1. The observed rate of cesarean birth was 37.42% (461/1232).

The 10-group Robson classification details and the estimated CS rates were presented in Table 2. The overall mean estimated CS rate of the study cohort was 30.5±1.06% (ranging between 0.8% and 99.9%).

The ROC curve analysis of the comparison between the estimated and observed CS rates was conducted (Figure 1). The area under the curve (AUC) of the C-Model to predict CS was 0.952 [95% confidence interval (CI)=0.940-0.965]. The optimal cut-off value of C-Model to predict the probability of CS was found as 19.6% with a sensitivity, specificity, positive and negative predictive value of 89%, 91%, 87% and 94%, respectively (Youden index: 0.79). The diagnostic odds ratio of the C-Model (determined based on cut-off point of 19.6%) was 75.9 (95% CI: 52.1 to 110.5, Z: 22.56, p<0.0001).

The overall estimated CS rate using the determined cut-off value (19.6%) of CS probability was 38.9%. The standardized CS ratios between the observed CS rate (37.42%) and the estimated CS rate using the determined cut-off value (38.9%) and mean estimated CS rate (30.5%) were 0.96 and 1.23, respectively.

Table 1. Demographics and pregnancy related clinical characteristics

Variables		Values
Age, mean (SD), y		27.45 (5.74)
BMI, mean (SD), kg/m^2		26.36 (4.41)
Parity, median (IQR)		1 (2)
Gestational age, mean (SD), week		38.67 (1.98)
		n (%)
Singleton pregnancy		1219 (98.9%)
Twin pregnancy		13 (1.1%)
Previous CS		312 (25.3%)
Fetal presentation (singleton)		
	Cephalic	1165 (94.6%)
	Breech	50 (4.1%)
	Transvers or obliqe lie	4 (1.1%)
Fetal status		
	Alive	1236 (99.28%)
	Stillbirth	9 (0.72%)
Complications of pregnancy		
	Oligohydramnios[a]	55 (4.5%)
	Pre-eclampsia	29 (2.4%)
	Gestational diabetes mellitus	29 (2.4%)
	Gestational hypertension	21 (1.7%)
	Polyhydramnios	19 (1.5%)
	Fetal growth restriction	16 (1.2%)
	Prelabour rupture of membrane	14 (1.1%)
	Chronic hypertension	7 (0.6%)
	Placental abruption	7 (0.6%)
	Cholestasis	6 (0.5%)
	Postterm	5 (0.4%)
	Placenta previa	5 (0.4%)
	Fetal macrosomia	5 (0.4%)
	Cardiac/renal dysfunction	4 (0.3%)
	Third-trimester bleeding	3 (0.3%)
	Eclampsia	2 (0.2%)
	Severe hyperemesis	1 (0.1%)
Maternal morbidities		
	Hypothyroidism	22 (1.8%)
	Hyperthyroidism	4 (0.3%)
	Other[b]	8 (0.6%)

[a]The common pregnancy complication, 26 of them were in group 2 (25.4% of group 2) and 14 of them were in group 4 (15.2% of group 4), [b]HIV, second degree burn on the abdomen, thalassemia minor, type 2 diabetes, hypophysis tumor, asthma, uterine prolapse, glaucoma for one of each 1(0.1%), SD: Standard deviation, IQR: Interquartile range, BMI: Body mass index, CS: Cesarean section, HIV: Human immunodeficiency virus

Analysis of the observed CS rates and mean estimated CS rates with regard to 10-group classification showed an overuse of CS in all Robson groups except group 4 (Table 2). The major contributor to CS rate was group 5 with 21.5% and this was followed by groups 2 and 10 (3.7% and 3.4%, respectively).

Birth characteristics and obstetric outcomes of the present cohort are presented in Table 3. The congenital fetal malformation rate was found as 4.1% (n=51). Those were as follows; testicular hydrocele (0.6%), hypospadias (0.5%), patent foramen ovale (0.5%), atrial septal defect (0.6%), umbilical hernia (0.2%), pes equinovarus (0.2%), Down Syndrome (0.2%), ventricular septal defect (0.2%), patent ductus arteriosus (0.2%) and others 12 (1%; including spina bifida aperta, cleft palate, tricuspid atresia, undescended testis, inguinal hernia, aortopulmonary collateral artery, Fallot tetralogy, meningomyelocele, amelia, trigonocephaly, tethered cord, polycystic kidney).

The CS indications of the most clinically relevant Robson groups are given in Table 4 (Groups 1-4, 7 and 10). The CS indications of groups 5, 6 and 8 were previous uterine scar, breech presentation and multiple pregnancy, respectively.

Seventy-seven (14.4%) women underwent labor induction. The indications for labor induction were oligohydramnios (25.7%), premature rupture of membrane (17.9%), post-term pregnancy (16.2%), polyhydramnios (7.3%), non-reassuring fetal heart rate trace (6.7%), gestational hypertension (5.6%), preeclampsia (5.6%), intrauterine fetal death (4%), cholestasis (4%), gestational diabetes (2.8%), fetal growth restriction (1.1%), uterovaginal bleeding in third trimester (0.6%) and reduced fetal movement (0.6%).

There was no maternal death in this cohort. Three women were admitted to the ICU and 12 women received blood transfusions (due to prepartum/postpartum hemorrhage or maternal anemia). There was one neonatal mortality and admission to the neonatal ICU rate was 10.8% (n=134).

The total rate of complications directly related to either vaginal or CD was 2.1% (n=26). These included uterine atony (0.5%, n=6), grade 3 or higher obstetrical anal sphincter tear (0.3%, n=4), wound infection (0.2%, n=3), vaginal hematoma (0.2%, n=2), and retained placenta (0.2%, n=2). Other complications specific to delivery were manual removal of the placenta, vulvar hematoma, subcutaneous hematoma, uterine rupture, difficulty in extraction of the fetal head in CS (T-incision), intraabdominal bleeding, re-laparotomy (0.7%, one case each). Additionally, there was one case of posterior reversible encephalopathy syndrome, which, while associated with preeclampsia rather than directly with delivery, was observed during the postpartum period.

DISCUSSION

In this study, the WHO's C-Model was used to determine a CS rate in a tertiary health care setting. The optimization of the estimated reference CS rate was ensured with further interpretation of the observed TGCS reports. The estimation ability of the C-Model in predicting the expected CS rate was high at the institutional level with an AUC rate of 0.952 (95% CI 0.940-0.965).

Table 2. The ten group classification system for the study population with estimated CS rate of each group

Group	Description	Number of CS/ group number (461/1232)	Group size 1 (%)	Group CS rate 2 (%)	Contribution of each group 3 (37.4%)	Estimated CS rate (mean percentage of C-Model for each group) (%)
1	Nulliparous women with a singleton cephalic pregnancy at ≥37 wk in spontaneous labor	15/170	13.8	8.8	1.2	3.30
2	Nulliparous women with a singleton cephalic pregnancy at ≥37 wk who either had labor induced or were delivered by CS before labor (provider initiated childbirth)	45/99	8	45.4	3.7	35.45
2[a]	Labor induced	23/77	6.2	29.9	1.9	33.61
2[b]	Pre-labor CS	22/22	1.8	100	1.8	41.87
3	Multiparous women without a previous uterine scar, with a singleton cephalic pregnancy at ≥37 wk in spontaneous labor	14/449	36.4	3.1	1.1	1.69
4	Multiparous women without a previous uterine scar, with a singleton cephalic pregnancy at ≥37 wk, who either had labor induced or were delivered by CS before labor (provider-initiated childbirth)	18/92	7.5	19.6	1.5	20.59
4[a]	Labor induced	9/83	6.7	10.8	0.73	20.57
4[b]	Pre-labour CS	9/9	0.8	100	0.73	20.78
5	All multiparous women with at least one previous CS, with a single cephalic pregnancy, ≥37 weeks gestation	265/267	21.7	99.3	21.5	84.09
5.1	With one previous CS	165/167	13.6	98.8	13.4	76.39
5.2	With two or more previous CSs	100/100	8.1	100	8.1	96.94
6	All nulliparous women with a singleton breech pregnancy	17/18	1.5	94.4	1.4	73.73
7	All multiparous women with a singleton breech pregnancy, including women with previous uterine scars	31/32	2.6	96.9	2.5	73.24
8	All women with multiple pregnancies, including women with previous uterine scars	10/13	1.1	76.9	0.8	47.27
9	All women with a singleton pregnancy with a transverse or oblique lie, including women with previous uterine scars	4/4	0.3	100	0.3	93.25
10	All women with a singleton cephalic pregnancy at ≤36 wk, including women with previous scars	42/88	7.1	47.7	3.4	42.29

1 group size (%) = n of women in the group/total n women delivered in the hospital x100, 2 group CS rate (%) = n of CS in the group/total n of women in the group x100, 3 contribution of each group (%) = n of CS in the group/total n of women delivered in the hospital x100. CS: Cesarean section, wk: Week

C-Model was produced in an international multi-country cohort with low CS rates (<30%) and with low intrapartum-related perinatal deaths (<6.8 deaths per 1000 births) as a tool to generate reference CS rates.[11] The absolute deviation of the estimated rate from observed CS rate was reported as minimal for countries with low CS rate and good perinatal outcomes, and the ratio between observed and predicted CS (standardized CS ratio) was found near 1 in those countries (e.g., Finland, Sri Lanka, France).[11] In the current study, the observed CS rate, and estimated CS rate based on the calculated cut-off value were 37.4% and 38.9%, respectively. The standardized CS ratio was 0.96 with an absolute deviation of 1.5%. Our results at a referral tertiary institutional level were found similar to Argentina's data in the original study (ratio of 0.95 with a deviation of 1.8% in the original study).[11] The relatively good balance between the observed and estimated CS rates of the current study can be explained by the interpretation of the Robson Classification.

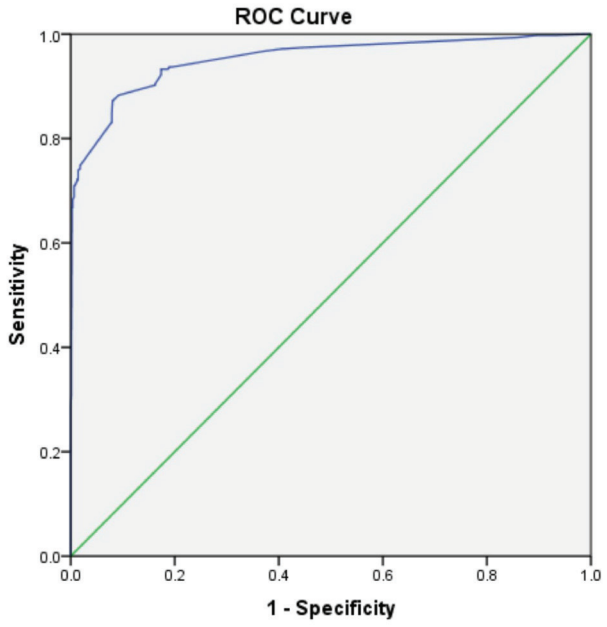

Figure 1. Comparison of the observed and the estimated CS rates of C-Model by ROC

ROC: Receiver operating curve, CS: Cesarean section

Our center fits the profile of a tertiary maternity hospital that manages high-risk pregnant women without a common practice of trial of labor after cesarean (TOLAC) and external cephalic version. The size of Group 5 was 21.5% and its relative contribution to the overall CS rate was 21.5%. The estimated CS rate by the C-Model and the observed CS rate in Group 5 were 84.1% and 99.3%, respectively, likely due to the absence of TOLAC practices at the study center. Previous CD was also the major CS indication (28.4%) in Group 10. These high CS rates were probably related to high overall cesarean rates mainly in Group 1 and 2 in past years.[14,15] The size of Group 10 was 7.1% which accounts for a higher rate of preterm births.[14,15] The ratio of the size of Group 1 versus Group 2 should usually be 2:1 or higher.[14,15] The ratio of 1.7 in the current study confirms the care of a high-risk population in nulliparous women with a high induction/prolabor CS rate of 14.4%. Similarly, almost one out of every five women had a high-risk pregnancy in this cohort (18.6%).

Both the observed and estimated CS rates of 37.5% and 38.9% were not consistent with the WHO's target of a 10-15% CS rate.[4] While the WHO's threshold aims to minimize unnecessary surgical interventions and associated risks, several factors make these rates challenging to achieve in certain populations. Firstly, changes in maternal demographics, such as increased maternal age and higher rates of obesity, have contributed to a rise in CS rates worldwide. Older mothers and those with higher body mass index are more likely to experience complications that necessitate a CD, such as hypertensive disorders, gestational diabetes, and obstructed labor.[16] Additionally, the growing prevalence of elective CS for non-medical reasons, driven by patient preference or cultural practices, has also contributed to higher rates.[17] Secondly, the management of high-risk pregnancies, particularly in tertiary care settings that handle a disproportionate number of complex cases, often justifies higher CS rates. For example, in settings with a high incidence of preterm births, multiple gestations, or previous

Table 3. Birth characteristics and obstetric outcomes

		Values
Fetal birth weight, mean (SD), gr		3268.46 (517.2)
Labor initiation		n (%)
	Spontaneous	704 (57.1%)
	Induced labor	177 (14.4%)
	Cesarean before labor	351 (28.5%)
Mode of birth		
	Spontaneous vaginal	771 (62.6%)
	Elective cesarean	237 (19.2%)
	Emergency cesarean	159 (12.9%)
	Intrapartum cesarean	65 (5.3%)
5th minute Apgar		
	<7	17 (1.4%)
	≥7	1215 (98.6%)
Neonatal ICU admission		
	Yes	134 (10.8%)
	No	1111 (89.2%)
Blood transfusion		
	Yes	12 (1%)
	No	1220 (99%)
Maternal ICU admission		
	Yes	3 (0.2%)
	No	1229 (99.8%)
Fetal complications		
	Hyperbilirubinemia[b]	38 (2.8%)
	Transient tachypnea of newborn[b]	30 (2.4%)
	Respiratory distress[b]	15 (1.2%)
	Sepsis[b]	13 (1.1%)
	Prematurity[b]	12 (1%)
	Asphyxia[b]	6 (0.5%)
	Meconium aspiration[b]	4 (0.3%)
	Clavicle fracture	3 (0.2%)
	Othera	6 (0.5%)
Congenital malformation		
	Yes	54 (4.3%)
	No	1191 (95.7%)

[a]Acute myocarditis[b], cephalohematoma, fetal scalp incision, perinatal death, pulmonary hypertension[b], neonatal pneumonia[b] 1 each. [b]The fetal complications which were causes of ICU admission. ICU: Intensive care unit, SD: Standard deviation

Table 4. Robson groups 1-4, 7 and 10 CS indications

CS indications	1	2[a]	2[b]	3	4[a]	4[b]	7	10
Fetal distress	6 (3.5%)	17 (22.1%)	4 (18.2%)	6 (1.3%)	3 (4.8%)	1 (11.1%)		7 (8%)
Suspected fetal macrosomia	3 (1.8%)		10 (45.5%)	2 (0.4%)		5 (55.6%)		
Maternal medical reason[a]	1 (0.6%)		2 (9.1%)			2 (22.2%)		1 (1.1%)
Labor arrest	3 (1.8%)	2 (2.6%)		2 (0.4%)	4 (6.3%)			1 (1.1%)
CPD	2 (1.2%)							
Failed induction		3 (3.9%)						
Placental abruption			1 (4.5%)	1 (0.2%)	1 (1.6%)		1 (3.1%)	4 (4.5%)
Pre-eclampsia/eclampsia			1 (4.5%)			1 (11.1%)		1 (1.1%)
Maternal request			2 (9.1%)		1 (1.6%)			
Fetal growth restriction			1 (4.5%)					1 (1.1%)
Placenta previa			1 (4.5%)					1 (1.1%)
Previous CD							13 (40.6%)	25 (28.4%)
Cord presentation								1 (1.1%)
Occiput posterior				1 (0.2%)				
Cord prolapsus				1 (0.2%)				
Arm prolapsus				1 (0.2%)				
Breech presentation							17 (53.1%)	
Twin pregnancy								
Total	15 (8.8%)	22 (28.6%)	22 (100%)	14 (3.1%)	9 (14.3%)	9 (100%)	31 (96.9%)	42 (47.5%)

[a]Lumbar hernia, previous brain operation, otosclerosis, orthopedic problem in the mother. CPD: Cephalopelvic disproportion, CS: Cesarean section, CD: Cesarean delivery

CS, the clinical imperative to minimize risks to both mother and baby may necessitate more frequent use of CD. This is consistent with findings from studies such as Silver et al.,[18] which highlight increased maternal morbidity associated with multiple repeat CS. Given these factors, setting targeted optimal CS rates for specific populations or maternal facilities and evaluating the rates using TGCS may be more realistic than adhering to a universal threshold. The use of tools like the C-Model, which provides customized reference CS rates based on specific population characteristics, is one way to establish more appropriate benchmarks that reflect local realities.

The study observed an overuse of CS across most Robson groups, except for group 4. This overuse is particularly pronounced in high-risk groups such as Groups 5 and 10, which consist of multiparous women with previous CS and all women with a singleton pregnancy with a transverse or oblique lie, respectively. Several factors contribute to the overuse of CS in high-risk groups, such as Groups 5 and 10. First, clinical decision-making is influenced by patient safety concerns, particularly with women who have had previous CS or have complex obstetric histories. The risk of uterine rupture in women attempting a vaginal birth after delivery (VBAC) often leads to opting for a repeat CS, despite guidelines suggesting VBAC as a safe option in appropriate circumstances.[19,20] Second, institutional policies favoring CD in specific clinical scenarios, especially where resources to manage potential complications are limited, can drive these decisions. Practitioner experience and comfort levels also play a role.[18]

The implications for clinical practice are substantial. Overuse of CS increases healthcare costs and resource utilization and exposes women to surgical risks, such as infections, hemorrhage, and prolonged recovery. It is crucial to promote evidence-based practices and shared decision-making between clinicians and patients. Implementing clinical audits and feedback mechanisms can help monitor CS rates and ensure that CS are medically justified.[21]

The C-Model, when used in conjunction with the TGCS, provides a valuable framework for institutional audits and policymaking. By identifying specific Robson groups where CS rates exceed expected benchmarks, institutions can target areas for improvement, such as promoting vaginal births when safe and appropriate, enhancing training for healthcare providers, and revising clinical guidelines to reduce unnecessary CSs. Additionally, regular audits using these tools can help track the impact of changes over time, ensuring continuous quality improvement and optimal maternal and neonatal outcomes.

This study's strengths include the large cohort size and the novel application of the C-Model in combination with the TGCS for assessing CS rates. Our findings contribute to the current literature by offering a detailed analysis of CS rates in a tertiary setting, identifying specific areas of overuse, and providing evidence-based recommendations for clinical practice and policy. This approach helps to optimize resource allocation and improve maternal and neonatal outcomes by setting realistic and tailored cesarean rate targets.

Study Limitations

The outcomes of TGCS are affected differently by the data quality, characteristics of the obstetric population, and practice variation.[11] Although the data were regarded as reliable, the present study was limited by the fact that it was collected from medical records retrospectively.

The data collection for this study was limited to a three-month period between December 2019 and February 2020. While this time frame was chosen to ensure data quality and completeness, we acknowledge that it could introduce seasonal or temporal biases, potentially affecting the generalizability of the findings. Different periods of the year may have varying CS rates due to seasonal trends in obstetric complications, staff availability, or policy changes. To mitigate this limitation, we ensured that the sample size was sufficiently large to provide robust statistical power, as detailed in our sample size calculation. Future studies could extend the data collection period to cover an entire year to explore seasonal variations more comprehensively.

CONCLUSION

As the original authors have emphasized, the C-Model should not be used prospectively in clinical decision-making within labor wards. However, it can serve as a valuable tool for initially assessing the balance between observed and estimated CS rates, guiding further interpretation of TGCS results. The C-Model offers a pragmatic approach to evaluate whether the standardized CS ratio is close to 1, helping to develop health policies based on realistic CS rates tailored to the obstetric profile of the population.

To maximize its utility, the C-Model should be combined with TGCS for comprehensive clinical audits, which are crucial for monitoring data quality and changes in obstetric practices over time. This combination enables healthcare institutions to identify specific Robson groups where CS rates exceed expected benchmarks, allowing for targeted interventions to optimize delivery outcomes.

Integrating the C-Model and TGCS into routine practice involves training healthcare providers on their interpretation, focusing on promoting vaginal births when appropriate. Establishing clinical guidelines that incorporate these tools can standardize decision-making and ensure medically justified CS. Regular audits can monitor CS rates, identify trends, and continuously refine practices.

By adopting these strategies, healthcare institutions can effectively use the combined insights of the C-Model and TGCS to optimize CS rates, improve resource allocation, and enhance maternal and neonatal outcomes. Future research should continue to refine these tools and explore their application across diverse settings to further improve global health outcomes.

Ethics

Ethics Committee Approval: University of Health Sciences Turkey, Sancaktepe Şehit Prof. Dr. İlhan Varank Training and Research Hospital Scientific Research Ethics Committee has approved the study (approval number: 2020/57, date: 16.12.2020).

Informed Consent: Retrospective study.

Authorship Contributions

Surgical and Medical Practices: E.A., A.B.T., K.S., N.T., Concept: A.B.T., Design: A.B.T., K.S., Data Collection or Processing: E.A., K.S., Analysis or Interpretation: M.Y., N.T., Literature Search: E.A., K.S., Writing: A.B.T., M.Y., N.T.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

REFERENCES

1. World Health Organization (WHO). WHO Recommendations: intrapartum care for a positive childbirth experience. 2018.
2. Villar J, Valladares E, Wojdyla D, et al. Caesarean delivery rates and pregnancy outcomes: the 2005 WHO global survey on maternal and perinatal health in Latin America. Lancet. 2006 Jun 3;367(9525):1819-1829.
3. O'Dwyer V, Hogan JL, Farah N, Kennelly MM, Fitzpatrick C, Turner MJ. Maternal mortality and the rising cesarean rate. Int J Gynaecol Obstet. 2012;116(2):162-4.
4. World Health Organization (WHO). Appropriate technology for birth. Lancet. 1985;2:436-437.
5. Boerma T, Ronsmans C, Melesse DY, et al. Global epidemiology of use of and disparities in caesarean sections. Lancet. 2018;392(10155):1341-1348.
6. Gibbons L, Belizán JM, Lauer JA, Betrán AP, Merialdi M, Althabe F. The global numbers and costs of additionally needed and unnecessary caesarean sections performed per year: overuse as a barrier to universal coverage. World Health Report. 2010;30(1):1-31.
7. D'Alton ME, Hehir MP. Cesarean delivery rates: revisiting a 3-decades-old dogma. JAMA. 2015;314(21):2238-2240.
8. Robson SJ, De Costa CM. Thirty years of the World Health Organization's target caesarean section rate: time to move on. Med J Aust. 2017;206(4):181-185.
9. Molina G, Weiser TG, Lipsitz SR, et al. Relationship between cesarean delivery rate and maternal and neonatal mortality. JAMA. 2015;314(21):2263-2270.
10. Betrán AP, Merialdi M, Lauer JA, et al. Rates of caesarean section: analysis of global, regional and national estimates. Paediatr Perinat Epidemiol. 2007;21(2):98-113.
11. Souza JP, Betran AP, Dumont A, et al. A global reference for caesarean section rates (C-Model): a multicountry cross-sectional study. BJOG. 2016;123(3):427-436.
12. Robson M. A global reference for CS at health facilities? Yes, but there is work to do. BJOG. 2016;123(3):437.
13. Abdel-Aleem H, Darwish A, Abdelaleem AA, Mansur M. Usefulness of the WHO C-model to optimize the cesarean delivery rate in a tertiary hospital setting. Int J Gynecol Obstet. 2017;137(1):40-44.
14. World Health Organization (WHO). Robson classification: Implementation manual. Geneva: World Health Organization; 2019.
15. Robson M, Murphy M, Byrne F. Quality assurance: the 10-group classification system (Robson classification), induction of labor, and cesarean delivery. Int J Gynecol Obstet. 2015;131
16. Lean SC, Derricott H, Jones RL, Heazell AEP. Advanced maternal age and adverse pregnancy outcomes: A systematic review and meta-analysis. PLoS One. 2017;12(10):e0186287.

17. Mazzoni A, Althabe F, Gutierrez L, et al. Women's preferences and mode of delivery in public and private hospitals: a prospective cohort study. BMC Pregnancy Childbirth. 2016;16:34.
18. Silver RM, Landon MB, Rouse DJ, et al. Maternal morbidity associated with multiple repeat cesarean deliveries. Obstet Gynecol. 2006;107(6):1226-1232.
19. Landon MB, Hauth JC, Leveno KJ, et al. Maternal and perinatal outcomes associated with a trial of labor after prior cesarean delivery. N Engl J Med. 2004;351(25):2581-2589.
20. Practice bulletin no. 184: Vaginal birth after cesarean delivery. Obstet Gynecol. 2017;130(5):e217-e233.
21. World Health Organization (WHO) Human Reproduction Programme, 10 April 2015. WHO Statement on caesarean section rates. Reprod Health Matters. 2015;23(45):149-150.