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Caesarean section rates analysed using Robson's Ten Group Classification System: A descriptive study at a tertiary hospital in Ethiopia

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Abstract

Objective: The aim of this study was to assess the Caesarean section **(**CS**)** rates using Robson's Ten-Group Classification System among women who gave birth at Hawassa University Referral Hospital in Southern Ethiopia.

Design: Descriptive design analysing CS rates by Robson's categories from a birth registry

Setting: Hawassa University Referral Hospital in South Ethiopia.

Participants: 4004 women who gave birth in Hawassa University Referral Hospital from June 2018 to June 2019.

Results: The 4004 women gave birth to 4165 babies. The overall CS rate was 32.8% (95% CI: 31.4%, 34.3%). The major contributors to the overall CS rates were: Robson Group 1 (nulliparous women with singleton pregnancy at term in spontaneous labour) 22.9%; Group 5 (multiparous women with at least one previous CS) 21.4%, and Group 3 (multiparous women without previous CS, with singleton pregnancy in spontaneous labour) 17.3%. The most commonly reported indications for CS were "foetal compromise" (35.3%) followed by previous CS (20.3%) and obstructed labour (10.7%).

Conclusion: A high proportion of delivering women at this hospital were given a CS, and many of them were in a low risk group. Few had trial of labour. More active use of partogram and auditing the appropriateness of CS indications may help to reduce the CS rate.

Strengths and limitations of this study

- It was the first study that assesses the CS rate using Robson ten group classification system for all labouring mothers in Ethiopia.
- The study used prospective birth registration, hence the risk of incomplete data minimized
- All women who gave birth in study hospital were included, reducing the risk for selection bias
- Since the study was conducted in single-hospital with high referral and most complicated cases, the finding might be less generalizable.
- The study used birth weight for gestational age determination for some mothers and the possibility of misclassification among the Robson group cannot be ruled out.

Introduction

Caesarean section (CS) is a life-saving intervention for both the woman and new-born if a complication occurs during late pregnancy and childbirth. It is the most common surgical intervention in many countries (1). The proportion of births delivered by CS is used by the World Health Organization as an indicator of the provision of lifesaving services for both mothers and newborns (2). WHO suggest that in normal populations CS rates should not exceed 10-15 % (3). However, there is a growing concern about the increasing percentage of CS globally. The CS rates above 15% are not associated with improved maternal and neonatal health (4), and reasons for a CS may be other than medical; in some countries, for example, it may be a cost free option for expecting mothers.

CS performed for women who do not need it can have negative consequences for the mothers as well as their babies, especially when the procedure is done in the absence of adequate facilities, skills and comprehensive care (5). Though CS is effective in reducing maternal and neonatal mortality and morbidity, the procedure is also associated with increased maternal risk of infection, bleeding, blood transfusion, hysterectomy, and death compared to normal delivery (6). Indeed, even small operations carry some risks and must be compared with the risks of not undertaking the procedure. A woman who undergoes a CS will have a slightly increased risk for her subsequent babies to have foetal distress, preterm birth, and stillbirth (7-9).

In 2016, globally, the population-based CS rate varied from 6% to 27.2% (10), and the global rate of CS births had doubled over the last 15 years (11). In Ethiopia, the national population-based CS rate had been the lowest in the world (10), (12), but a national review conducted in 2011 covering 797 facilities indicated a CS rate of 15% in public facilities and 46.1% in privately owned facilities (13). The CS rate at a University hospital in eastern Ethiopia was 25.7% (14). Many of these facility-based CS rates represent a selected population of women, and hence not necessarily representing the CS rate in the population.

Though there is no consensus in defining the optimal CS rate at any level due to lack of reliable and internationally accepted classification system, the Ten-Group Classification System created by Robson has now been accepted and used in many countries (15, 16). This system helps

institution-specific monitoring and auditing and offers a standardized comparison method for use between institutions, countries, and time points (17).

WHO has been recommending using this system to assess, monitor and compare CS rates since 2015 (2), but it is not yet implemented in Ethiopia. A study on CS was conducted using Robson's classification system at a university hospital in eastern Ethiopia (14) but was limited to women who underwent CS, and was not done according to the Robson implementation manual (18). Therefore, the aim of our study was to determine CS rate using Ten-Group Classification System among all the women who gave birth at Hawassa University Referral Hospital in Southern Ethiopia in 2018/2019.

Materials and Methods:

Study setting:

The study was conducted at Hawassa University Referral Hospital, which is 275 km to the south of Addis Ababa, the capital city of Ethiopia. The hospital provides health care services as both primary health care for Hawassa city and its nearby districts, and as tertiary care services for the region Southern Nation Nationalities and Peoples, including some neighbouring regions. It serves more than 15 million people in the catchment area. According to 2019 Ethiopian Mini Demographic and Health Survey report, 69.4%, 47.6% and 32% of the women had at least one antenatal care (ANC) follow up, health facility delivery and postnatal care follow up, respectively, in Southern Nation Nationalities and Peoples region (19). All pregnant women are encouraged to have a minimum of 4 ANC visit and to deliver at health facilities. Preventive services such as screening for HIV/AIDS, Syphilis, tetanus toxoid vaccination and iron folate supplementation are routinely given for pregnant mothers during their ANC follow up. Hawassa University Referral Hospital is providing both basic and comprehensive management of maternal, new-born and child health services for more than 4500 births annually. The Department of Obstetrics and Gynaecology had 6 obstetricians and gynaecologists, 80 midwives, and 39 nurses, as well as its own operation theatre for obstetrics cases.

Study Design and participants

The design was descriptive and included all deliveries at the hospital between June 2018 and June 2019. A medical birth registry was adapted from the Kilimanjaro Christian Medical Centre in Tanzania (20) and used to collect the data.

Variables

The main outcome variable was the rate of CS, in all deliveries. Other variables were as follows: socio-demographic characteristics (maternal age, residence, educational status, occupational status), maternal characteristics (history of CS, parity, and gravidity), and pregnancy-related information (gestational age, foetal presentation, number of foetuses and onset of labour). For those women who underwent CS, information about the indications of CS was also collected.

The CS rates were categorised by the Robson classification system shown in Box 1 (18) using five delivery parameters: 1) *Foetal presentations* were classified as cephalic, breech or transverse/oblique. Gestational age was categorised as a term (≥37 weeks) or preterm (<37 weeks). 2) *Gestational age* was assessed using early prenatal ultrasound or last menstrual period. In the case of no early ultrasound or unknown last menstrual period, a combination of physical examination, third-trimester ultrasound, and estimated foetal weight were used for estimation of gestational age. For cases with undocumented gestational age, we used a birth weight of ≥2500 grams as a proxy to term pregnancy. 3) The *onset of labour* was categorised as spontaneous, induced or CS before labour. 4) *Parity* was classified as nulliparous or multiparous. 5) The *number of foetuses* was categorised as singleton or multiples. We categorised the need for CS as "Absolute indication" and "Not absolute indication" (21).

Box 1: Robson's 10-group classification

Group	Description
1	Nulliparous, singleton, cephalic, ≥37 weeks' gestation, in spontaneous labour
2	Nulliparous, singleton, cephalic, ≥37 weeks' gestation, induced labour or CS before labour
2a	Labour induced
2b	Prelabour CS
3	Multiparous (excluding previous CS), singleton, cephalic, ≥37 weeks' gestation, in spontaneous labour
4	Multiparous without a previous CS, with singleton, cephalic pregnancy, ≥37 weeks' gestation, induced or CS before labour
4a	Labour induced
4b	Prelabour CS
5	Previous CS, singleton, cephalic, ≥37 weeks' gestation
5.1	With one previous CS
5.2	With two or more previous CSs
6	All nulliparous with a single breech
7	All multiparous with a single breech (including previous CS)
8	All multiple pregnancies (including previous CS)
9	All women with a single pregnancy in a transverse or oblique lie (including those with previous CS)
10	All singleton, cephalic, <37 weeks' gestation pregnancies (including CS).

Source: WHO. Robson classification. Geneva: WHO, 2017.

Data collection

Data was recorded by three midwives in the maternity ward. Data collectors and supervisors were trained and supervised by the Principal Investigator. Information about the socio-demographic characteristics of delivering mothers was collected through interviews at the time of admission if the women were stable or before discharge from the hospital. Information about CS was retrieved from the operation theatre register and double-checked with the midwives' delivery logbook and the admission and discharge registers. Completeness of data was checked by the Principal Investigator.

Data processing and analysis

All registered data were double entered using EpiData Version 3.1 (EpiData Association, Odense, Denmark) and consistency was checked and any necessary corrections were made before data analysis. Data were analysed using SPSS Version 25 (IBM, Chicago, IL).

Descriptive statistics with frequencies and percentages for categorical data, as well as means and standard deviation for numerical data, were used to summarize the data. The WHO Robson implementation manual was used to interpret the results of this study (18). For determining CS rate, we used those mothers with complete data on Robson's group parameters. Those mothers with missing data were excluded from analysis.

Patient and Public involvement

Patients or public were not involved in the design, or conduct, or reporting, or dissemination plan of our research.

Results

In the 12-month study period, there were 4031 women coming to deliver at Hawassa Regional Hospital. Of these clients, 27 had incomplete records and were excluded, resulting in 4004 women giving birth to 4165 babies for analysis. The mean age of the women was 26 years. It ranged from 13 to 45 years. Their sociodemographic characteristics are shown in Table 1. We notice that many were urban dwellers and housewives, and most had some basic formal education.

Table 1: Socio-demographic characteristics of women who gave birth at Hawassa University Referral Hospital, Ethiopia, 2018.

Variables		Number	Percent
Total		4004	100
Maternal Age (Years)	<20	187	4.7
	20-34	3467	86.6
	35 and above	347	8.7
	Not recorded	2	0.1
Residence	Urban	3669	91.6
	Rural	318	7.9
	Not recorded	17	0.4
Educational level	Cannot read and write	283	7.1
	Primary (1-8)	1741	43.5
	Secondary (9-12)	1233	30.8
	College and above	715	17.9
	Not recorded	32	0.8
Occupational status	Housewife	2834	70.8
	Merchant	307	7.7
	Employer	624	15.6
	Others*	167	4.2
	Not recorded	72	1.8
Marital status	Married	3949	98.6
	Single	29	0.7
	Divorced/Widowed	9	0.2
	Not recorded	17	0.4

*Daily labourer, student, farmer

The obstetric characteristics of the study participants and the outcomes of the deliveries are given in Table 2. Two out of five (41.1%) of the study participants were primigravidae. Almost all of the study participants had had at least one ANC visit during this pregnancy. Of all deliveries, 15.1% were preterm. CS was performed on 1314 (32.8%) women, 165 (12.6%) of them planned.

Table 2: Obstetrics characteristics of women who gave birth and their outcomes, at Hawassa University Referral Hospital, Ethiopia.

Variables		Number	Percent
Age at first marriage	18 years or less	1091	27.2
	Above 18 years	2861	71.5
	Not recorded	52	1.3
Age at first Pregnancy	18 years or less	748	18.7
	Above 18 years	3205	80.0
	Not recorded	50	1.3
Parity	0	1646	41.1
	1-4	2185	54.6
	>4	173	4.3
ANC this pregnancy	Yes	3931	98.2
	No	57	1.4
	Not recorded	16	0.4
Gestational Age	Pre-term (<37 weeks)	606	15.1
	Term (37-42 weeks)	3253	81.2
	Post-term (>42 weeks)	145	3.6
Onset of labour	Induced	398	9.9
	Spontaneous	3441	85.9
	Pre-labour CS	165	4.2
Foetal presentation	Cephalic	3844	96.0
	Breech	143	3.6
	Transverse/Oblique	17	0.4
Mode of Delivery	Spont.Vaginal Delivery	2605	65.1
	Instrumental delivery	85	2.1
	CS	1314	32.8
	CS emergency	1149	87.4
	CS planned	165	12.6
Number of foetus at birth (n=4165)	Singleton	3850	92.4
	Multiple	315	7.6

Type of multiple births (n=315)	Twin	292	92.7
	Triplets	19	6.0
	Quadruplets	4	1.3
Birth Weight (in grams) (n=4165)	<2500	592	14.2
	2500-4000	3355	80.6
	>4000	188	4.5
	Note recorded	30	0.7
Previous CS (n=2358)	Yes	438	18.6
	No	1920	81.4

Instrumental delivery includes; vacuum and forceps delivery. ANC- antenatal clinic visit, CS caesarean section

Robson Ten Group Classification System

Table 3 shows the classification of women who delivered, according to Robson. We notice that the largest groups were: multiparous women without previous CS; women with a singleton pregnancy in spontaneous labour (group 3); nulliparous women with singleton pregnancy in spontaneous labour (group 1); and women with pre-term birth (group 10).

The overall CS rate in this study was 32.8% (95% CI: 31.4%, 34.3%). The major contributors to the overall CS rate were: Group 1 (nulliparous women with singleton pregnancy in spontaneous labour), group 5 (multiparous women with at least one previous CS) and group 3 (multiparous women without previous CS, with singleton pregnancy in spontaneous labour) (Table 3).

From an obstetrician's perspective, the most common indications for CS were foetal compromise, obstructed labour and previous CS (Figure 1). In this study, 227/1314 (17.3%) CS were performed for absolute maternal indications. For non-absolute indications, CS was performed in 968/1314 (73.7%) of cases, mainly non-reassuring foetal heartbeat pattern (foetal distress). The remaining 9.0% of CS could not be classified in this way, and included post-term pregnancy, premature rupture of membrane, multiple pregnancies, and polyhydramnios/oligohydramnios.

Table 3. Robson's Classification system among women who gave birth at Hawassa University Referral Hospital, Hawassa, South Ethiopia.

Robson Group	CS in Group	Number in Group	Group size (%)	CS in group (%)	Absolute group contribution to overall CS rate (%)	Relative contribution of the group to the overall CS rate (%)
Group 1 (nulliparous with singleton pregnancy in spontaneous labour)	301	1094	27.3	27.5	7.5	22.9
Group 2 (nulliparous women with singleton pregnancy who had induced labour or pre-labour CS)	97	227	5.7	42.7	2.4	7.4
Group 2a (induced labour)	55	185	4.6	29.7	1.4	4.2
Group 2b (pre-labour CS)	42	42	1.1	100.0	1.0	3.2
Group 3 (multiparous women without previous CS, with singleton pregnancy in spontaneous labour)	227	1356	33.9	16.7	5.7	17.3
Group 4 (multiparous without previous CS, singleton with induced labour or pre-labour CS)	68	158	3.9	43.0	1.7	5.2
Group 4a (induced labour)	33	123	3.1	26.8	0.8	2.5
Group 4b (pre-labour CS)	35	35	0.8	100.0	0.9	2.7

Group 5 (multiparous women with at least one previous CS)	281	362	9.0	77.6	7.0	21.4
Group 5.1 (one previous CS)	214	290	7.2	73.8	5.3	16.3
Group 5.2 (two or more previous CS)	57	72	1.8	79.2	1.4	4.3
Group 6 (nulliparous women with singleton breech)	38	46	1.2	82.6	0.9	2.9
Group 7 (multiparous women with singleton breech)	58	65	1.6	89.2	1.4	4.4
Group 8 (all multiple pregnancies)	91	154	3.9	59.1	2.3	6.9
Group 9 (all women with transverse or oblique lie)	16	16	0.4	100.0	0.4	1.2
Group 10 (all women with pre-term delivery)	137	526	13.1	26.0	3.4	10.4
Total	**1314**	**4004**	**100.00**	**32.8**	**32.8**	**100.00**

Group size (%) =n of women in the group/total number of women delivered in the hospital × 100.

Group CS rate (%) =n of CS in the group/total number of women in the group × 100.

Absolute contribution (%) =n of CS in the group/total number of women delivered in the hospital × 100.

Relative contribution (%) =n of CS in the group/total number of CS in the hospital × 100.

Discussion

A high proportion of deliveries in Hawassa University Referral Hospital were CS, almost a third. The major contributors to the overall CS rate were group 1 (nulliparous with singleton pregnancy in spontaneous labour), group 5 (multiparous women with at least one previous CS) and group 3 (multiparous women without previous CS, with singleton pregnancy in spontaneous labour). The most commonly reported indications for CS were a foetal compromise, previous CS and obstructed labour.

In this study we interpreted the findings based on Robson's implementation manual (18): We assessed the quality of the data, the population attending the services (shown in Appendix 1), and we evaluated the proportion of CS in each group (shown in Appendix 2). The evaluation of the CS rates is useful for auditing obstetric services.

Our study had several strengths. To our knowledge, this study is the first study at a major hospital in Ethiopia that assessed the CS rate using Robson's Ten Group Classification System for all labouring mothers. The birth registration was prospective and consecutive; hence the risk of incomplete data was minimized. All women who gave birth in the hospital during the study were included and this may have reduced the risk for selection bias.

The study also had some weaknesses. The study was conducted in a single hospital, and since it is a referral hospital, the selection of participants may be biased to some degree, and for this reason the findings might be less generalizable. However, standardization according to Robson is able to be used in this situation. Its use permits valid and useful comparisons to be done even at different levels of care. Another weakness is that the study used birth weight to determine gestational age for some mothers, and this could lead to a misclassification of some births into a wrong Robson group. We assessed whether this results in misclassification among Robson group according to WHO Robson implementation manual and the risk of misclassification was minimal. A third potential weakness involved inconsistent use of partogram and foetal heartbeat. This makes the criteria for decisions and indications for CS unclear and left much up to individual doctor's discretion.

The manual for interpretation of CS rates recommends that the size of group 9 (women

with *transverse lie*, singletons pregnancy), should be less than 1% of the total and the CS rate should be 100% for this group (18). In our study, the size of group 9 was 0.4% and the CS rate in this group was 100%, suggesting minimal misclassification in this group, and the size of group 9 was similar to other studies (18, 22, 23)

In our study several indicators were in line with the comparison populations given in Robson's manual; the proportion of women with *breech* pregnancy (group 6 and 7), the ratio of the size of group 1 (nulliparous women with singleton pregnancy in *spontaneous labour*) and group 2 (nulliparous women with singleton pregnancy, who had induced labour or *pre-labour CS*), as well as the ratio of the size of group 3 (multiparous women without *previous CS*, with singleton pregnancy in *spontaneous labour*) and group 4 (multiparous women without *previous CS*, with singleton pregnancy, who had induced labour or *pre-labour CS*) (18, 22, 23). However, the proportion of group 1 (*nulliparous* women with singleton pregnancy in *spontaneous labour*) and group 2 (*nulliparous* women with singleton pregnancy, who had induced labour or *pre-labour CS*) was slightly lower than the comparison populations (18, 22, 23). This may be due to the low proportions of nulliparous women in our study. The proportion of group 3 (*multiparous* women without previous CS, with singleton pregnancy in *spontaneous labour*) and group 4 (*multiparous* women without previous CS, with singleton pregnancy, who had induced labour or *pre-labour CS*) was higher than the Robson reference population (18). This may be explained by the fact that we had a high proportion of multiparous women in our study populations. According to Robson, the proportion of group 5 (multiparous women with at least one *previous CS*) should, be about half of all the CS. In our study, the proportion of group 5 represents less than 10% of the total women delivered in the hospital, which may reflect a low CS rate in previous years. The proportion of group 8 (women with multiple pregnancies) and group 10 (women with preterm pregnancy) in our study was similar with the comparison population (18, 22, 23).

The CS rate in Robson group 1 (*nulliparous* women with singleton pregnancy in *spontaneous labour*) was 27.5%, which is much higher than Robson's recommendation of under 10% (18). This may reflect a selection among nullipara, where many normal spontaneous deliveries take place at lower health facilities (health centres and primary

hospitals), and those who attend this referral hospital are selected, either referred or they decided themselves for unknown reasons to attend the hospital. Alternatively, it may reflect a low "threshold" interpreting criterion for a CS.

The CS rate in group 2 (*nulliparous* women with singleton pregnancy, who had labour induced or *pre-labour CS*) was similar to the comparison populations (22, 23), but higher than Robson's recommendation (18). This may reflect that the threshold for deciding on doing CS is too low, and this may happen at extremely busy labour wards; for example, the ward is so busy that calling a doctor and suggesting a CS in a case of slow progress may be preferred to a time-consuming trial of labour. This "low" CS threshold may explain why group 3 (*multiparous* women without previous CS, with singleton pregnancy in spontaneous labour) also had a higher CS rate (17%) than the comparisons (3-5%) (18, 22, 23). It could also be partly due to some misclassification by including women from group 5 (multiparous women with at least one *previous CS*) in group 3, but this is less likely.

Robson recommends that the CS rate in group 4 (*multiparous* women without a previous CS, with singleton pregnancy, who had induced labour or *pre-labour CS*) should be less than 15%, while in our study this rate was much higher (43%). This may be because of the high CS rate in women who underwent induction of labour (group 4a) (26.8%), which contributed to the high overall CS rate in group 4. Also, it may partly be due to a high proportion of failed inductions, or possible misclassifications by including group 5 (multiparous women with at least one *previous CS*) in group 4.

The CS rate in group 5 (multiparous women with at least one *previous CS*) in our study was 77.6%, which is higher than the Robson reference (50-60%) (18). This indicates that in our study, too few women were offered a trial of labour after having had previous CS.

The CS rate for breech in group 6 (*nulliparous* women with singleton *breech* pregnancy) and group 7 (*multiparous* women with a singleton *breech* pregnancy including previous CS) in our study was similar to comparison populations (18, 22, 23).

Robson recommends that nullipara and women with a previous CS should make up around 66% of CS at the hospital, comprising group 1 (*nulliparous* women with singleton pregnancy in *spontaneous labour*), group 2 (*nulliparas* women with singleton pregnancy, who had induced labour or *pre-labour CS*) and group 5 (*multiparous* women with at least one *previous CS*) (18). In our study, the relative contribution of these three groups (1,2,5) to the overall CS rate was 51.7%. This difference may be that the study area had few nullipara with planned CS, as seen in the low relative contribution of group 2 (*nulliparas* women with singleton pregnancy, who had induced labour or *pre-labour CS*) to the overall CS rate which in our study was (7.38%).

Our study showed that Robson group 1 (*nulliparous* women with singleton pregnancy in *spontaneous labour*), group 5 (multiparous women with at least one *previous CS*) and group 3 (*multiparous* women without previous CS, with singleton pregnancy in *spontaneous labour*) were the major contributors to the overall CS rate. These same groups were the major contributors in the eastern Ethiopia and elsewhere (14, 24-29), though the order was different. The difference in the order of these groups among the studies may because of the variation in study populations and overall CS rate (18). The high contribution of emergency CS in nullipara (group 1, nulliparous women with singleton pregnancy in spontaneous labour) in our study may be related to inappropriate indications of CS delivery in this group in our study hospital. More than one third (35%) of CS performed in this group is due to abnormal foetal heartbeat patterns. This was high, indicating the possibility of misdiagnosis of abnormal foetal heartbeat pattern. A more active use of the partogram as a tool for decision-making would help clinicians and midwives decide more consistently, instead of relying on too heavily health care workers individual assessment in

a busy ward.

The most commonly reported indications for CS were foetal compromise, previous CS and obstructed labour; similar indications have been reported from eastern Ethiopia (14) and elsewhere in Africa, Asia and Australia (27, 29-32).

In conclusion, this study has shown a high overall CS rate at Hawassa University Referral Hospital. Nulliparous women with singleton pregnancy in spontaneous labour (group 1), multiparous women with at least one previous CS (group 5) and multiparous women without previous CS, with singleton pregnancy, in spontaneous labour (group 3) were the major contributors to the overall high CS rates. Foetal compromise, previous CS and obstructed labour were the major indications for performing CS. There was a high CS rate in low-risk groups (group 1 and 3). We recommend that all labouring women be regularly followed with partogram, and that they be given the opportunity for instrumental delivery to decrease the use of primary CS among low risk groups. The reasons for the high CS rate among low-risk groups should be explored and the appropriateness of CS should be evaluated to reduce the overall CS rate, which benefits the health system, in general.

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Author Contributions:
AAA and BL conceived the study and analysed the data. AAA wrote the proposal and the first draft of the manuscript. SGH, AGT, and BL supervised and provided mentorship. All authors

contributed to the writing and reviewed the article and approved the final version of the manuscript.

Patient consent: Written consent was obtained from all delivering mothers to participate in this study. The consent was made according to ethical principles of "autonomy" by including statements that give participants the right to decline participation in the study at any time. The consent also included statements of potential risk, benefits and confidentiality.

Ethics approval: This study was approved by Hawassa University College of Medicine and Health Sciences Institutional Review Board (ref.no.IRB/007/10), and Regional Ethical Committee (Rek Vest) (ref.no.2018/595) in Norway.

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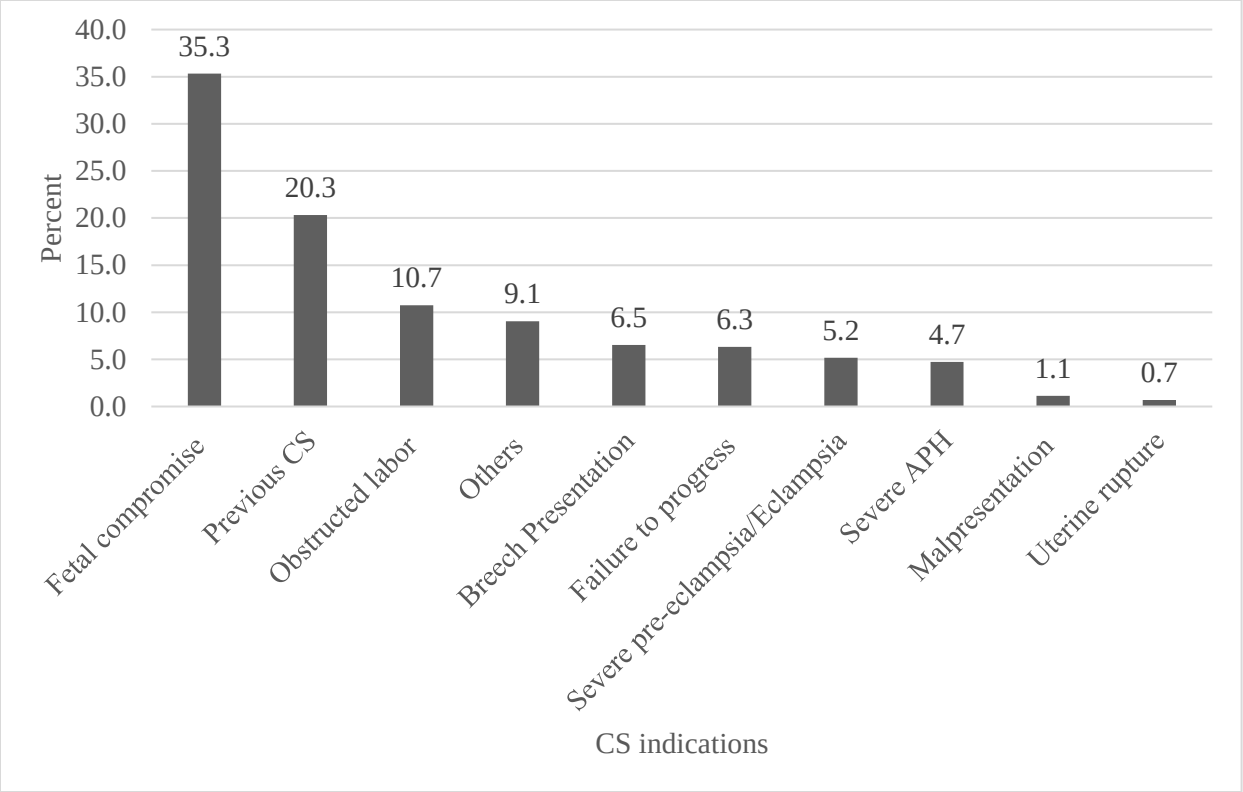

Figure 1. Indications for performing caesarean section (CS) among women who gave birth at Hawassa University Referral Hospital, Ethiopia, 2018-2019**.**

Foetal compromise = Foetal distress, cord prolapse, and intrauterine growth restriction. Failure to progress = Prolonged labour, cervical arrest, and failed induction. Obstructed labour = Cephalopelvic disproportion, macrosomia, and unspecified disproportions. Malpresentation = Transverse, oblique or brow. Others = Post term pregnancy, premature rupture of membrane, multiple pregnancies and polyhydramnios/oligohydramnios.

APH, antepartum haemorrhage.

Appendix 1: Assessment of the type of Populations among women who gave birth at Hawassa University Referral Hospital, Hawassa, South Ethiopia.

Steps for Interpretation	Interpretation by Robson	Example: MCS Population	Sri Lanka study	Our finding	Additional information from the data	Final Interpretation
Step 1: Size of group1+ 2	35-42%	38.1%	38.1%	32.99%	Nulliparas in our population 41.1%	Rate is lower than all the three references by Robson, MCS and Sri Lanka populations. This might be due to a low proportion of nullipara women in our Hospital. There is also a possibility of misclassification (group 1 misclassified as group 10) since we determined gestational based new-born birth weight.
Step 2: Size of Group 3+4	30%	46.5%	37.3%	37.81%	Multiparous in our population 58.9%	Rate higher than Robson reference population, in line with Sri Lanka reference population and lower than MCS examples. This may be explained by a high proportion of multiparous women in our population
Step 3: Size of group 5	Half of the total CS rate	7.2%	10.9%	9.04%	-	Lower than half of total CS. This, as suggested by the WHO manual, may be due to relatively low CS rate in the previous years, or to a recently increased CS rate or misclassification.
Step 4: size of group 6+7	3-4%	2.7%	3.4%	2.77%	-	Rate is in line with Robson, MCS and Sri Lanka reference populations
Step 5: Size of group 8	1.5-2%	0.9%	1.1%	3.85%	36.7% of women delivered in our Hospitals	Rate is higher than Robson, MCS and Sri Lanka reference populations. This may be due to high referral cases in our hospital as suggested by the WHO manual.

					were referred cases	
Step 6: Size of group 10	<10%	4.2%	7.8%	13.14%	15.1% of all women who gave birth in our hospital delivered preterm birth.	Rate is higher than Robson, MCS and Sri Lanka reference populations. This may be due to high referral cases and high preterm birth in our hospital. The hospital is a tertiary hospital were most high-risk pregnancies referred to. There is also a possibility of misclassification since we determined gestational based new-born birth weight.
Step 7: Ratio of the size of group 1 versus group 2	Ratio 2 or higher	Ratio 3.3	Ratio 1.5	Ratio 4.8	-	The rate in line with Robson and MCS example reference populations
Step 8: Ratio of size of group 3 versus group 4	>2:1	Ratio 6.3	Ratio 2.6	Ratio 8.6	-	Rate in line with Robson and MCS example refence populations
Step 9: Ratio of size of group 6 versus group 7	Usually 2:1	Ratio 0.8	Ratio 1.2	Ratio 0.7	Multiparous in our population 58.9%	The rate in line with MCS and Sri Lanka reference populations, but lower than Robson references. This may be explained by a high proportion of Multiparous women in our population.

Appendix 2: Assessment of CS Rates among women who gave birth at Hawassa University Referral Hospital, Hawassa, South Ethiopia.

Steps for Interpretation	Interpretation by Robson	Example: MCS Population	Sri Lanka study	Our finding	Additional information from the data	Final Interpretation
Step 1: CS rate in group 1	Under 10% are achievable	9.8%	18.8%	27.5%	35.0% of CS delivery is due to Abnormal foetal heartbeat pattern in our hospital	CS rate is higher than Robson, MCS, and Sri Lanka. This might due to a high ratio of group 1 to group 2 population in our study which indicates a higher CS rate in these groups as suggested by the WHO manual. It might also due to inappropriate indications of CS delivery in our hospital.
Step 2: CS rate in group 2	Consistently around 20%–35%	39.8%	41.0%	42.7%	- Failed induction was an indication in 36.0% of group 2a.	CS rate in line with Sri Lanka, but higher than MCS and Robson references. This may be possibly due to inappropriate indications of CS in the induction of labour and pre-labour CS.
Step 3: CS rate in Group 3	Not higher than 3.0%.	3.0%	5.2%	16.7%	-Obstructed labour was an indication in 51.5%.	CS rate is higher than Robson, MCS, and Sri Lanka. This may be explained by misclassification (group 5 misclassified as group 3).
Step 4: CS rate for group 4	It rarely should be higher than 15%	23.7%	16.8%	43.04%	Failed induction was an indication in 24.0% of group 4a.	CS rate is higher than Robson, MCS, and Sri Lanka. There was a high CS rate in group 4a (26.8%) which contributed to the high CS rate in group 4 in our study. The possible explanation may high failed induction or there might be misclassifications (group 5 misclassified as group 4).

Step 5: CS rate in group 5	Rates of 50%– 60% are considered appropriate	74.4%	81.8%	77.6%	Previous CS was the indication in 72.8%. Rate of prelabour CS was 33.9%	CS rate is higher than Robson and MCS examples but lower than the Sri Lanka study. This may be due to a high indication of CS due to previous CS, low offer of a trial of labour or VBAC (Vaginal birth after CS delivery), women's preference for repeating CS.
Step 6: CS rate for group 8	Usually around 60%	57.7%	80.9%	59.1%	-	CS rate in line with Robson and MCS example.
Step 7: CS rate in group 10	Usually around 30%	25.1%	41.1%	26.05%	-	CS rate in line with Robson and MCS example
Step 8: Relative contribution of groups 1, 2 and 5 to the overall CS rate	Normally contribute to 2/3 (66%) of all CS performed in most hospitals	Contributed to 63.7% of all CS	63.9%	51.7%	The relative contribution of group 2 to the overall CS rate was low (7.38%).	CS rate lower than Robson, MCS example and Sri Lanka study. This may be due to the relative contribution of group 2 to the overall CS rate which was low. The size of group 2 may also be contributed due to the misclassification of the pre-term as a term.
Step 9: Absolute contribution of group 5 to overall CS rate	NA	Responsible for 28.9% of all CS	Absolute contribution: 8.87% Relative contribution: 29.59%	Absolute contribution: 7.02% Relative contribution: 21.39%	-	The absolute contribution was not indicated in the WHO Robson manual, but our study finding was lower than the MCS example and Sri Lanka study.

STROBE_ Cross sectional Check list

		Reporting Item	Page Number
Title and abstract			
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	#3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	#4	Present key elements of study design early in the paper	4
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	4
	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5

Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	5,6
Bias	#9	Describe any efforts to address potential sources of bias	6
Study size	#10	Explain how the study size was arrived at	N/A, we have included all laboring mothers during the study period.
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	5
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	6,7
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	N/A, our study was purely descriptive
Statistical methods	#12c	Explain how missing data were addressed	7
Statistical methods	#12d	If applicable, describe analytical methods taking account of sampling strategy	N/A, our study design descriptive and no sampling strategy used
Statistical methods	#12e	Describe any sensitivity analyses	N/A, we used WHO Robson implementation manual to assess misclassification among Robson's group
Results			
Participants	#13a	Report numbers of individuals at each stage of	8

		study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	
Participants	#13b	Give reasons for non-participation at each stage	8
Participants	#13c	Consider use of a flow diagram	8, we used text description instead of flow diagram
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	8,9
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	9, 10
Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	9, 10, 11
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	N/A, our study was descriptive
Main results	#16b	Report category boundaries when continuous variables were categorized	9,10,11
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A, our study was descriptive
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	N/A, our study was descriptive

Discussion			
Key results	#18	Summarise key results with reference to study objectives	14
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	14
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	14-18
Generalisability	#21	Discuss the generalisability (external validity) of the study results	14
Other Information			
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	19

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Caesarean section rates analysed using Robson's Ten Group Classification System: A cross-sectional study at a tertiary hospital in Ethiopia

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Caesarean section rates analysed using Robson's Ten Group Classification System: A cross-sectional study at a tertiary hospital in Ethiopia

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Abstract

Objective: The aim of this study was to assess the Caesarean section **(**CS**)** rates using Robson's Ten-Group Classification System among women who gave birth at Hawassa University Referral Hospital in Southern Ethiopia.

Design: Cross-sectional study design to determine CS rate using Robson's Ten-group classification system.

Setting: Hawassa University Referral Hospital in South Ethiopia.

Participants: 4004 women who gave birth in Hawassa University Referral Hospital from June 2018 to June 2019.

Results: The 4004 women gave birth to 4165 babies. The overall CS rate was 32.8% (95% CI: 31.4%, 34.3%). The major contributors to the overall CS rates were: Robson Group 1 (nulliparous women with singleton pregnancy at term in spontaneous labour) 22.9%; Group 5 (multiparous women with at least one previous CS) 21.4%, and Group 3 (multiparous women without previous CS, with singleton pregnancy in spontaneous labour) 17.3%. The most commonly reported indications for CS were "foetal compromise" (35.3%) followed by previous CS (20.3%) and obstructed labour (10.7%).

Conclusion: A high proportion of women giving birth at this hospital were given a CS, and many of them were in a low risk group. Few had trial of labour. More active use of partogram, improving foetal heartbeat monitoring system and auditing the appropriateness of CS indications may help to reduce the CS rate.

Strengths and limitations of this study

- It was the first study in Ethiopia that assesses the CS rate using Robson ten group classification system for all labouring mothers in a hospital.
- The study used prospective birth registration, hence the risk of incomplete data minimized
- All women who gave birth in study hospital were included, reducing the risk for selection bias
- Since the study was conducted in single-hospital with high referral and most complicated cases, the finding might be less generalizable.
- The study used birth weight for gestational age determination for some mothers and the possibility of misclassification among the Robson group cannot be ruled out.

Introduction

Caesarean section (CS) is a life-saving intervention for both the woman and new-born if a complication occurs during late pregnancy and childbirth. It is the most common surgical intervention in many countries (1). The proportion of women giving birth by CS is used by the World Health Organization as an indicator of the provision of lifesaving services for both mothers and newborns (2). WHO suggest that in normal populations CS rates should not exceed 10-15 % (3). However, there is a growing concern about the increasing percentage of CS globally. The CS rates above 15% are not associated with improved maternal and neonatal health (4), and reasons for a CS may be other than medical; in some countries, for example, it may be a cost free option for expecting mothers (5, 6).

CS performed for women who do not need it can have negative consequences for the mothers as well as their babies, especially when the procedure is done in the absence of adequate facilities, skills and comprehensive care (7). Though CS is effective in reducing maternal and neonatal mortality and morbidity, the procedure is also associated with increased maternal risk of infection, bleeding, blood transfusion, hysterectomy, and death compared to normal delivery (8). Indeed, even small operations carry some risks and must be compared with the risks of not undertaking the procedure. A woman who undergoes a CS will have a slightly increased risk for her subsequent babies to have foetal distress, preterm birth, and stillbirth (9-11).

In 2016, globally, the population-based CS rate varied from 6% to 27.2% (12), and the global rate of CS births had doubled over the last 15 years (13). In Ethiopia, the national population-based CS rate had been the lowest in the world (12), (14), but a national review conducted in 2011 covering 797 facilities indicated a CS rate of 15% in public facilities and 46.1% in privately owned facilities (15). The CS rate at a University hospital in eastern Ethiopia was 25.7% (16). Many of these facility-based CS rates represent a selected population of women, and hence not necessarily representing the CS rate in the population.

Though there is no consensus in defining the optimal CS rate at any level due to lack of reliable and internationally accepted classification system, the Ten-Group Classification System created by Robson has now been accepted and used in many countries (17, 18). This system helps

institution-specific monitoring and auditing and offers a standardized comparison method for use between institutions, countries, and time points (19).

WHO has been recommending using this system to assess, monitor and compare CS rates since 2015 (2), but it is not yet implemented in Ethiopia. A study on CS was conducted using Robson's classification system at a university hospital in eastern Ethiopia (16) but was limited to women who underwent CS, and was not done according to the Robson implementation manual (20). Therefore, the aim of our study was to determine CS rate using Ten-Group Classification System among all the women who gave birth at Hawassa University Referral Hospital in Southern Ethiopia in 2018/2019.

Materials and Methods:

Study setting:

The study was conducted at Hawassa University Referral Hospital, which is 275 km to the south of Addis Ababa, the capital city of Ethiopia. The hospital provides health care services as both primary health care for Hawassa city and its nearby districts, and as tertiary care services for the region Southern Nation Nationalities and Peoples, including some neighbouring regions. Although it provides tertiary care for a population of 15 million, over 90% of the mothers came from two towns (Shashamanne and Hawassa). According to 2019 Ethiopian Mini Demographic and Health Survey report, 69.4%, 47.6% and 32% of the women had at least one antenatal care (ANC) follow up, health facility delivery and postnatal care follow up, respectively, in Southern Nation Nationalities and Peoples region (21). All pregnant women are encouraged to have a minimum of 4 ANC visit and to deliver at health facilities. Preventive services such as screening for HIV/AIDS, Syphilis, tetanus toxoid vaccination and iron folate supplementation are routinely given for pregnant mothers during their ANC follow up. All services related to delivery, including CS are expected to be given free of charge for delivering mothers at the Hospital. But sometimes the women are requested to buy drugs, intravenous fluids or gloves, when unavailable in the hospital dispensary. No payment (in addition to ordinary salary) is given to the obstetrician for performing CS. Hawassa University Referral Hospital is providing both basic and comprehensive management of maternal, new-born and child health services for more than 4500 births annually. The hospital is also serving as teaching hospital for health science and medical students including residency programs. The Department of Obstetrics and Gynaecology had 6 obstetricians and gynaecologists, 80 midwives, as well as its own operation theatre for obstetrics

cases. According to national guidelines for staffing, the recommended number of obstetrician for specialized hospital is 13 and the number at this hospital is less than recommended (22).

Study Design and participants

The design was cross-sectional and included all women who gave birth at the hospital between June 2018 and June 2019. A medical birth registry was adapted from the Kilimanjaro Christian Medical Centre in Tanzania (23) and used to collect the data.

Variables

The main outcome variable was the rate of CS, in all deliveries. Other variables were as follows: socio-demographic characteristics (maternal age, residence, educational status, occupational status), maternal characteristics (history of CS and parity), and pregnancy-related information (gestational age, foetal presentation, number of fetuses and onset of labour). For those women who underwent CS, information about the indications of CS was also collected.

The CS rates were categorised by the Robson classification system shown in Box 1 (20) using six obstetric parameters: 1) *Foetal lie and presentations* were classified as cephalic, breech or transverse/oblique. Gestational age was categorised as a term (≥37 weeks) or preterm (<37 weeks). 2) *Gestational age* assessment should ideally be done by early ultrasound. But in our study, since most of the women did not have early ultrasound measurement, we used the date of last menstrual period and third trimester ultrasound to assess gestational age. In the case of no third trimester ultrasound or unknown last menstrual period, a combination of physical examination, and estimated foetal weight were used for estimation of gestational age. For cases with undocumented gestational age, we used a birth weight of ≥2500 grams as a proxy to term pregnancy. 3) The *onset of labour* was categorised as spontaneous, induced or CS before labour. 4) *Parity* was classified as nulliparous or multiparous. 5) The *number of foetuses* was categorised as singleton or multiples. 6) History of previous CS was categorised as one, and two or more.

Foetal compromise was defined as a foetus having one of the following conditions: foetal distress, cord prolapse or intra-uterine growth restriction (IUGR). The hospital has one Cardiotocography (CTG) that was not used. Ultrasound was occasionally used, but in most of the cases the foetal heartbeat was monitored using fetoscope. We categorised the need for CS as "Absolute indication" and "Not absolute indication" (24).

Box 1: Robson's 10-group classification

Group	Description
1	Nulliparous, singleton, cephalic, ≥37 weeks' gestation, in spontaneous labour
2	Nulliparous, singleton, cephalic, ≥37 weeks' gestation, induced labour or CS before labour
2a	Labour induced
2b	Prelabour CS
3	Multiparous (excluding previous CS), singleton, cephalic, ≥37 weeks' gestation, in spontaneous labour
4	Multiparous without a previous CS, with singleton, cephalic pregnancy, ≥37 weeks' gestation, induced or CS before labour
4a	Labour induced
4b	Prelabour CS
5	Previous CS, singleton, cephalic, ≥37 weeks' gestation
5.1	With one previous CS
5.2	With two or more previous CSs
6	All nulliparous with a single breech
7	All multiparous with a single breech (including previous CS)
8	All multiple pregnancies (including previous CS)
9	All women with a single pregnancy in a transverse or oblique lie (including those with previous CS)
10	All singleton, cephalic, <37 weeks' gestation pregnancies (including CS).

Source: WHO. Robson classification. Geneva: WHO, 2017.

Data collection

Data were recorded by three midwives in the maternity ward. Data collectors and supervisors were trained and supervised by the Principal Investigator. Information about the socio-demographic characteristics of delivering mothers were collected through interviews at the time of admission if the women were stable or before discharge from the hospital. Information about CS was retrieved from the operation theatre register and double-checked with the midwives' delivery logbook and the admission and discharge registers. Completeness of data were checked by the Principal Investigator.

Data processing and analysis

All registered data were double entered using EpiData Version 3.1 (EpiData Association, Odense, Denmark) and consistency were checked and any necessary corrections were made before data analysis. Data were analysed using SPSS Version 25 (IBM, Chicago, IL).

Descriptive statistics with frequencies and percentages for categorical data, as well as means and standard deviation for numerical data were used to summarize the data. The WHO Robson implementation manual was used to interpret the results of this study (20). For determining CS rate, we used those mothers with complete data on Robson's group parameters. Those mothers with missing data were excluded from analysis.

Patient and Public involvement

Patients or public were not involved in the design, or conduct, or reporting, or dissemination plan of our research.

Results

In the 12-month study period, there were 4031 women coming to give birth at Hawassa University Referral Hospital. Of these clients, 27 had incomplete records and were excluded, resulting in 4004 women giving birth to 4165 babies for analysis. The mean age of the women was 26 years. It ranged from 13 to 45 years. Their sociodemographic characteristics are shown in Table 1. We notice that many were urban dwellers and housewives, and most had some basic formal education.

Table 1: Socio-demographic characteristics of women who gave birth at Hawassa University Referral Hospital, Ethiopia, 2018-2019.

Variables		Number	Percent (%)
Total		4004	100
Maternal Age (Years)	<20	187	4.7
	20-34	3467	86.6
	35 and above	347	8.7
	Not recorded	2	0.1
Residence	Urban	3669	91.6
	Rural	318	7.9
	Not recorded	17	0.4
Educational level	Cannot read and write	283	7.1
	Primary (1-8)	1741	43.5
	Secondary (9-12)	1233	30.8
	College and above	715	17.9
	Not recorded	32	0.8
Occupational status	Housewife	2834	70.8
	Merchant	307	7.7
	Employer	624	15.6
	Others*	167	4.2
	Not recorded	72	1.8
Marital status	Married	3949	98.6
	Single	29	0.7
	Divorced/Widowed	9	0.2
	Not recorded	17	0.4
Referred to give birth	Yes	1468	36.7
	No	2536	63.3

*Daily labourer, student, farmer

The obstetric characteristics of the study participants and the outcomes of the women who gave birth are given in Table 2. Two out of five (41.1%) of the study participants were nulliparous. Almost all of the study participants had had at least one ANC visit during this pregnancy. Of all births, 15.1% were preterm. CS was performed on 1314 (32.8%) women, 165 (12.6%) of them planned. The perinatal mortality was 75 perinatal death/1000 live births was based on deaths occurring in the hospital.

Table 2: Obstetrics characteristics of women who gave birth and their outcomes, at Hawassa University Referral Hospital, Ethiopia, 2018-2019

Variables		Number	Percent (%)
Age at first marriage	18 years or less	1091	27.2
	Above 18 years	2861	71.5
	Not recorded	52	1.3
Age at first Pregnancy	18 years or less	748	18.7
	Above 18 years	3205	80.0
	Not recorded	50	1.3
Parity	0	1646	41.1
	1-4	2185	54.6
	>4	173	4.3
ANC this pregnancy	Yes	3931	98.2
	No	57	1.4
	Not recorded	16	0.4
Gestational Age	Pre-term (<37 weeks)	606	15.1
	Term (37-42 weeks)	3253	81.2
	Post-term (>42 weeks)	145	3.6
Onset of labour	Induced	398	9.9
	Spontaneous	3441	85.9
	Pre-labour CS	165	4.2
Foetal lie and presentation	Cephalic	3844	96.0
	Breech	143	3.6
	Transverse/Oblique	17	0.4
Mode of Delivery	Spont.Vaginal Delivery	2605	65.1
	Instrumental delivery	85	2.1
	CS	1314	32.8
	CS emergency	1149	87.4
	CS planned	165	12.6
Number of fetus at birth (n=4165)	Singleton	3850	92.4
	Multiple	315	7.6

Type of multiple births (n=315)	Twin	292	92.7
	Triplets	19	6.0
	Quadruplets	4	1.3
Birth Weight (in grams) (n=4165)	<2500	592	14.2
	2500-4000	3355	80.6
	>4000	188	4.5
	Not recorded	30	0.7
Previous CS (n=2358)	Yes	438	18.6
	No	1920	81.4

Instrumental delivery includes; vacuum and forceps delivery. ANC- antenatal clinic visit, CS caesarean section

Robson Ten Group Classification System

Table 3 shows the women who gave birth according to Robson classification. We notice that the groups most represented by type of obstetrics population (group size) were: multiparous women without previous CS; women with a singleton pregnancy in spontaneous labour (group 3); nulliparous women with singleton pregnancy in spontaneous labour (group 1); and women with pre-term birth (group 10).

The overall CS rate in this study was 32.8% (95% CI: 31.4%, 34.3%). The major contributors to the overall CS rate were: Group 1 (nulliparous women with singleton pregnancy in spontaneous labour), group 5 (multiparous women with at least one previous CS) and group 3 (multiparous women without previous CS, with singleton pregnancy in spontaneous labour) (Table 3).

From an obstetrician's perspective, the most common indications for CS were foetal compromise, obstructed labour and previous CS (Figure 1: Indications for performing caesarean section (CS) among women who gave birth at Hawassa University Referral Hospital, Ethiopia, 2018-2019). In this study, 227/1314 (17.3%) CS were performed for absolute maternal indications. For non-absolute indications, CS was performed in 968/1314 (73.7%) of cases, mainly non-reassuring foetal heartbeat pattern (foetal distress). The remaining 9.0% of CS could not be classified in this way, and included post-term pregnancy, premature rupture of membrane, multiple pregnancies, and polyhydramnios/oligohydramnios.

Table 3. Robson's Classification system among women who gave birth at Hawassa University Referral Hospital, Hawassa, South Ethiopia, 2018-2019

Robson Group	CS in Group	Number in Group	Group size (%)	CS in group (%)	Absolute group contribution to overall CS rate (%)	Relative contribution of the group to the overall CS rate (%)
Group 1 (nulliparous with singleton pregnancy in spontaneous labour)	301	1094	27.3	27.5	7.5	22.9
Group 2 (nulliparous women with singleton pregnancy who had induced labour or pre-labour CS)	97	227	5.7	42.7	2.4	7.4
Group 2a (induced labour)	55	185	4.6	29.7	1.4	4.2
Group 2b (pre-labour CS)	42	42	1.1	100.0	1.0	3.2
Group 3 (multiparous women without previous CS, with singleton pregnancy in spontaneous labour)	227	1356	33.9	16.7	5.7	17.3
Group 4 (multiparous without previous CS, singleton with induced labour or pre-labour CS)	68	158	3.9	43.0	1.7	5.2
Group 4a (induced labour)	33	123	3.1	26.8	0.8	2.5
Group 4b (pre-labour CS)	35	35	0.8	100.0	0.9	2.7

Group 5 (multiparous women with at least one previous CS)	281	362	9.0	77.6	7.0	21.4
Group 5.1 (one previous CS)	214	290	7.2	73.8	5.3	16.3
Group 5.2 (two or more previous CS)	57	72	1.8	79.2	1.4	4.3
Group 6 (nulliparous women with singleton breech)	38	46	1.2	82.6	0.9	2.9
Group 7 (multiparous women with singleton breech)	58	65	1.6	89.2	1.4	4.4
Group 8 (all multiple pregnancies)	91	154	3.9	59.1	2.3	6.9
Group 9 (all women with transverse or oblique lie)	16	16	0.4	100.0	0.4	1.2
Group 10 (all women with pre-term delivery)	137	526	13.1	26.0	3.4	10.4
Total	**1314**	**4004**	**100.00**	**32.8**	**32.8**	**100.00**

Group size (%) =n of women in the group/total number of women who gave birth in the hospital × 100.

Group CS rate (%) =n of CS in the group/total number of women in the group × 100.

Absolute contribution (%) =n of CS in the group/total number of women who gave birth in the hospital × 100.

Relative contribution (%) =n of CS in the group/total number of CS in the hospital × 100.

Discussion

A high proportion of women who gave birth in Hawassa University Referral Hospital were through CS, almost a third. The major contributors to the overall CS rate were group 1 (nulliparous with singleton pregnancy in spontaneous labour), group 5 (multiparous women with at least one previous CS) and group 3 (multiparous women without previous CS, with singleton pregnancy in spontaneous labour). The most commonly reported indications for CS were a foetal compromise, previous CS and obstructed labour.

In this study we interpreted the findings based on Robson's implementation manual (20): thus, we assessed the quality of the data, the population attending the services (shown in Appendix 1), and we analysed the proportion of CS in each group (shown in Appendix 2).

Our study had several strengths. To our knowledge, this study is the first study at a major hospital in Ethiopia that assessed the CS rate using Robson's Ten Group Classification System for all labouring mothers. The birth registration was prospective and consecutive; hence the risk of incomplete data were minimized. All women who gave birth in the hospital during the study were included and this may have reduced selection bias.

The study also had some weaknesses. The study was conducted in a single hospital, and since it is a referral hospital, the selection of participants may be biased to some degree, and for this reason the findings might be less generalizable. However, standardization according to Robson is able to be used in such situations. Its use permits valid and useful comparisons to be done even at different levels of care. Another weakness is that the study used birth weight to determine gestational age for some mothers, and this could lead to a misclassification of some births into a wrong Robson group. We assessed whether this results in misclassification among Robson group according to WHO Robson implementation manual and the risk of misclassification was minimal. A third potential weakness involved inconsistent use of partogram and foetal heartbeat. This makes the criteria for decisions and indications for CS unclear and left much up to individual doctor's discretion.

The manual for interpretation of CS rates stated that the size of group 9 (women with *transverse lie*, singletons pregnancy), should be less than 1% of the total and the CS rate

should be 100% for this group (20). In our study, the size of group 9 was 0.4% and the CS rate in this group was 100%, suggesting minimal misclassification in this group, and the size of group 9 was similar to other studies (20, 25, 26)

In our study several indicators were in line with the comparison populations given in Robson's manual; the proportion of women with *breech* pregnancy (group 6 and 7), the ratio of the size of group 1 (nulliparous women with singleton pregnancy in *spontaneous labour*) and group 2 (nulliparous women with singleton pregnancy, who had induced labour or *pre-labour CS*), as well as the ratio of the size of group 3 (multiparous women without *previous CS*, with singleton pregnancy in *spontaneous labour*) and group 4 (multiparous women without *previous CS*, with singleton pregnancy, who had induced labour or *pre-labour CS*) (20, 25, 26). However, the proportion of group 1 (*nulliparous* women with singleton pregnancy in *spontaneous labour*) and group 2 (*nulliparous* women with singleton pregnancy, who had induced labour or *pre-labour CS*) was slightly lower than the comparison populations (20, 25, 26). This may be due to the low proportions of nulliparous women in our study. The proportion of group 3 (*multiparous* women without previous CS, with singleton pregnancy in *spontaneous labour*) and group 4 (*multiparous* women without previous CS, with singleton pregnancy, who had induced labour or *pre-labour CS*) was higher than the Robson reference population (20). This may be explained by the fact that we had a high proportion of multiparous women in our study populations. According to Robson, the proportion of group 5 (multiparous women with at least one *previous CS*) should, be about half of all the CS. In our study, the proportion of group 5 represents less than 10% of the total women delivered in the hospital, which may reflect a low CS rate in previous years. The proportion of group 8 (women with multiple pregnancies) and group 10 (women with preterm pregnancy) in our study was similar with the comparison population (20, 25, 26).

The CS rate in Robson group 1 (*nulliparous* women with singleton pregnancy in *spontaneous labour*) was 27.5%, which is much higher than Robson's examples showing that rates under 10% are achievable (20). This may reflect a selection among nullipara, where many normal spontaneous deliveries take place at lower health facilities (health centres and primary hospitals), and those who attend this referral hospital are selected,

either referred or they decided themselves for unknown reasons to attend the hospital. Alternatively, it may reflect a low "threshold" interpreting criterion for a CS.

The CS rate in group 2 (*nulliparous* women with singleton pregnancy, who had labour induced or *pre-labour CS*) was similar to the comparison populations (25, 26), but higher than Robson's guideline (CS rate between 20-35) (20). This may reflect that the threshold for deciding on doing CS is too low, and this may happen at extremely busy labour wards; for example, the ward is so busy that calling a doctor and suggesting a CS in a case of slow progress may be preferred to a time-consuming trial of labour. This "low" CS threshold may explain why group 3 (*multiparous* women without previous CS, with singleton pregnancy in spontaneous labour) also had a higher CS rate (17%) than the comparisons (3-5%) (20, 25, 26). It could also be partly due to some misclassification by including women from group 5 (multiparous women with at least one *previous CS*) in group 3, but this is less likely.

Robson guideline stated that the CS rate in group 4 (*multiparous* women without a previous CS, with singleton pregnancy, who had induced labour or *pre-labour CS*) is rarely should be higher than 15%, while in our study this rate was much higher (43%). This may be because of the high CS rate in women who underwent induction of labour (group 4a) (26.8%), which contributed to the high overall CS rate in group 4. Also, it may partly be due to a high proportion of failed inductions, or possible misclassifications by including group 5 (multiparous women with at least one *previous CS*) in group 4.

The CS rate in group 5 (multiparous women with at least one *previous CS*) in our study was 77.6%, which is higher than the Robson guideline (50-60%) (20). This indicates that in our study, too few women were offered a trial of labour after having had previous CS.

The CS rate for breech in group 6 (*nulliparous* women with singleton *breech* pregnancy) and group 7 (*multiparous* women with a singleton *breech* pregnancy including previous CS) in our study was similar to comparison populations (20, 25, 26).

The examples given by Robson in his guideline stated that nullipara and women with a previous CS contribute to 66% of CS at the hospital, comprising group 1 (*nulliparous* women with singleton pregnancy in *spontaneous labour*), group 2 (*nulliparas* women with singleton pregnancy, who had induced labour or *pre-labour CS*) and group 5 (*multiparous* women with at least one *previous CS*) (20). In our study, the relative contribution of these three groups (1,2,5) to the overall CS rate was 51.7%. This difference may be that the study area had few nullipara with planned CS, as seen in the low relative contribution of group 2 (*nulliparas* women with singleton pregnancy, who had induced labour or *pre-labour CS*) to the overall CS rate which in our study was (7.38%).

The overall CS rate in our hospital (32.8%) is higher than the WHO recommendation 10-15% (3). The high CS rate in our study may be due to several issues. One probable factor could be that the hospital is a referral hospital where more than a third of women referred to this hospital with different emergency situations that may need emergency management through CS delivery. Another factor could be that Hawassa University referral hospital as a teaching hospital has doctors under specialist training performing CS without following strict indications for performing CS. Another possible driving factors for this high CS rate could be the hospital is a referral hospital where more than a third of women referred to this hospital with different emergency situations that may need emergency management through CS delivery (27). Nearly three-quarters (73.7%) of CS in this study was performed for non-absolute maternal indications, mainly foetal distress, and CS may be performed for some women without clear appropriate indications. Foetal monitoring was not optimal, and this may have contributed to the high prevalence of "foetal distress". Also, a large proportion were urban women (91.6%) who gave birth in the hospital, and urban women are shown to have higher CS rates than the rural women in other settings also (28-30).

Our study showed that Robson group 1 (*nulliparous* women with singleton pregnancy in *spontaneous labour*), group 5 (multiparous women with at least one *previous CS*) and group 3 (*multiparous* women without previous CS, with singleton pregnancy in *spontaneous labour*) were the major contributors to the overall CS rate. These same groups were the major contributors in the eastern Ethiopia and elsewhere (16, 31-36), though the

order was different. The difference in the order of these groups among the studies may because of the variation in study populations and overall CS rate (20). The high contribution of emergency CS in nullipara (group 1, nulliparous women with singleton pregnancy in spontaneous labour) in our study may be related to inappropriate indications of CS delivery in this group in our study hospital. More than one third (35%) of CS performed in this group is due to abnormal foetal heartbeat patterns. This was high, indicating the possibility of misdiagnosis of abnormal foetal heartbeat pattern. A more active use of the partogram as a tool for decision-making would help clinicians and midwives decide more consistently, instead of relying on too heavily health care workers individual assessment in a busy ward.

The most commonly reported indications for CS were foetal compromise, previous CS and obstructed labour; similar indications have been reported from eastern Ethiopia (16) and elsewhere in Africa, Asia and Australia (34, 36-39).

In conclusion, this study has shown a high overall CS rate at Hawassa University Referral Hospital. Nulliparous women with singleton pregnancy in spontaneous labour (group 1), multiparous women with at least one previous CS (group 5) and multiparous women without previous CS, with singleton pregnancy, in spontaneous labour (group 3) were the major contributors to the overall high CS rates. Foetal compromise, previous CS and obstructed labour were the major indications for performing CS. There was a high CS rate in low-risk groups (group 1 and 3). We recommend that all labouring women be regularly followed with partogram, and that they be given the opportunity for instrumental delivery to decrease the use of primary CS among low risk groups. Foetal heartbeat monitoring system should be improved to reduce unnecessary CS that could be done due to misdiagnosis of foetal distress. The reasons for the high CS rate among low-risk groups should be explored and the appropriateness of CS should be evaluated to reduce the overall CS rate, which benefits the health system, in general.

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Author Contributions:

AAA and BL conceived the study and analysed the data. AAA wrote the proposal and the first draft of the manuscript. SGH, AGT, and BL supervised and provided mentorship. All authors contributed to the writing and reviewed the article and approved the final version of the manuscript.

Patient consent: Written consent was obtained from all delivering mothers to participate in this study. The interview was conducted at a convenient time for the women; before delivery and after delivery before discharge from the hospital, and no woman declined to participate in the study. Written consent was obtained from illiterate women after data collectors read information described in the consent form in the language they can understand. After they agreed on the information read for them, they signed on the consent form by using their thumb stump (fingerprint).

The consent was made according to ethical principles of "autonomy" by including statements that give participants the right to decline participation in the study at any time. The consent also included statements of potential risk, benefits and confidentiality.

Ethics approval: This study was approved by Hawassa University College of Medicine and Health Sciences Institutional Review Board (ref.no.IRB/007/10), and Regional Ethical Committee (Rek Vest) (ref.no.2018/595) in Norway.

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Figure 1. Indications for performing caesarean section (CS) among women who gave birth at Hawassa University Referral Hospital, Ethiopia, 2018-2019)

Box 1. Robson's 10-group classification

Table 1. Socio-demographic characteristics of women who gave birth at Hawassa University Referral Hospital, Ethiopia, 2018-2019.

Table 2. Obstetrics characteristics of women who gave birth and their outcomes, at Hawassa University Referral Hospital, Ethiopia**,** 2018-2019

Table 3. Robson's Classification system among women who gave birth at Hawassa University Referral Hospital, Hawassa, South Ethiopia, 2018-2019

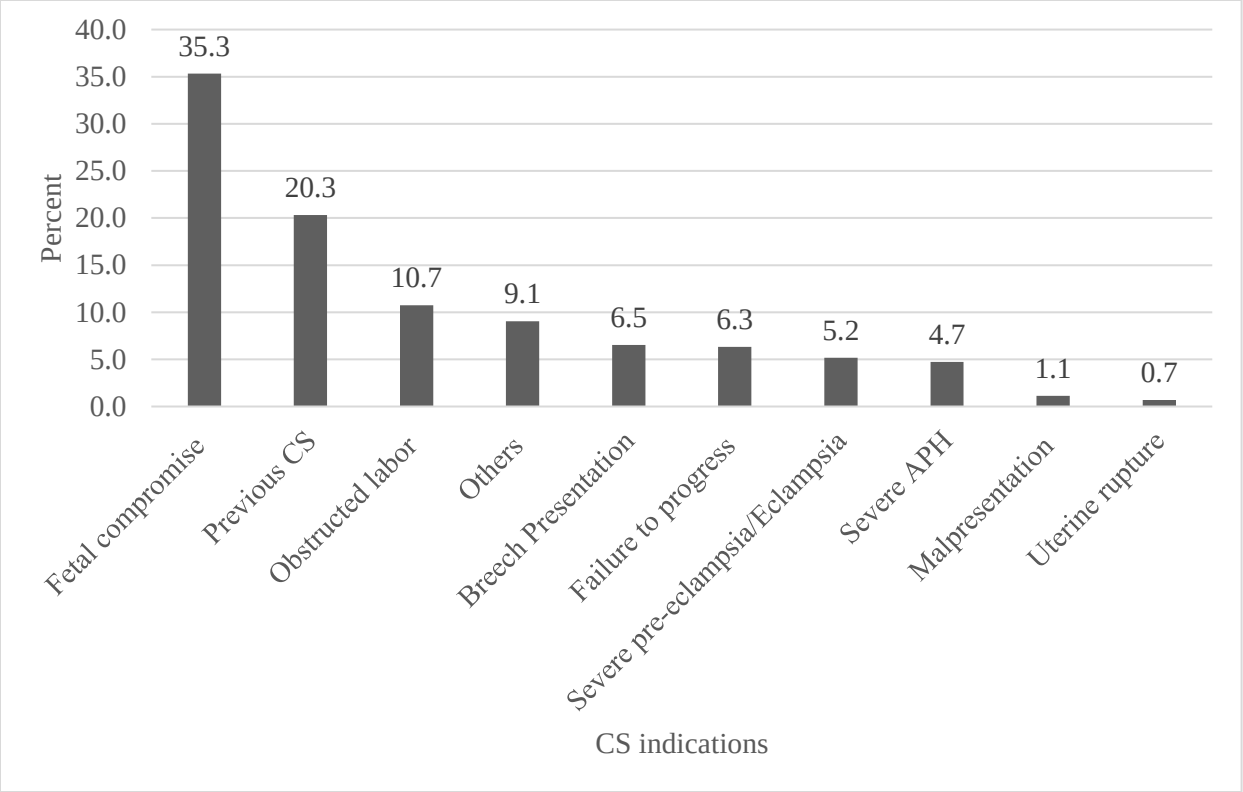

Figure 1. Indications for performing caesarean section (CS) among women who gave birth at Hawassa University Referral Hospital, Ethiopia, 2018-2019**.**

Foetal compromise = Foetal distress, cord prolapse, and intrauterine growth restriction. Failure to progress = Prolonged labour, cervical arrest, and failed induction. Obstructed labour = Cephalopelvic disproportion, macrosomia, and unspecified disproportions. Malpresentation = Transverse, oblique or brow. Others = Post term pregnancy, premature rupture of membrane, multiple pregnancies and polyhydramnios/oligohydramnios.

APH, antepartum haemorrhage.

Appendix 1: Assessment of the type of Populations among women who gave birth at Hawassa University Referral Hospital, Hawassa, South Ethiopia.

Steps for Interpretation	Interpretation by Robson	Example: MCS Population	Sri Lanka study	Our finding	Additional information from the data	Final Interpretation
Step 1: Size of group1+ 2	35-42%	38.1%	38.1%	32.99%	Nulliparas in our population 41.1%	Rate is lower than all the three references by Robson, MCS and Sri Lanka populations. This might be due to a low proportion of nullipara women in our Hospital. There is also a possibility of misclassification (group 1 misclassified as group 10) since we determined gestational based new-born birth weight.
Step 2: Size of Group 3+4	30%	46.5%	37.3%	37.81%	Multiparous in our population 58.9%	Rate higher than Robson reference population, in line with Sri Lanka reference population and lower than MCS examples. This may be explained by a high proportion of multiparous women in our population
Step 3: Size of group 5	Half of the total CS rate	7.2%	10.9%	9.04%	-	Lower than half of total CS. This, as suggested by the WHO manual, may be due to relatively low CS rate in the previous years, or to a recently increased CS rate or misclassification.
Step 4: size of group 6+7	3-4%	2.7%	3.4%	2.77%	-	Rate is in line with Robson, MCS and Sri Lanka reference populations
Step 5: Size of group 8	1.5-2%	0.9%	1.1%	3.85%	36.7% of women delivered in our Hospitals	Rate is higher than Robson, MCS and Sri Lanka reference populations. This may be due to high referral cases in our hospital as suggested by the WHO manual.

					were referred cases	
Step 6: Size of group 10	<10%	4.2%	7.8%	13.14%	15.1% of all women who gave birth in our hospital delivered preterm birth.	Rate is higher than Robson, MCS and Sri Lanka reference populations. This may be due to high referral cases and high preterm birth in our hospital. The hospital is a tertiary hospital were most high-risk pregnancies referred to. There is also a possibility of misclassification since we determined gestational based new-born birth weight.
Step 7: Ratio of the size of group 1 versus group 2	Ratio 2 or higher	Ratio 3.3	Ratio 1.5	Ratio 4.8	-	The rate in line with Robson and MCS example reference populations
Step 8: Ratio of size of group 3 versus group 4	>2:1	Ratio 6.3	Ratio 2.6	Ratio 8.6	-	Rate in line with Robson and MCS example refence populations
Step 9: Ratio of size of group 6 versus group 7	Usually 2:1	Ratio 0.8	Ratio 1.2	Ratio 0.7	Multiparous in our population 58.9%	The rate in line with MCS and Sri Lanka reference populations, but lower than Robson references. This may be explained by a high proportion of Multiparous women in our population.

Appendix 2: Assessment of CS Rates among women who gave birth at Hawassa University Referral Hospital, Hawassa, South Ethiopia.

Steps for Interpretation	Interpretation by Robson	Example: MCS Population	Sri Lanka study	Our finding	Additional information from the data	Final Interpretation
Step 1: CS rate in group 1	Under 10% are achievable	9.8%	18.8%	27.5%	35.0% of CS delivery is due to Abnormal foetal heartbeat pattern in our hospital	CS rate is higher than Robson, MCS, and Sri Lanka. This might due to a high ratio of group 1 to group 2 population in our study which indicates a higher CS rate in these groups as suggested by the WHO manual. It might also due to inappropriate indications of CS delivery in our hospital.
Step 2: CS rate in group 2	Consistently around 20%–35%	39.8%	41.0%	42.7%	- Failed induction was an indication in 36.0% of group 2a.	CS rate in line with Sri Lanka, but higher than MCS and Robson references. This may be possibly due to inappropriate indications of CS in the induction of labour and pre-labour CS.
Step 3: CS rate in Group 3	Not higher than 3.0%.	3.0%	5.2%	16.7%	-Obstructed labour was an indication in 51.5%.	CS rate is higher than Robson, MCS, and Sri Lanka. This may be explained by misclassification (group 5 misclassified as group 3).
Step 4: CS rate for group 4	It rarely should be higher than 15%	23.7%	16.8%	43.04%	Failed induction was an indication in 24.0% of group 4a.	CS rate is higher than Robson, MCS, and Sri Lanka. There was a high CS rate in group 4a (26.8%) which contributed to the high CS rate in group 4 in our study. The possible explanation may high failed induction or there might be misclassifications (group 5 misclassified as group 4).

Step 5: CS rate in group 5	Rates of 50%– 60% are considered appropriate	74.4%	81.8%	77.6%	Previous CS was the indication in 72.8%. Rate of prelabour CS was 33.9%	CS rate is higher than Robson and MCS examples but lower than the Sri Lanka study. This may be due to a high indication of CS due to previous CS, low offer of a trial of labour or VBAC (Vaginal birth after CS delivery), women's preference for repeating CS.
Step 6: CS rate for group 8	Usually around 60%	57.7%	80.9%	59.1%	-	CS rate in line with Robson and MCS example.
Step 7: CS rate in group 10	Usually around 30%	25.1%	41.1%	26.05%	-	CS rate in line with Robson and MCS example
Step 8: Relative contribution of groups 1, 2 and 5 to the overall CS rate	Normally contribute to 2/3 (66%) of all CS performed in most hospitals	Contributed to 63.7% of all CS	63.9%	51.7%	The relative contribution of group 2 to the overall CS rate was low (7.38%).	CS rate lower than Robson, MCS example and Sri Lanka study. This may be due to the relative contribution of group 2 to the overall CS rate which was low. The size of group 2 may also be contributed due to the misclassification of the pre-term as a term.
Step 9: Absolute contribution of group 5 to overall CS rate	NA	Responsible for 28.9% of all CS	Absolute contribution: 8.87% Relative contribution: 29.59%	Absolute contribution: 7.02% Relative contribution: 21.39%	-	The absolute contribution was not indicated in the WHO Robson manual, but our study finding was lower than the MCS example and Sri Lanka study.

STROBE_ Cross sectional Check list

		Reporting Item	Page Number
Title and abstract			
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	#3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	#4	Present key elements of study design early in the paper	4
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	4
	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5

Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	5,6
Bias	#9	Describe any efforts to address potential sources of bias	6
Study size	#10	Explain how the study size was arrived at	N/A, we have included all laboring mothers during the study period.
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	5
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	6,7
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	N/A, our study was purely descriptive
Statistical methods	#12c	Explain how missing data were addressed	7
Statistical methods	#12d	If applicable, describe analytical methods taking account of sampling strategy	N/A, our study design descriptive and no sampling strategy used
Statistical methods	#12e	Describe any sensitivity analyses	N/A, we used WHO Robson implementation manual to assess misclassification among Robson's group
Results			
Participants	#13a	Report numbers of individuals at each stage of	8

		study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	
Participants	#13b	Give reasons for non-participation at each stage	8
Participants	#13c	Consider use of a flow diagram	8, we used text description instead of flow diagram
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	8,9
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	9, 10
Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	9, 10, 11
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	N/A, our study was descriptive
Main results	#16b	Report category boundaries when continuous variables were categorized	9,10,11
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A, our study was descriptive
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	N/A, our study was descriptive

Discussion			
Key results	#18	Summarise key results with reference to study objectives	14
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	14
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	14-18
Generalisability	#21	Discuss the generalisability (external validity) of the study results	14
Other Information			
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	19

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Caesarean section rates analysed using Robson's Ten Group Classification System: A cross-sectional study at a tertiary hospital in Ethiopia

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Abstract

Objective: The aim of this study was to assess the Caesarean section **(**CS**)** rates using Robson's Ten-Group Classification System among women who gave birth at Hawassa University Referral Hospital in Southern Ethiopia.

Design: Cross-sectional study design to determine CS rate using Robson's Ten-group classification system.

Setting: Hawassa University Referral Hospital in South Ethiopia.

Participants: 4004 women who gave birth in Hawassa University Referral Hospital from June 2018 to June 2019.

Results: The 4004 women gave birth to 4165 babies. The overall CS rate was 32.8% (95% CI: 31.4%, 34.3%). The major contributors to the overall CS rates were: Robson Group 1 (nulliparous women with singleton pregnancy at term in spontaneous labour) 22.9%; Group 5 (multiparous women with at least one previous CS) 21.4%, and Group 3 (multiparous women without previous CS, with singleton pregnancy in spontaneous labour) 17.3%. The most commonly reported indications for CS were "fetal compromise" (35.3%) followed by previous CS (20.3%) and obstructed labour (10.7%).

Conclusion: A high proportion of women giving birth at this hospital were given a CS, and many of them were in a low risk group. Few had trial of labour. More active use of partogram, improving fetal heartbeat monitoring system, implementing midwife-led care, involving a companion during labour, and auditing the appropriateness of CS indications may help to reduce the CS rate.

Strengths and limitations of this study

- It was the first study in Ethiopia that assesses the CS rate using Robson ten group classification system for all labouring mothers in a hospital.
- The study used prospective birth registration, hence the risk of incomplete data minimized
- All women who gave birth in study hospital were included, reducing the risk for selection bias
- Since the study was conducted in single-hospital with high referral and most complicated cases, the finding might be less generalizable.
- The study used birth weight for gestational age determination for some mothers and the possibility of misclassification among the Robson group cannot be ruled out.

Introduction

Caesarean section (CS) is a life-saving intervention for both the woman and new-born if a complication occurs during late pregnancy and childbirth. It is the most common surgical intervention in many countries (1). The proportion of women giving birth by CS is used by the World Health Organization as an indicator of the provision of lifesaving services for both mothers and newborns (2). WHO suggest that in normal populations CS rates should not exceed 10-15 % (3). However, there is a growing concern about the increasing percentage of CS globally. The CS rates above 15% are not associated with improved maternal and neonatal health (4), and reasons for a CS may be other than medical; in some countries, for example, it may be a cost free option for expecting mothers (5, 6).

CS performed for women who do not need it can have negative consequences for the mothers as well as their babies, especially when the procedure is done in the absence of adequate facilities, skills and comprehensive care (7). Though CS is effective in reducing maternal and neonatal mortality and morbidity, the procedure is also associated with increased maternal risk of infection, bleeding, blood transfusion, hysterectomy, and death compared to normal delivery (8). Indeed, even small operations carry some risks and must be compared with the risks of not undertaking the procedure. A woman who undergoes a CS will have a slightly increased risk for her subsequent babies to have fetal distress, preterm birth, and stillbirth (9-11).

In 2016, globally, the population-based CS rate varied from 6% to 27.2% (12), and the global rate of CS births had doubled over the last 15 years (13). In Ethiopia, the national population-based CS rate had been the lowest in the world (12), (14), but a national review conducted in 2011 covering 797 facilities indicated a CS rate of 15% in public facilities and 46.1% in privately owned facilities (15). The CS rate at a University hospital in eastern Ethiopia was 25.7% (16). Many of these facility-based CS rates represent a selected population of women, and hence not necessarily representing the CS rate in the population.

Though there is no consensus in defining the optimal CS rate at any level due to lack of reliable and internationally accepted classification system, the Ten-Group Classification System created by Robson has now been accepted and used in many countries (17, 18). This system helps

institution-specific monitoring and auditing and offers a standardized comparison method for use between institutions, countries, and time points (19).

WHO has been recommending using this system to assess, monitor and compare CS rates since 2015 (2), but it is not yet implemented in Ethiopia. A study on CS was conducted using Robson's classification system at a university hospital in eastern Ethiopia (16) but was limited to women who underwent CS, and was not done according to the Robson implementation manual (20). Therefore, the aim of our study was to determine CS rate using Ten-Group Classification System among all the women who gave birth at Hawassa University Referral Hospital in Southern Ethiopia in 2018/2019.

Materials and Methods:

Study setting:

The study was conducted at Hawassa University Referral Hospital, which is 275 km to the south of Addis Ababa, the capital city of Ethiopia. The hospital provides health care services as both primary health care for Hawassa city and its nearby districts, and as tertiary care services for the region Southern Nation Nationalities and Peoples, including some neighbouring regions. Although it provides tertiary care for a population of 15 million, over 90% of the mothers came from two towns (Shashamanne and Hawassa). According to 2019 Ethiopian Mini Demographic and Health Survey report, 69.4%, 47.6% and 32% of the women had at least one antenatal care (ANC) follow up, health facility delivery and postnatal care follow up, respectively, in Southern Nation Nationalities and Peoples region (21). All pregnant women are encouraged to have a minimum of 4 ANC visit and to deliver at health facilities. Preventive services such as screening for HIV/AIDS, Syphilis, tetanus toxoid vaccination and iron folate supplementation are routinely given for pregnant mothers during their ANC follow up. All services related to delivery, including CS are expected to be given free of charge for delivering mothers at the Hospital. But sometimes the women are requested to buy drugs, intravenous fluids or gloves, when unavailable in the hospital dispensary. No payment (in addition to ordinary salary) is given to the obstetrician for performing CS. Hawassa University Referral Hospital is providing both basic and comprehensive management of maternal, new-born and child health services for more than 4500 births annually. The hospital is also serving as teaching hospital for health science and medical students including residency programs. The Department of Obstetrics and Gynaecology had 6 obstetricians and gynaecologists, 80 midwives, as well as its own operation theatre for obstetrics

cases. According to national guidelines for staffing, the recommended number of obstetrician for specialized hospital is 13 and the number at this hospital is less than recommended (22).

Study Design and participants

The design was cross-sectional and included all women who gave birth at the hospital between June 2018 and June 2019. A medical birth registry was adapted from the Kilimanjaro Christian Medical Centre in Tanzania (23) and used to collect the data.

Variables

The main outcome variable was the rate of CS, in all deliveries. Other variables were as follows: socio-demographic characteristics (maternal age, residence, educational status, occupational status), maternal characteristics (history of CS and parity), and pregnancy-related information (gestational age, fetal presentation, number of fetuses and onset of labour). For those women who underwent CS, information about the indications of CS was also collected.

The CS rates were categorised by the Robson classification system shown in Box 1 (20) using six obstetric parameters: 1) *Fetal lie and presentations* were classified as cephalic, breech or transverse/oblique. Gestational age was categorised as a term (≥37 weeks) or preterm (<37 weeks). 2) *Gestational age* assessment should ideally be done by early ultrasound. But in our study, since most of the women did not have early ultrasound measurement, we used the date of last menstrual period and third trimester ultrasound to assess gestational age. In the case of no third trimester ultrasound or unknown last menstrual period, a combination of physical examination, and estimated fetal weight were used for estimation of gestational age. For cases with undocumented gestational age, we used a birth weight of ≥2500 grams as a proxy to term pregnancy. 3) The *onset of labour* was categorised as spontaneous, induced or CS before labour. 4) *Parity* was classified as nulliparous or multiparous. 5) The *number of fetuses* was categorised as singleton or multiples. 6) History of previous CS was categorised as one, and two or more.

Fetal compromise was defined as a fetus having one of the following conditions: fetal distress, cord prolapse or intra-uterine growth restriction (IUGR). The hospital has one Cardiotocography (CTG) that was not used. Ultrasound was occasionally used, but in most of the cases the fetal heartbeat was monitored using fetoscope. We categorised the need for CS as "Absolute indication" and "Not absolute indication" (24).

Box 1: Robson's 10-group classification

Group	Description
1	Nulliparous, singleton, cephalic, ≥37 weeks' gestation, in spontaneous labour
2	Nulliparous, singleton, cephalic, ≥37 weeks' gestation, induced labour or CS before labour
2a	Labour induced
2b	Prelabour CS
3	Multiparous (excluding previous CS), singleton, cephalic, ≥37 weeks' gestation, in spontaneous labour
4	Multiparous without a previous CS, with singleton, cephalic pregnancy, ≥37 weeks' gestation, induced or CS before labour
4a	Labour induced
4b	Prelabour CS
5	Previous CS, singleton, cephalic, ≥37 weeks' gestation
5.1	With one previous CS
5.2	With two or more previous CSs
6	All nulliparous with a single breech
7	All multiparous with a single breech (including previous CS)
8	All multiple pregnancies (including previous CS)
9	All women with a single pregnancy in a transverse or oblique lie (including those with previous CS)
10	All singleton, cephalic, <37 weeks' gestation pregnancies (including CS).

Source: WHO. Robson classification. Geneva: WHO, 2017.

Data collection

Data were recorded by three midwives in the maternity ward. Data collectors and supervisors were trained and supervised by the Principal Investigator. Information about the socio-demographic characteristics of delivering mothers were collected through interviews at the time of admission if the women were stable or before discharge from the hospital. Information about CS was retrieved from the operation theatre register and double-checked with the midwives' delivery logbook and the admission and discharge registers. Completeness of data were checked by the Principal Investigator.

Data processing and analysis

All registered data were double entered using EpiData Version 3.1 (EpiData Association, Odense, Denmark) and consistency were checked and any necessary corrections were made before data analysis. Data were analysed using SPSS Version 25 (IBM, Chicago, IL).

Descriptive statistics with frequencies and percentages for categorical data, as well as means and standard deviation for numerical data were used to summarize the data. The WHO Robson implementation manual was used to interpret the results of this study (20). For determining CS rate, we used those mothers with complete data on Robson's group parameters. Those mothers with missing data were excluded from analysis.

Patient and Public involvement

Patients or public were not involved in the design, or conduct, or reporting, or dissemination plan of our research.

Results

In the 12-month study period, there were 4031 women coming to give birth at Hawassa University Referral Hospital. Of these clients, 27 had incomplete records and were excluded, resulting in 4004 women giving birth to 4165 babies for analysis. The mean age of the women was 26 years. It ranged from 13 to 45 years. Their sociodemographic characteristics are shown in Table 1. We notice that many were urban dwellers and housewives, and most had some basic formal education.

Table 1: Socio-demographic characteristics of women who gave birth at Hawassa University Referral Hospital, Ethiopia, 2018-2019.

Variables		Number	Percent (%)
Total		4004	100
Maternal Age (Years)	<20	187	4.7
	20-34	3467	86.6
	35 and above	347	8.7
	Not recorded	2	0.1
Residence	Urban	3669	91.6
	Rural	318	7.9
	Not recorded	17	0.4
Educational level	Cannot read and write	283	7.1
	Primary (1-8)	1741	43.5
	Secondary (9-12)	1233	30.8
	College and above	715	17.9
	Not recorded	32	0.8
Occupational status	Housewife	2834	70.8
	Merchant	307	7.7
	Employer	624	15.6
	Others*	167	4.2
	Not recorded	72	1.8
Marital status	Married	3949	98.6
	Single	29	0.7
	Divorced/Widowed	9	0.2
	Not recorded	17	0.4
Referred to give birth	Yes	1468	36.7
	No	2536	63.3

*Daily labourer, student, farmer

The obstetric characteristics of the study participants and the outcomes of the women who gave birth are given in Table 2. Two out of five (41.1%) of the study participants were nulliparous. Almost all of the study participants had had at least one ANC visit during this pregnancy. Of all births, 15.1% were preterm. CS was performed on 1314 (32.8%) women, 165 (12.6%) of them planned. The perinatal mortality was 75 perinatal death/1000 live births was based on deaths occurring in the hospital.

Table 2: Obstetrics characteristics of women who gave birth and their outcomes, at Hawassa University Referral Hospital, Ethiopia, 2018-2019

Variables		Number	Percent (%)
Age at first marriage	18 years or less	1091	27.2
	Above 18 years	2861	71.5
	Not recorded	52	1.3
Age at first Pregnancy	18 years or less	748	18.7
	Above 18 years	3205	80.0
	Not recorded	50	1.3
Parity	0	1646	41.1
	1-4	2185	54.6
	>4	173	4.3
ANC this pregnancy	Yes	3931	98.2
	No	57	1.4
	Not recorded	16	0.4
Gestational Age	Pre-term (<37 weeks)	606	15.1
	Term (37-42 weeks)	3253	81.2
	Post-term (>42 weeks)	145	3.6
Onset of labour	Induced	398	9.9
	Spontaneous	3441	85.9
	Pre-labour CS	165	4.2
Fetal lie and presentation	Cephalic	3844	96.0
	Breech	143	3.6
	Transverse/Oblique	17	0.4
Mode of Delivery	Spont.Vaginal Delivery	2605	65.1
	Instrumental delivery	85	2.1
	CS	1314	32.8
	CS emergency	1149	87.4
	CS planned	165	12.6
Number of fetus at birth (n=4165)	Singleton	3850	92.4
	Multiple	315	7.6

Type of multiple births (n=315)	Twin	292	92.7
	Triplets	19	6.0
	Quadruplets	4	1.3
Birth Weight (in grams) (n=4165)	<2500	592	14.2
	2500-4000	3355	80.6
	>4000	188	4.5
	Not recorded	30	0.7
Previous CS (n=2358)	Yes	438	18.6
	No	1920	81.4

Instrumental delivery includes; vacuum and forceps delivery. ANC- antenatal clinic visit, CS caesarean section

Robson Ten Group Classification System

Table 3 shows the women who gave birth according to Robson classification. We notice that the groups most represented by type of obstetrics population (group size) were: multiparous women without previous CS; women with a singleton pregnancy in spontaneous labour (group 3); nulliparous women with singleton pregnancy in spontaneous labour (group 1); and women with pre-term birth (group 10).

The overall CS rate in this study was 32.8% (95% CI: 31.4%, 34.3%). The major contributors to the overall CS rate were: Group 1 (nulliparous women with singleton pregnancy in spontaneous labour), group 5 (multiparous women with at least one previous CS) and group 3 (multiparous women without previous CS, with singleton pregnancy in spontaneous labour) (Table 3).

From an obstetrician's perspective, the most common indications for CS were fetal compromise, obstructed labour and previous CS (Figure 1: Indications for performing caesarean section (CS) among women who gave birth at Hawassa University Referral Hospital, Ethiopia, 2018-2019). In this study, 227/1314 (17.3%) CS were performed for absolute maternal indications. For non-absolute indications, CS was performed in 968/1314 (73.7%) of cases, mainly non-reassuring fetal heartbeat pattern (fetal distress). The remaining 9.0% of CS could not be classified in this way, and included post-term pregnancy, premature rupture of membrane, multiple pregnancies, and polyhydramnios/oligohydramnios.

Table 3. Robson's Classification system among women who gave birth at Hawassa University Referral Hospital, Hawassa, South Ethiopia, 2018-2019

Robson Group	CS in Group	Number in Group	Group size (%)	CS in group (%)	Absolute group contribution to overall CS rate (%)	Relative contribution of the group to the overall CS rate (%)
Group 1 (nulliparous with singleton pregnancy in spontaneous labour)	301	1094	27.3	27.5	7.5	22.9
Group 2 (nulliparous women with singleton pregnancy who had induced labour or pre-labour CS)	97	227	5.7	42.7	2.4	7.4
Group 2a (induced labour)	55	185	4.6	29.7	1.4	4.2
Group 2b (pre-labour CS)	42	42	1.1	100.0	1.0	3.2
Group 3 (multiparous women without previous CS, with singleton pregnancy in spontaneous labour)	227	1356	33.9	16.7	5.7	17.3
Group 4 (multiparous without previous CS, singleton with induced labour or pre-labour CS)	68	158	3.9	43.0	1.7	5.2
Group 4a (induced labour)	33	123	3.1	26.8	0.8	2.5
Group 4b (pre-labour CS)	35	35	0.8	100.0	0.9	2.7

Group 5 (multiparous women with at least one previous CS)	281	362	9.0	77.6	7.0	21.4
Group 5.1 (one previous CS)	214	290	7.2	73.8	5.3	16.3
Group 5.2 (two or more previous CS)	57	72	1.8	79.2	1.4	4.3
Group 6 (nulliparous women with singleton breech)	38	46	1.2	82.6	0.9	2.9
Group 7 (multiparous women with singleton breech)	58	65	1.6	89.2	1.4	4.4
Group 8 (all multiple pregnancies)	91	154	3.9	59.1	2.3	6.9
Group 9 (all women with transverse or oblique lie)	16	16	0.4	100.0	0.4	1.2
Group 10 (all women with pre-term delivery)	137	526	13.1	26.0	3.4	10.4
Total	**1314**	**4004**	**100.00**	**32.8**	**32.8**	**100.00**

Group size (%) =n of women in the group/total number of women who gave birth in the hospital × 100.

Group CS rate (%) =n of CS in the group/total number of women in the group × 100.

Absolute contribution (%) =n of CS in the group/total number of women who gave birth in the hospital × 100.

Relative contribution (%) =n of CS in the group/total number of CS in the hospital × 100.

Discussion

A high proportion of women who gave birth in Hawassa University Referral Hospital were through CS, almost a third. The major contributors to the overall CS rate were group 1 (nulliparous with singleton pregnancy in spontaneous labour), group 5 (multiparous women with at least one previous CS) and group 3 (multiparous women without previous CS, with singleton pregnancy in spontaneous labour). The most commonly reported indications for CS were a fetal compromise, previous CS and obstructed labour.

In this study we interpreted the findings based on Robson's implementation manual (20): thus, we assessed the quality of the data, the population attending the services (shown in Appendix 1), and we analysed the proportion of CS in each group (shown in Appendix 2).

Our study had several strengths. To our knowledge, this study is the first study at a major hospital in Ethiopia that assessed the CS rate using Robson's Ten Group Classification System for all labouring mothers. The birth registration was prospective and consecutive; hence the risk of incomplete data were minimized. All women who gave birth in the hospital during the study were included and this may have reduced selection bias.

The study also had some weaknesses. The study was conducted in a single hospital, and since it is a referral hospital, the selection of participants may be biased to some degree, and for this reason the findings might be less generalizable. However, standardization according to Robson is able to be used in such situations. Its use permits valid and useful comparisons to be done even at different levels of care. Another weakness is that the study used birth weight to determine gestational age for some mothers, and this could lead to a misclassification of some births into a wrong Robson group. We assessed whether this results in misclassification among Robson group according to WHO Robson implementation manual and the risk of misclassification was minimal. A third potential weakness involved inconsistent use of partogram and fetal heartbeat. This makes the criteria for decisions and indications for CS unclear and left much up to individual doctor's discretion.

The manual for interpretation of CS rates stated that the size of group 9 (women with *transverse lie*, singletons pregnancy), should be less than 1% of the total and the CS rate

should be 100% for this group (20). In our study, the size of group 9 was 0.4% and the CS rate in this group was 100%, suggesting minimal misclassification in this group, and the size of group 9 was similar to other studies (20, 25, 26)

In our study several indicators were in line with the comparison populations given in Robson's manual; the proportion of women with *breech* pregnancy (group 6 and 7), the ratio of the size of group 1 (nulliparous women with singleton pregnancy in *spontaneous labour*) and group 2 (nulliparous women with singleton pregnancy, who had induced labour or *pre-labour CS*), as well as the ratio of the size of group 3 (multiparous women without *previous CS*, with singleton pregnancy in *spontaneous labour*) and group 4 (multiparous women without *previous CS*, with singleton pregnancy, who had induced labour or *pre-labour CS*) (20, 25, 26). However, the proportion of group 1 (*nulliparous* women with singleton pregnancy in *spontaneous labour*) and group 2 (*nulliparous* women with singleton pregnancy, who had induced labour or *pre-labour CS*) was slightly lower than the comparison populations (20, 25, 26). This may be due to the low proportions of nulliparous women in our study. The proportion of group 3 (*multiparous* women without previous CS, with singleton pregnancy in *spontaneous labour*) and group 4 (*multiparous* women without previous CS, with singleton pregnancy, who had induced labour or *pre-labour CS*) was higher than the Robson reference population (20). This may be explained by the fact that we had a high proportion of multiparous women in our study populations. According to Robson, the proportion of group 5 (multiparous women with at least one *previous CS*) should, be about half of all the CS. In our study, the proportion of group 5 represents less than 10% of the total women delivered in the hospital, which may reflect a low CS rate in previous years. The proportion of group 8 (women with multiple pregnancies) and group 10 (women with preterm pregnancy) in our study was similar with the comparison population (20, 25, 26).

The CS rate in Robson group 1 (*nulliparous* women with singleton pregnancy in *spontaneous labour*) was 27.5%, which is much higher than Robson's examples showing that rates under 10% are achievable (20). This may reflect a selection among nullipara, where many normal spontaneous deliveries take place at lower health facilities (health centres and primary hospitals), and those who attend this referral hospital are selected,

either referred or they decided themselves for unknown reasons to attend the hospital. Alternatively, it may reflect a low "threshold" interpreting criterion for a CS.

The CS rate in group 2 (*nulliparous* women with singleton pregnancy, who had labour induced or *pre-labour CS*) was similar to the comparison populations (25, 26), but higher than Robson's guideline (CS rate between 20-35) (20). This may reflect that the threshold for deciding on doing CS is too low, and this may happen at extremely busy labour wards; for example, the ward is so busy that calling a doctor and suggesting a CS in a case of slow progress may be preferred to a time-consuming trial of labour. This "low" CS threshold may explain why group 3 (*multiparous* women without previous CS, with singleton pregnancy in spontaneous labour) also had a higher CS rate (17%) than the comparisons (3-5%) (20, 25, 26). It could also be partly due to some misclassification by including women from group 5 (multiparous women with at least one *previous CS*) in group 3, but this is less likely.

Robson guideline stated that the CS rate in group 4 (*multiparous* women without a previous CS, with singleton pregnancy, who had induced labour or *pre-labour CS*) is rarely should be higher than 15%, while in our study this rate was much higher (43%). This may be because of the high CS rate in women who underwent induction of labour (group 4a) (26.8%), which contributed to the high overall CS rate in group 4. Also, it may partly be due to a high proportion of failed inductions, or possible misclassifications by including group 5 (multiparous women with at least one *previous CS*) in group 4.

The CS rate in group 5 (multiparous women with at least one *previous CS*) in our study was 77.6%, which is higher than the Robson guideline (50-60%) (20). This indicates that in our study, too few women were offered a trial of labour after having had previous CS.

The CS rate for breech in group 6 (*nulliparous* women with singleton *breech* pregnancy) and group 7 (*multiparous* women with a singleton *breech* pregnancy including previous CS) in our study was similar to comparison populations (20, 25, 26).

The examples given by Robson in his guideline stated that nullipara and women with a previous CS contribute to 66% of CS at the hospital, comprising group 1 (*nulliparous* women with singleton pregnancy in *spontaneous labour*), group 2 (*nulliparas* women with singleton pregnancy, who had induced labour or *pre-labour CS*) and group 5 (*multiparous* women with at least one *previous CS*) (20). In our study, the relative contribution of these three groups (1,2,5) to the overall CS rate was 51.7%. This difference may be that the study area had few nullipara with planned CS, as seen in the low relative contribution of group 2 (*nulliparas* women with singleton pregnancy, who had induced labour or *pre-labour CS*) to the overall CS rate which in our study was (7.38%).

The overall CS rate in our hospital (32.8%) is higher than the WHO recommendation 10-15% (3). The high CS rate in our study may be due to several issues. One probable factor could be that the hospital is a referral hospital where more than a third of women referred to this hospital with different emergency situations that may need emergency management through CS delivery. Another factor could be that Hawassa University referral hospital as a teaching hospital has doctors under specialist training performing CS without following strict indications for performing CS. In our study hospital, there is no one-to-one midwifery-led care, and this may also be a possible reason for the high caesarean section rate in our study. Several studies have shown midwifery-led care to significantly reduce caesarean section rate (27-31). In addition, there was no support of companion during labour in our hospital, and several studies showed that support from a companion during labour and childbirth reduced caesarean section rate and improved maternal and newborn birth outcomes (32-34). Another possible driving factors for this high CS rate could be the hospital is a referral hospital where more than a third of women referred to this hospital with different emergency situations that may need emergency management through CS delivery (35). Nearly three-quarters (73.7%) of CS in this study was performed for non-absolute maternal indications, mainly fetal distress, and CS may be performed for some women without clear appropriate indications. Fetal monitoring was not optimal, and this may have contributed to the high prevalence of "fetal distress". Also, a large proportion were urban women (91.6%) who gave birth in the hospital, and urban women are shown to have higher CS rates than the rural women in other settings also (36-38).

Our study showed that Robson group 1 (*nulliparous* women with singleton pregnancy in *spontaneous labour*), group 5 (multiparous women with at least one *previous CS*) and group 3 (*multiparous* women without previous CS, with singleton pregnancy in *spontaneous labour*) were the major contributors to the overall CS rate. These same groups were the major contributors in the eastern Ethiopia and elsewhere (16, 39-44), though the order was different. The difference in the order of these groups among the studies may because of the variation in study populations and overall CS rate (20). The high contribution of emergency CS in nullipara (group 1, nulliparous women with singleton pregnancy in spontaneous labour) in our study may be related to inappropriate indications of CS delivery in this group in our study hospital. More than one third (35%) of CS performed in this group is due to abnormal fetal heartbeat patterns. This was high, indicating the possibility of misdiagnosis of abnormal fetal heartbeat pattern. A more active use of the partogram as a tool for decision-making would help clinicians and midwives decide more consistently, instead of relying on too heavily health care workers individual assessment in a busy ward.

The most commonly reported indications for CS were fetal compromise, previous CS and obstructed labour; similar indications have been reported from eastern Ethiopia (16) and elsewhere in Africa, Asia and Australia (42, 44-47).

In conclusion, this study has shown a high overall CS rate at Hawassa University Referral Hospital. Nulliparous women with singleton pregnancy in spontaneous labour (group 1), multiparous women with at least one previous CS (group 5) and multiparous women without previous CS, with singleton pregnancy, in spontaneous labour (group 3) were the major contributors to the overall high CS rates. Fetal compromise, previous CS and obstructed labour were the major indications for performing CS. There was a high CS rate in low-risk groups (group 1 and 3). We recommend that all labouring women be regularly followed with partogram, and that they be given the opportunity for instrumental delivery to decrease the use of primary CS among low risk groups. Fetal heartbeat monitoring system should be improved to reduce unnecessary CS that could be done due to misdiagnosis of fetal distress. The implementation of midwife-led care and involvement of a companion during labour and childbirth should also be considered. The reasons for the high CS rate among low-risk groups should be explored and the appropriateness of CS

should be evaluated to reduce the overall CS rate, which benefits the health system, in general.

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Author Contributions:
AAA and BL conceived the study and analysed the data. AAA wrote the proposal and the first draft of the manuscript. SGH, AGT, and BL supervised and provided mentorship. All authors contributed to the writing and reviewed the article and approved the final version of the manuscript.

Patient consent: Written consent was obtained from all delivering mothers to participate in this study. The interview was conducted at a convenient time for the women; before delivery and after delivery before discharge from the hospital, and no woman declined to participate in the study. Written consent was obtained from illiterate women after data collectors read information described in the consent form in the language they can understand. After they agreed on the information read for them, they signed on the consent form by using their thumb stump (fingerprint).

The consent was made according to ethical principles of "autonomy" by including statements

that give participants the right to decline participation in the study at any time. The consent also included statements of potential risk, benefits and confidentiality.

Ethics approval: This study was approved by Hawassa University College of Medicine and Health Sciences Institutional Review Board (ref.no.IRB/007/10), and Regional Ethical Committee (Rek Vest) (ref.no.2018/595) in Norway.

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LEGENDS

Figure 1. Indications for performing caesarean section (CS) among women who gave birth at Hawassa University Referral Hospital, Ethiopia, 2018-2019)

Box 1. Robson's 10-group classification

Table 1. Socio-demographic characteristics of women who gave birth at Hawassa University Referral Hospital, Ethiopia, 2018-2019.

Table 2. Obstetrics characteristics of women who gave birth and their outcomes, at Hawassa University Referral Hospital, Ethiopia**,** 2018-2019

Table 3. Robson's Classification system among women who gave birth at Hawassa University Referral Hospital, Hawassa, South Ethiopia, 2018-2019

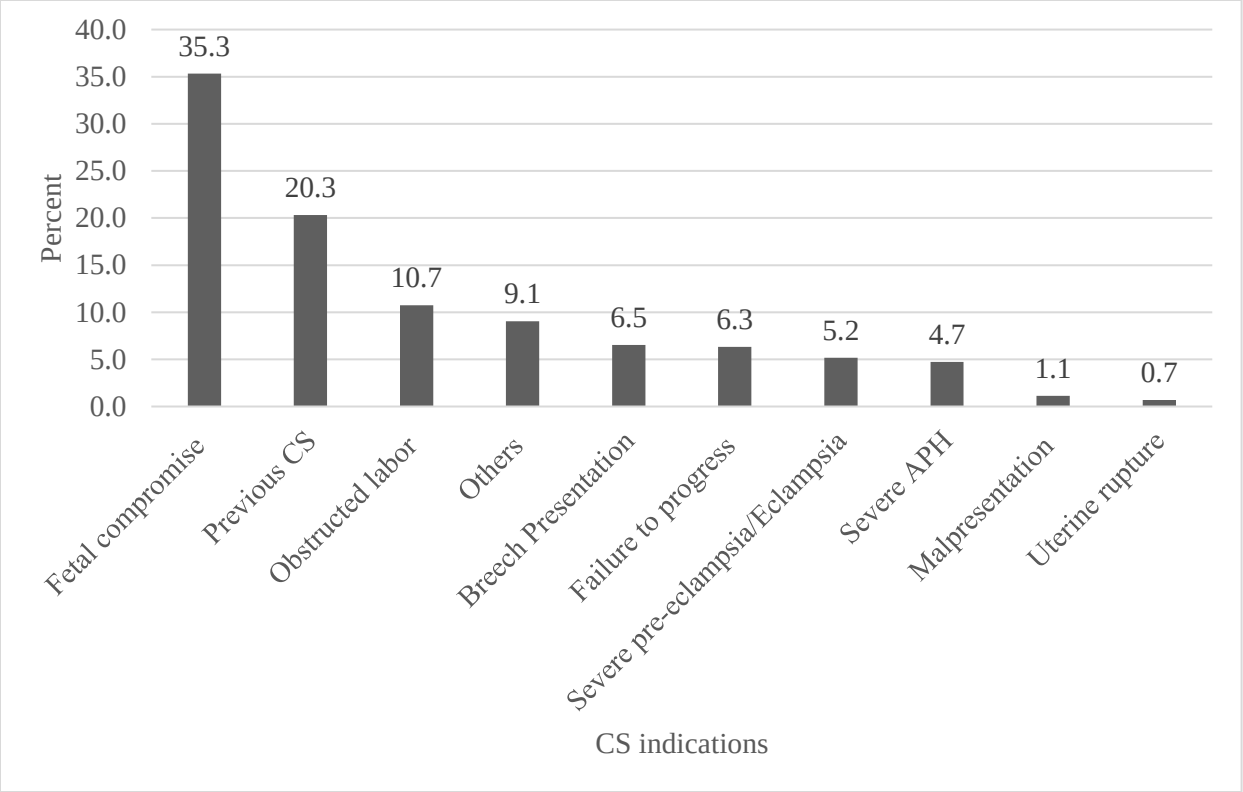

Figure 1. Indications for performing caesarean section (CS) among women who gave birth at Hawassa University Referral Hospital, Ethiopia, 2018-2019**.**

Foetal compromise = Foetal distress, cord prolapse, and intrauterine growth restriction. Failure to progress = Prolonged labour, cervical arrest, and failed induction. Obstructed labour = Cephalopelvic disproportion, macrosomia, and unspecified disproportions. Malpresentation = Transverse, oblique or brow. Others = Post term pregnancy, premature rupture of membrane, multiple pregnancies and polyhydramnios/oligohydramnios.

APH, antepartum haemorrhage.

Appendix 1: Assessment of the type of Populations among women who gave birth at Hawassa University Referral Hospital, Hawassa, South Ethiopia.

Steps for Interpretation	Interpretation by Robson	Example: MCS Population	Sri Lanka study	Our finding	Additional information from the data	Final Interpretation
Step 1: Size of group1+ 2	35-42%	38.1%	38.1%	32.99%	Nulliparas in our population 41.1%	Rate is lower than all the three references by Robson, MCS and Sri Lanka populations. This might be due to a low proportion of nullipara women in our Hospital. There is also a possibility of misclassification (group 1 misclassified as group 10) since we determined gestational based new-born birth weight.
Step 2: Size of Group 3+4	30%	46.5%	37.3%	37.81%	Multiparous in our population 58.9%	Rate higher than Robson reference population, in line with Sri Lanka reference population and lower than MCS examples. This may be explained by a high proportion of multiparous women in our population
Step 3: Size of group 5	Half of the total CS rate	7.2%	10.9%	9.04%	-	Lower than half of total CS. This, as suggested by the WHO manual, may be due to relatively low CS rate in the previous years, or to a recently increased CS rate or misclassification.
Step 4: size of group 6+7	3-4%	2.7%	3.4%	2.77%	-	Rate is in line with Robson, MCS and Sri Lanka reference populations
Step 5: Size of group 8	1.5-2%	0.9%	1.1%	3.85%	36.7% of women delivered in our Hospitals	Rate is higher than Robson, MCS and Sri Lanka reference populations. This may be due to high referral cases in our hospital as suggested by the WHO manual.

					were referred cases	
Step 6: Size of group 10	<10%	4.2%	7.8%	13.14%	15.1% of all women who gave birth in our hospital delivered preterm birth.	Rate is higher than Robson, MCS and Sri Lanka reference populations. This may be due to high referral cases and high preterm birth in our hospital. The hospital is a tertiary hospital were most high-risk pregnancies referred to. There is also a possibility of misclassification since we determined gestational based new-born birth weight.
Step 7: Ratio of the size of group 1 versus group 2	Ratio 2 or higher	Ratio 3.3	Ratio 1.5	Ratio 4.8	-	The rate in line with Robson and MCS example reference populations
Step 8: Ratio of size of group 3 versus group 4	>2:1	Ratio 6.3	Ratio 2.6	Ratio 8.6	-	Rate in line with Robson and MCS example refence populations
Step 9: Ratio of size of group 6 versus group 7	Usually 2:1	Ratio 0.8	Ratio 1.2	Ratio 0.7	Multiparous in our population 58.9%	The rate in line with MCS and Sri Lanka reference populations, but lower than Robson references. This may be explained by a high proportion of Multiparous women in our population.

Appendix 2: Assessment of CS Rates among women who gave birth at Hawassa University Referral Hospital, Hawassa, South Ethiopia.

Steps for Interpretation	Interpretation by Robson	Example: MCS Population	Sri Lanka study	Our finding	Additional information from the data	Final Interpretation
Step 1: CS rate in group 1	Under 10% are achievable	9.8%	18.8%	27.5%	35.0% of CS delivery is due to Abnormal foetal heartbeat pattern in our hospital	CS rate is higher than Robson, MCS, and Sri Lanka. This might due to a high ratio of group 1 to group 2 population in our study which indicates a higher CS rate in these groups as suggested by the WHO manual. It might also due to inappropriate indications of CS delivery in our hospital.
Step 2: CS rate in group 2	Consistently around 20%–35%	39.8%	41.0%	42.7%	- Failed induction was an indication in 36.0% of group 2a.	CS rate in line with Sri Lanka, but higher than MCS and Robson references. This may be possibly due to inappropriate indications of CS in the induction of labour and pre-labour CS.
Step 3: CS rate in Group 3	Not higher than 3.0%.	3.0%	5.2%	16.7%	-Obstructed labour was an indication in 51.5%.	CS rate is higher than Robson, MCS, and Sri Lanka. This may be explained by misclassification (group 5 misclassified as group 3).
Step 4: CS rate for group 4	It rarely should be higher than 15%	23.7%	16.8%	43.04%	Failed induction was an indication in 24.0% of group 4a.	CS rate is higher than Robson, MCS, and Sri Lanka. There was a high CS rate in group 4a (26.8%) which contributed to the high CS rate in group 4 in our study. The possible explanation may high failed induction or there might be misclassifications (group 5 misclassified as group 4).

Step 5: CS rate in group 5	Rates of 50%– 60% are considered appropriate	74.4%	81.8%	77.6%	Previous CS was the indication in 72.8%. Rate of prelabour CS was 33.9%	CS rate is higher than Robson and MCS examples but lower than the Sri Lanka study. This may be due to a high indication of CS due to previous CS, low offer of a trial of labour or VBAC (Vaginal birth after CS delivery), women's preference for repeating CS.
Step 6: CS rate for group 8	Usually around 60%	57.7%	80.9%	59.1%	-	CS rate in line with Robson and MCS example.
Step 7: CS rate in group 10	Usually around 30%	25.1%	41.1%	26.05%	-	CS rate in line with Robson and MCS example
Step 8: Relative contribution of groups 1, 2 and 5 to the overall CS rate	Normally contribute to 2/3 (66%) of all CS performed in most hospitals	Contributed to 63.7% of all CS	63.9%	51.7%	The relative contribution of group 2 to the overall CS rate was low (7.38%).	CS rate lower than Robson, MCS example and Sri Lanka study. This may be due to the relative contribution of group 2 to the overall CS rate which was low. The size of group 2 may also be contributed due to the misclassification of the pre-term as a term.
Step 9: Absolute contribution of group 5 to overall CS rate	NA	Responsible for 28.9% of all CS	Absolute contribution: 8.87% Relative contribution: 29.59%	Absolute contribution: 7.02% Relative contribution: 21.39%	-	The absolute contribution was not indicated in the WHO Robson manual, but our study finding was lower than the MCS example and Sri Lanka study.

STROBE_ Cross sectional Check list

		Reporting Item	Page Number
Title and abstract			
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	#3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	#4	Present key elements of study design early in the paper	4
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	4
	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5

Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	5,6
Bias	#9	Describe any efforts to address potential sources of bias	6
Study size	#10	Explain how the study size was arrived at	N/A, we have included all laboring mothers during the study period.
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	5
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	6,7
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	N/A, our study was purely descriptive
Statistical methods	#12c	Explain how missing data were addressed	7
Statistical methods	#12d	If applicable, describe analytical methods taking account of sampling strategy	N/A, our study design descriptive and no sampling strategy used
Statistical methods	#12e	Describe any sensitivity analyses	N/A, we used WHO Robson implementation manual to assess misclassification among Robson's group
Results			
Participants	#13a	Report numbers of individuals at each stage of	8

		study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	
Participants	#13b	Give reasons for non-participation at each stage	8
Participants	#13c	Consider use of a flow diagram	8, we used text description instead of flow diagram
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	8,9
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	9, 10
Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	9, 10, 11
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	N/A, our study was descriptive
Main results	#16b	Report category boundaries when continuous variables were categorized	9,10,11
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A, our study was descriptive
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	N/A, our study was descriptive

Discussion			
Key results	#18	Summarise key results with reference to study objectives	14
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	14
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	14-18
Generalisability	#21	Discuss the generalisability (external validity) of the study results	14
Other Information			
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	19