Use of an individual-patient database for analysing caesarean section practices according to the WHO Manual for Robson classification and for developing quality improvement recommendations: a study in Sri Lanka

Supplementary file

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Supplementary Table 1. Missing cases for the variables of interest

Variables	Total	Missing	% Missing
Maternal age	7504	34	0.4
Parity	7504	34	0.4
Gestational age at delivery	7504	47	0.6
Previous caesarean section	7504	38	0.5
If previous caesarean section, trial of labour	7504	91	1.2
Multiple pregnancies	7504	35	0.4
Presentation	7504	43	0.6
Labour onset	7504	36	0.4
Delivery	7504	32	0.4
Delivery mode	7504	37	0.4
If operative delivery, indication	7504	38	0.5
If caesarean section, type	7504	37	0.4
Indication of labour	7504	36	0.4
Mode of induction	7504	42	0.5
Pre-gestational diabetes	7504	35	0.4
Gestational diabetes mellitus in diet	7504	35	0.4
Gestational diabetes mellitus in drug therapy	7504	36	0.4
Pre-gestational hypertension	7504	33	0.4
Gestational hypertension (no proteinuria)	7504	35	0.4
Pre-eclampsia not severe	7504	35	0.4
Pre-eclampsia severe	7504	35	0.4
Eclampsia	7504	34	0.4
BMI	7504	53	0.7
Maternal cardiac disease	7504	34	0.4
Polyhydramnios	7504	36	0.4
Oligohydramnios	7504	38	0.4
IUGR	7504	36	0.4
APH/major placentia previa	7504	37	0.4
Severe anaemia	7504	38	0.5
Chorioamnionitis	7504	36	0.4

Abbreviation: APH= Antepartum haemorrhage; BMI= Body mass index; IUGR= Intrauterine growth restriction.

Supplementary Table 2. Steps to assess quality of data [1]

Step	Interpretation by Robson	Example: MCS population*	Further Interpretation
1. Look at the total numbers of CS and of women delivered in your hospital	These numbers should be identical to the total number of CS and of women delivered in your hospital.	NA	If these numbers do not match, then data is missing or incorrect. Some women may not have been classified in the Robson groups because of missing variables or were incorrectly classified as to type of delivery. Sometimes multiple pregnancies are counted as babies rather than mothers.
2. Look at the size of Group 9. Singletons in transverse or oblique lie	It should be less than 1%.	0.4%	If this is > 1%, it is probable that women with breech (or other) presentations have been misclassified as transverse /oblique lie and allocated to this group. As the classification includes all women who have delivered, if any one group is smaller or bigger, look to the other groups which sometimes will show where the misclassification is.
3. Look at the CS rate of Group 9	It should be 100% by convention.	88.6%	By convention, if the woman gives birth vaginally by internal version, it should be classified as either cephalic or breech. The CS rate in Group 9 should be 100%

Notes: *MCS reference population was the population of the MCS with relatively low CS rates and, at the same time, with good outcomes of labour and childbirth.

Abbreviations: CS= caesarean section; NA= not available.

[1] World Health Organization. Robson Classification: Implementation Manual. Geneva, 2017.http://www.who.int/reproductivehealth/publications/maternal_perinatal_health/robson-classification/en/ (accessed 28 June 2018)

Supplementary Table 3. Steps to assess type of population [1]

Step	Interpretation by Robson	Example: MCS population*	Further Interpretation
1. Look at the size of Groups 1 + Group 2. Nulliparous women ≥37 weeks gestation singleton cephalic	This usually represents 35-42% of obstetric population of most hospitals.	38.1%	In settings with high proportion of women who have only one child rather than more than one child, the group of nulliparous women i.e. Groups 1 and 2 tends to be larger. In settings where the opposite is true, the size of Groups 1 + Group 2 will be smaller since most of the population will be represented by multiparous women.
2. Look at the size of Groups 3 + 4 -Multiparous women ≥37 weeks gestation singleton cephalic, without previous CS	This usually represents about 30% of women.	46.5%	In settings with high proportion of women with more than one child rather than only one child, the size of Groups 3 + Group 4 will be higher than 30% (provided they have delivered vaginally). Another reason for a low size of Groups 3 and 4 could be that the size of Group 5 is very high which would be accompanied by a very high overall CS rate.
3. Look at the size of Group 5 - Multiparous women ≥37 weeks gestation singleton cephalic with previous CS	It is related to the overall CS rate. The size of Group 5 is roughly usually about half of the total CS rate. In settings with low overall CS rates, it is usually under 10%.	7.2%	The size of Group 5 is usually related to the overall CS rate. If the size of this group is larger, it means that there has been a high CS rate in the past years in that hospital and mainly in Groups 1 and 2. In places with high CS rates, the size of this group could be > 15%.
4. Look at the size of Groups 6 + 7 Breeches in nulliparous & multiparous women	It should be 3-4%	2.7%	If the total is much over 4%, the most common reason is usually a high rate of preterm deliveries or a higher proportion of nulliparous women. Therefore, look at size of Group 10. If that is over 4-5%, this hypothesis

[1] World Health Organization. Robson Classification: Implementation Manual. Geneva, 2017.http://www.who.int/reproductivehealth/publications/maternal_perinatal_health/robson-classification/en/ (accessed 28 June 2018)

			could be true.
5. Look at the size of Groups 8 - Multiples	It should be 1.5-2%	0.9%	If it is higher, the hospital is probably tertiary (high risk, referral) or runs a fertilization program. If lower, probably a lot of the twins are referred out especially if the remaining twins have a low caesarean section rate
6. Look at the size of Groups 10 - Preterm cephalic singletons	It should be less than 5% in most normal risk settings.	4.2%	If it is higher, the hospital is probably tertiary (high risk, referral) or there is a high risk of preterm births in the population that the hospital serves. If, in addition, the CS rate is low in this group, it could represent a preponderance of spontaneous preterm labour. If the CS rate in this group is high, it could suggest more provider-initiated pre-labour CS for foetal growth restriction or pre-eclampsia and other pregnancy or medical complications.
7. Look at the Ratio of the size of Group 1 versus Group 2 (Divide the size of Group 1 by the size of Group 2) - Nullipara term cephalic singletons spontaneous labour / Nullipara term cephalic singletons induced or pre-labour CS	It is usually 2:1 or higher	Ratio 3.3	If it is lower, suspect poor data quality: nulliparous women who received oxytocin for augmentation (acceleration) of labour (and should be in Group 1) may have been misclassified as “induction” (and incorrectly classified as Group 2). If data collection is correct, a lower ratio may indicate that you have a high induction/prelabour CS issue which may indicate a high-risk population in nulliparous women and are likely therefore to have a high CS rate. Additional information on pre-labour stillbirths would be the next question to ask. On the contrary, if the ratio is very high, you may want to look at your pre-labour stillbirth rate in this population which may indicate that

			you are not inducing enough. Or alternatively you may have a very low risk population
8. Look at the Ratio of the size of Group 3 versus Group 4. (Divide the size of Group 3 by the size of Group 4): Multipara without previous CS, term cephalic singletons spontaneous labour / Multipara without previous CS, term cephalic singletons induced or pre-labour CS	It is always higher than the ratio of Group 1/Group 2 in the same institution, i.e, larger than 2:1. This is very reliable finding in confirming data quality and culture of the organization.	Ratio 6.3	If it is lower, suspect poor data quality: multiparous women who received oxytocin for "augmentation" of labour (and should be in Group 3) may have been misclassified as "induction" (and incorrectly classified as Group 4). A low ratio (due to large Group 4b) may suggest a poor previous maternal experience in vaginal delivery and a request for pre-labour CS in multiparous women. Another explanation may be pre-labour CS done to perform tubal ligation (common in settings where family planning is not easily available).
9. Look at the Ratio of the size of Group 6 versus Group 7. (Divide the size of Group 6 by the size of Group 7) Nullipara breech / Multipara breech	It is usually a 2:1 because breeches are more frequent in nulliparous women than in multiparous women.	Ratio 0.8	If the ratio is different, suspect either unusual nullipara/multipara ratio or inaccurate data collection.

Notes: *MCS reference population was the population of the MCS with relatively low CS rates and, at the same time, with good outcomes of labour and childbirth.

Abbreviation: CS= caesarean section.

Supplementary Table 4. Steps to assess caesarean section rates [1]

Step	Interpretation by Robson	Example: MCS population*	Further Interpretation
1. Look at the CS rate for Group 1	Rates under 10% are achievable	9.8%	This rate can only be interpreted accurately when you have considered the ratio of the sizes of Groups 1 and 2. In principle, the higher the ratio of size of Groups 1:2, the higher the likelihood of both the CS rate in Group 1 and 2 being individually higher. However, the overall CS rate in Groups 1 and 2 combined may still be low or the same.
2. Look at the CS rate for Group 2	Consistently around 20-35%	39.9%	CS rates in Group 2 reflect the size and rates in 2a and 2b. If size of Group 2b is large, the overall CS rates in Group 2 is also going to be large. If Group 2b is relatively small, then high rates of CS in Group 2 may indicate poor success rates for induction or poor choice of women to induce and consequently a high rate of CS in Group 2a. Remember the general principle of not interpreting one single subgroup on its own without knowing what is left out. The interpretation of group 2a requires knowing the relative sizes of Groups 1 and 2b.
3. Look at the CS rate for Group 3	Normally, no higher than 3.0%.	3.0%	In units with higher CS rates in this group, this may be due to poor data collection. It is possible that women with previous scars (Group 5) were incorrectly classified as Group 3. Other possible reasons for high rates could be for example to do tubal ligation in settings with poor access to contraception, or maternal request.
4. Look at the CS rate for Group 4	It rarely should be higher than 15%	23.7%	CS rates in Group 4 reflect the size and rates in 4a and 4b. If size of Group 4b is large, the overall CS rates in Group 4 is also going to be high. If Group 4b is relatively small, then high rates of CS in Group 4 may indicate poor success rates for induction or poor choice of women to induce and consequently a high rate of CS in Group 4a. Poor data collection could also be a reason for high

[1] World Health Organization. Robson Classification: Implementation Manual. Geneva, 2017.http://www.who.int/reproductivehealth/publications/maternal_perinatal_health/robson-classification/en/ (accessed 28 June 2018)

			CS rates in Group 4; for example, due to inclusion of women with previous scars in this group (when they should be in Group 5). Lastly, a high CS rate in Group 4 may reflect a high maternal request for CS even if these women have delivered their first pregnancy vaginally. This may be because of a previously traumatic or prolonged labour or to do tubal ligation in settings with poor access to contraception.
5.Look at the CS rate for Group 5	Rates of 50-60% are considered appropriate provided you have good maternal and perinatal outcome.	74.4%	If rates are higher, this is possibly due to a large Group 5.2 (women with 2 or more previous CS). This could also be due to a policy of scheduling pre-labour CS for all women with 1 previous scar without attempting a trial of labour.
6. Look at the CS rate for Group 8	It is usually around 60%.	57.7%	Variations will depend on the type of twin pregnancy and the ratio of nulliparous/multiparous with or without a previous scar.
7. Look at the CS rate in Group 10	In most populations it is usually around 30%	25.1%	If higher than 30%, it is usually due to many cases of high risk pregnancies (e.g. foetal growth restriction, preeclampsia) that will need preterm pre-labour CS. If lower than 30%, it suggests a relatively higher rate of preterm spontaneous labour and hence a lower overall CS rate.
8. Look at the relative contribution of Groups 1, 2 and 5 to the overall CS rate (add the contribution of each of these groups)	These three groups combined normally contribute to 2/3 (66%) of all CS performed in most hospitals.	These three groups combined contributed to 63.7% of all CS	These three groups should be the focus of attention if the hospital is trying to lower the overall CS rate. The higher the overall CS rate, the greater the focus should be in Group 1.
9. Look at the absolute contribution of Group 5 to the overall		This group was responsible for 28.9% of all CS	If it is very high, this may indicate that in previous years, CS rates in Groups 1 and 2 have been high and it is worth exploring further.

CS rate			

Notes: *MCS reference population was the population of the MCS with relatively low CS rates and, at the same time, with good outcomes of labour and childbirth.

Abbreviation: CS= caesarean section.

Supplementary Table 5. Template for agreeing actions at hospital level to improve the quality of care

Date: **Group Participants:**

Key findings from the analysis	Possible explanations	Agreed recommendations for quality improvement

Instructions:

1. Identify a moderator whose duty is to make sure that the pre-defined template is filled in pre-established time (90 minutes total), that everyone has the right to speak and actively participate, and that the final version of the table corresponds to group opinions
2. Identify a secretary whose job is to take notes, summarize the opinions of the group in the template, act as a presenter in plenary (15 min maximum), save the template in an electronic file (the results will be attached to final report that will be distributed)
3. Participants are requested to make concise and specific interventions lasting up to 1-2 minutes, leaving the possibility to express their opinions to others. It is required to make proposals with a problem-solving attitude
4. We recommend to fill the first column first (key findings) and then the other lines in horizonal
5. Is not necessary to identify many priorities, 5-10 are enough. For the same priority it's possible to specify 1 or more actions
6. Some examples of different possible actions:
   - *development of policies and operational plans (for training, quality, work conditions, improve data collection and other aspects of database)*
   - *development of protocols and procedures*
   - *theoretical and practical training (related to EBM clinical practices or quality of care)*
   - *periodical audit (clinical, on indicators) or team meetings*
   - *adopt quality standards and targets and implement a monitoring system with periodic analyzes and discussions of data*

Actions should be **SMART: Specific, Measurable, Achievable, Realistic, Time-bound** in the real context of the hospital.

Supplementary Table 6. Characteristics of the population

Population	n (N=7504)	%
Maternal age		
<18 years	95	1.2
18-24 years	1862	24.8
25-34 years	4253	56.6
35-39 years	1036	13.8
>40 years	224	2.9
Parity		
0	3342	44.5
≥1	4128	55.0
Gestational age		
<28 weeks	41	0.5
28-31 weeks	96	1.3
32-36 weeks	571	7.6
>37 weeks	6749	89.9
Previous caesarean section	956	12.7
Cephalic	7122	94.9
Breech	273	3.6
Other	66	0.9
Multiple pregnancies	84	1.1
Labour onset		
Spontaneous	4726	62.9
Induction	1849	24.6
Pre-labour caesarean section	893	11.9
Mode of delivery		
Vaginal spontaneous	4906	65.3
Vaginal operative	310	4.1
Caesarean section	2251	30.0
At least one maternal or foetal pathological conditions	2845	37.9
Pre-gestational diabetes	266	3.5
Gestational diabetes, total	1002	13.4
On diet	417	5.6
On drug therapy	585	7.8
Hypertensive disorders of pregnancy, any	506	6.7
Pre-gestational hypertension	168	2.2
Gestational hypertension	179	2.4
Pre-eclampsia not severe	78	1.0
Pre-eclampsia severe	69	0.9

Eclampsia	12	0.2
Obesity (BMI > 27.5)*	440	5.9
Maternal age > 40 years	224	2.9
Maternal cardiac disease	234	3.1
Oligohydramnios	131	1.8
Polyhydramnios	96	1.3
IUGR**	504	6.7
APH/major placentia previa	112	1.5
Severe anaemia (Hb <7)	40	0.5
Chorioamnionitis	11	0.2

Notes: *as defined on data collection form; **defined as weight < 10 centile of estimated weight for gestational age or < 10 centile for abdominal circumference (Bangladesh growth chart), based on ultrasound.

Abbreviation: APH= Antepartum haemorrhage; BMI= Body mass index; Hb= Haemoglobin; IUGR= Intrauterine growth restriction.

Supplementary Table 7. Main indications to CS

Main indication	n (N=2251)	%
CTG abnormal/suspected foetal distress	610	27.1
Past caesarean section	538	23.9
Failure to progress or failed IOL	261	11.6
Failed IOL	109	4.8
Dystocia 1st stage	77	3.4
Dystocia 2nd stage	75	3.3
Breech/abnormal lie	184	8.2
Hypertension/preeclampsia/eclampsia	100	4.4
IUGR	82	3.6
APH/major placenta previa	68	3.0
Prelabour diagnosis of CPD	57	2.5
History of subfertility/bad obstetric history	47	2.1
Cardiac disease	45	2.0
Maternal request	43	1.9
Multiple pregnancies	40	1.8
Diabetes	25	1.1
Thick meconium	16	0.7
Pre-term	10	0.4
Other	118	5.2
Missing	7	0.3

Abbreviation: APH= Antepartum haemorrhage; CPD= Cephalopelvic disproportion; CTG= Cardiotocography; IOL= induction of labour; IUGR= Intrauterine growth restriction.

Supplementary Table 8. Main indications to CS by Robson group

Robson group Main indication	1	2a	2b	3	4a	4b	5	6	7	8	9	10	Missing	Total
CTG abnormal/suspected foetal distress	155	175	48	60	49	9	49	5	6	3	2*	48	1	610
Past caesarean section	0	0	0	3*	0	1*	467	6	18	2	7*	34	0	538
Failure to progress or failed induction														
Failed induction	0	63	0	0	21	0	15	0	1	1	0	8	0	109
Dystocia 1st stage	27	27	2	8	3	3*	3	0	1	0	0	3	0	77
Dystocia 2nd stage	13	16	3*	1	3	0	33	0	0	0	2*	3	1	75
Breech/abnormal lie	1*	0	1*	1*	0	0	1*	91	55	7	26	1*	0	184
Hypertension/preeclampsia/eclampsia	6	4	9	2	0	4	18	1	0	3	0	52	1	100
IUGR	11	3	9	6	0	3	9	2	4	2	0	32	1	82
APH/major placenta previa	8	2	6	6	0	1	9	2	2	1	3*	27	1	68
Prelabour diagnosis of CPD	25	3	14	0	0	3	7	0	0	2	1*	2	0	57
History of subfertility/bad obstetric history	14	0	16	0	0	2	0	5	0	0	1*	9	0	47
Cardiac disease	7	0	9	2	0	7	10	1	1	1	0	7	0	45
Maternal request	8	0	10	1	0	3	21	0	0	0	0	0	0	43
Multiple pregnancies	0	0	1	0	0	0	1*	0	0	37	0	1*	0	40
Diabetes	5	0	2	2	1	1	7	0	1	0	0	6	0	25
Thick meconium	10	4	1	1	0	0	0	0	0	0	0	0	0	16
Pre-term	0	0	3*	0	0	1*	4*	0	0	1	0	1	0	10
Other	22	3	23	11	4	10	10	1	1	3	5	24	1	118
Missing	2	0	1	1	0	1	2	0	0	0	0	0	0	7
Total	314	300	158	105	81	49	666	114	90	63	47	258	6	2251

Note: * Possible groups misclassifications;

Abbreviation: APH= Antepartum haemorrhage; CPD= Cephalopelvic disproportion; CTG= Cardiotocography; IUGR= Intrauterine growth restriction.

Key findings and comments:

Indications for CS in Group 1:

• Abnormal CTG = 49.4%

• Potentially inappropriate indications (antepartum diagnosis of CPD, bad obstetric history, subfertility, maternal request) = 15%

• Dystocia = 12.7%

Indications for CS in Group 2a:

• Abnormal CTG = 58.3%

• Failed induction = 21%

• Dystocia = 14.3%

Indications for CS in Group 2b:

• Abnormal CTG = 30.4%

• Potentially inappropriate indications (antepartum diagnosis of CPD, bad obstetric history, subfertility, maternal request) = 25%

Indications for CS in Group 3:

• Abnormal CTG = 57.1%

• Dystocia = 8.5%

Indications for CS in Group 4a:

• Abnormal CTG = 60.5%

• Failed induction = 25.9%

• Dystocia = 7.4%

Indications for CS in Group 4b:

• Abnormal CTG = 18.4%

• Maternal/foetal issues = 32.6%

• Other = 20.4%

Indications for CS in Group 5:

• Previous CS = 70.1%
• Abnormal CTG = 7.4%
• Dystocia = 5.4%
• Maternal request = 3.2%

Indications for CS in Group 8:
• Multiple pregnancy = 58.7%
• Breech/abnormal lie = 11.1%

Indications for CS in Group 10:
• Maternal/fetal issues (preeclampsia/diabetes/maternal cardiac diseases/IUGR/APH) 48.1%
• Abnormal CTG 18.6%