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Trends in Caesarean section rates between 2007 and 2013 in obstetric risk groups inspired by the Robson classification: Results from population based surveys in a low resource setting

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Running Title: Birth by Caesarean section in obstetric risk groups in Tanzania

Abstract

Objective

To describe Caesarean section rates and neonatal mortality to assess change in access to life-saving interventions in a rural low resource setting between 2007 and 2013

Design

Population-based cross-sectional study

Setting

Southern Tanzania

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Population
A total of 34,063 women who gave birth in the previous year from 384,549 households

Methods
Using data collected in two geo-referenced household surveys in 2007 and 2013 conducted in the context of two cluster-randomized controlled trials, we described trends in Caesarean section and neonatal mortality in obstetric risk groups, inspired by the 10-group 'Robson' classification

Main outcome measures
Rates of self-reported birth by Caesarean section and neonatal mortality

Results
Population-based Caesarean Section rates increased from 4.0% in 2007 to 6.4% in 2013. In 2013 the lowest Caesarean Section rate was found in multipara whose labour was not induced or augmented (4.4%, 95% CI 3.9-4.9), group that showed an increase of over 50% from 2007 (adjusted prevalence ratio 1.57 (95% Confidence interval 1.34-1.82). Nullipara whose labour was not induced or augmented had rates of 6.2% in 2007 and 8.5% in 2013. Caesarean rates in multiple pregnancies were low at 8.1% (95% CI 5.6-10.5) in 2007 and 14.6% (9.4-19.8) in 2013. Overall neonatal mortality was high: 3.5% in 2007 and 3.2% in 2013 with rates being lowest in multiparous women whose labour was not induced or augmented: 2.4% (95% CI 2.2-2.7%) and 1.7% (95% CI 1.4-2.0%), in 2007 and 2013, respectively.

Conclusion
Although use of caesarean section remains insufficient, and higher rates do not necessarily imply better quality of care our analysis highlights improvements in reaching women with Caesarean section. Rates in multiple birth remained low compared with high income settings

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Keywords: Caesarean section, obstetric risk, Robson classification, neonatal mortality, equity

Tweetable abstract: In Southern Tanzania Caesarean section rates increased over time, but the rate in high-risk births remained alarming low

Abbreviations

CS Caesarean section
PR Prevalence ratio
CI Confidence intervals
WHO World Health Organization

Introduction

Caesarean Section (CS) is the most widely performed operative intervention globally. Without doubt CS can prevent – when medically justified – many maternal and perinatal deaths. Trends in CS are globally monitored as an indicator of access to emergency obstetric care[1] and as part of the Ending Preventable Maternal Mortality strategy.[2] Very low population-based rates of CS reflect a lack of access to life-saving interventions.[3-6]

The optimal CS rate remains controversial with studies suggesting ranges from 10% to 20% to be beneficial for maternal and neonatal mortality.[7-10] However, national rates mask over- and under-provision of CS which often coexist.[8,9,11-13] The overuse of CS is of increasing concern for patient safety.[14] A six-fold higher risk of morbidity and mortality for the mother compared to spontaneous vaginal birth has been described, with even higher risks in sub-Saharan Africa.[15] Unnecessary CS increases costs for health systems and individuals and creates barriers to universal health coverage.[16,17]

Disparate rates have prompted the publications of several classification systems to enable improved comparisons and benchmarking.[18,19] The Robson classification (also called the 10-group classification, Panel 1) categorises births in mutually exclusive groups based on clearly defined obstetric characteristic and has therefore been recommended by the WHO.[14,20]

Most published studies using the Robson classification, particularly in low-income countries, have been based on data from a single hospital. While this is very helpful to analyse trends within institutions, only population-based data will allow the disaggregation by wealth or place of living, allowing insights into equity of access. Accurate recording of variables such as gestational age or onset of labour as well as availability of exact fetal presentation may be challenging in many low-resource settings. Where sub-optimal data and missing information prevents the use of the 10-group classification, a temporary adaptation, such as merging groups, may be a first step.

Inspired by the possibilities of the Robson classification to describe over- and under-provision of CS the objective of this study was three-fold: to explore the usefulness of adapted risk groups, mirroring the Robson groups as far as possible, in settings where sub-optimal data precludes the use of the rigorous Robson classification; to describe trends in CS and neonatal mortality between 2007 and

2013 from population-based household survey data in these adapted groups; and to describe inequalities in access to CS rates in the obstetric risk groups by distance to hospital and wealth status of the household.

Methods

Tanzania is a low-income country and national CS rates have increased from 2% (1991-1995), to 5% (2005-10) and 6% (2011-15).[21,22] High CS rates of above 30% – including in groups with low obstetric risk – are described from large teaching hospitals in Dar-es-Salaam,[23] and in Moshi, Northern Tanzania.[24,25] In contrast, most rural settings have very low CS rates.[22,26,27]

We used data collected in two geo-referenced household surveys in 2007 and 2013 in Southern Tanzania conducted in the context of two cluster-randomized controlled trials. The first survey, a 2007 census of all 243,612 households in five districts, assessed the impact on survival of a strategy of intermittent preventive treatment for malaria in infants (IPTi).[28] In 2013, we surveyed a representative sample of households in the same districts to assess the impact of a home-based counselling strategy on neonatal survival.[29] There was a two-stage sampling procedure within each ward (an administrative structure between village and district), first sampling sub-villages (typically including 80-100 households) with probability proportional to number of households in the sub-village based on the national 2012 census list and reports from ward executive officers. At the second stage we included all households for smaller sub-villages, and used segmentation for sub-villages with more than 131 households. We sampled 169,324 of the 247,350 households listed in the 2012 national census list.[29]

The data were collected in five rural and poor districts of the Lindi and Mtwara regions The area is served by a dense network of 171 primary health facilities where the median distance to any facility was 2.2km in 2013.[27] Emergency obstetric care including CS and blood transfusion is available in six hospitals in the study area and a further two hospitals in neighbouring urban centres. Although funding from the African Development Bank was made available from 2007 to upgrade five larger health centres to provide CS services, none of the resulting operating theatres were functioning in 2013. Maternal health care is free in Tanzania, however, families are often requested to purchase drugs and supplies because of stock-outs.[30]

Data collection

Details on methods are described in detail elsewhere.[28,29] In short, we used a modular questionnaire in Swahili, the national language, adapted from established health surveys.[31] We asked the household head to report on household assets, housing type, and ethnic group. Geo-coordinates were recorded by a mapper. A birth history module for all women of reproductive age (13-49 years) included childbirth outcomes and mode of delivery for live births in the year prior to the survey, including markers of obstetric risk such as multiple births and use of methods to speed up labour. In 2013 the questionnaire also recorded the birth weight, abstracted from the child health card if this

was available. Data collection was done electronically using Personal Digital Assistants (HP iPAQ HX2490 v6.1) and quality assurance included checks of standard ranges, consistency and completeness at the time of data entry.[32]

Definition of outcomes and other variables

Our main outcome is live birth by CS as reported by mothers. As the wording in Swahili is inexact (literally *delivery by operation*) and might be misunderstood as episiotomy or an assisted delivery, we recoded 14 reported CS from 2007 as missing where the mother reported having delivered at home or in a primary facility. In 2013 we included a check question asking any mother who reported a CS if her abdomen was truly cut to increase the accuracy. The application also automatically checked against the place of birth so that no CS was recorded where the mother delivered at home or in a primary facility.

We attempted to categorise the CS according to the Robson classification[14,20] and adapted the categories based on obstetric risk factors in our data set (Panel 1). To define premature birth in the 2007 data, we used the mother's responses on whether the perceived size of the baby was normal or smaller than normal. In the 2013 data set we defined prematurity as a recorded birth weight <2500g or, when this information was missing, the mothers perception of the size of the baby. Parity was available from the birth history information, but as an assessment of stillbirths was not included, parity was constructed based on live births only. In both surveys we asked mothers whether anything was done to speed up labour but we could not formally distinguish whether labour was induced or augmented. We rated any positive answer to this question as a proxy for induction. Information on whether the baby was a singleton or multiple was available from the birth histories. Using this information we categorised the CS in six risk groups (Panel 1).

We were not able to classify women to Robson group 5 'multipara with a previous CS', as no information on previous CS was noted by our questionnaire. Women with a previous scar are rarely if ever induced as practitioners fear uterine rupture. For this reason, we assigned women with a previous CS to group 3 'multipara, no induction or augmentation'. We were also not able to make a separate group for breech presentation (Robson groups 6 and 7) or transverse lie (Robson group 9) as such information was not recorded. This means that groups 1 through 4, which in the original classification would include only cephalic pregnancies, also included transverse lies and breech presentations. In summary, our risk groups computes groups 1 through 4 (including previous CS, breech presentation and transverse lie), group 8 and group 10.

Neonatal mortality was assessed asking mothers about babies born during the past year about their survival.[29] For multiple births, mortality was only assessed for the first twin.

We used information on household wealth and distance to the hospitals at the two different time periods. Wealth quintiles were constructed based on ten household assets using principal component analysis and broken down in five quintiles separately for both surveys.[33] Distance to the hospitals was calculated as straight-line distance based on geographical positioning of each household and the hospital, including three hospitals adjacent to the study districts using the 'nearstat' command provided in Stata 13.

Statistical analysis

We estimated for both surveys separately and for each obstetric group 1) the relative size of the population, reflecting the share of the births taking place in this group; 2) the CS rate; 3) the absolute contribution to the overall CS rate (ie the percentage contributed to the overall CS rate by a group); and 4) the relative contribution to the total CS rate (ie, the absolute contribution expressed as a percentage of the overall rate, reflecting the extent that CS in one group contributes to the overall CS rate).[20,34] We also assessed neonatal mortality in the obstetric risk groups by estimating the proportion of babies who died in the neonatal period.

We used generalised linear models of prevalence ratios (PR) using a binominal distribution and a log link to model risks in wealth and distance groups. These models adjusted for clustering of observations within sub-villages and wards. We further present models adjusted for wealth, distance to hospital, education, occupation, and age.

We imputed the adapted Robson group for 3,984 and 13 births from 2007 and 2013, respectively, which were not classified as mothers felt unable to report on the gestation or the weight of the baby (Figure 1). We used multiple imputation with chained equations suitable for the imputed variables.[35-37] We imputed 20 data sets and the estimations were combined using Rubin's rules (Table S1).[36] Data management and analysis used Stata version 13 (Stata Corp LP, Texas).

Funding

The two surveys were funded by the Bill & Melinda Gates Foundation through the Saving Newborn Lives program of Save the Children. The funders had no role in data gathering, data analysis, or manuscript writing.

Patient involvement

This study uses secondary data analysis, which is why we do not report on patient involvement. The main study included mothers and communities in the development and conduct of the trials. [28,29]

Results

The 2007 and 2013 surveys identified 243,612 and 169,324 households, respectively. We interviewed 196,330 and 127,226 women of reproductive age (13-49 years) (Figure S1). The women reported on 22,243 and 13,820 live births in the year prior to the surveys. 20,271 and 13,793 interviews were linkable to household information and the survival of newborns. We included 20,174 and 13,771 live births in 2007 and 2013, respectively, with information on CS classified into the obstetric risk groups.

The CS rate increased from 4.0% in 2007 to 6.4% in 2013, respectively (adjusted PR 1.51, 95% CI 1.37-1.68)(Table 1). There were important variations in CS rates in relation to wealth (8.3% in the least poor compared to 5.1% in the poorest wealth group), and education (7.0% in women with completed primary or higher education compared to 5.3% in women with no education) in 2013. We found lower CS rates with increasing parity (9.0% in primipara and 5.4% in multiparous women) and higher CS rates in multiples compared to singletons (14.6% in multiple pregnancies and 6.4% in singletons) in 2013. Similar patterns were seen in 2007.

Table 2 shows for each of the obstetric groups, the proportion of women included, the CS rate, the relative and absolute contribution of each group to the overall CS rate as well as neonatal mortality. The majority of women giving birth in these populations were multiparous whose labour was not induced or augmented: 67.1% and 59.1% in 2007 and 2013, respectively. This group was the largest contributor to the overall CS rate both years (44.5% and 40.7%) with a CS rate of 2.7% in 2007 and 4.4% in 2013.

Changes over time show an increase in the CS rate in all groups except those women who were induced or augmented (Table S2). We observed an increase in the CS rate of nearly 60% in multiparous women with a singleton pregnancy without induction or augmentation (adjusted PR 1.57, 95% CI 1.34-1.83). There was a statistically significant reduction in neonatal mortality in this group which was already lower than in the other groups (adjusted PR 0.74, 95% CI 0.60-0.91) while there was no evidence of change in overall neonatal mortality between the two surveys (adjusted PR 0.95, 95% CI 0.84-1.08). The CS rate was 8.1% and 14.6% in multiple pregnancies and 3.5% and 4.4% in small babies in 2007 and 2013, respectively, but mortality rates, which were over 10% in these groups, showed no evidence of improvement despite the increase.

The equity analysis indicated that in all groups, except nullipara, singleton with no induction or augmentation in 2013, CS rates were highest in the least poor quintile and those who lived within 10 km of a hospital. In 2007, we observed a 38% lower CS rate in women of the poorest compared to the least poor quintile in nulliparous women without induction or augmentation of labour (crude PR 0.62, 95% CI 0.43-0.91) (Figure 1A, Table S3). Similarly, we observed a 50% lower CS rate in multiparous women belonging to the poorest compared to the least poor quintile (crude PR 0.50,

95% CI 0.34-0.71). In 2013, there was no evidence of a difference in CS rate between the poorest and least poor in nulliparous women (crude PR 1.03, 95% CI 0.71-1.46) but multiparous women belonging to the poorest quintile had a 60% lower CS rate compared to the least poor quintile (crude PR 0.40, 95% CI 0.27-0.60). We also observed large differences in CS rates between women living furthest (>= 25 km) and nearest (<10km) from a hospital (Figure 1B, Table S4).

Discussion

Main Findings

Our analysis of two large representative household surveys in Southern Tanzania using obstetric risk groups indicated that CS rates remained low in all groups despite a roughly 50% increase in the overall CS rate from 4.0% in 2007 to 6.4% in 2013. Increases in CS rates were seen in all groups except in women whose labour was induced or augmented. Nevertheless, wealth and distance-related inequities did not decrease. Over half of the CS in both years were in multiparous women with singleton, normal size babies. CS rates in multiple births and small babies were low at 15% and 4%, respectively, in 2013. As expected, neonatal mortality was highest in multiple pregnancies and small babies and lowest in multiparous women where labour was neither induced nor augmented.

The low CS rate mirrors the massive access challenge in Sub-Saharan Africa.[5,38] In our study area, facility births almost doubled between the two survey periods, from 41% to 79%.[27] In our view the main reasons for this increase include community awareness of the importance of facility delivery, improved communication and an increase in the availability of motorised transport.[27,29]

A large increase in CS rates between the two surveys was seen in multipara. As our group 3 included women with a previous CS we believe that the increase is largely driven by repeated CS. Trials of labour after a first CS were rarely done in the study area as clinicians fear rupture of the uterus. Thus we interpret the increase as the 'domino' effect that with increasing CS rates more women are in need of a subsequent CS.[39] Although there was a statistically significant increase of CS rates in multiples, rates were very low in both years and likely insufficient to meet the needs: 8% in 2007 and 15% in 2013. Population-based studies from high income countries report levels of 50% and above.[40,41] We also report very low CS rates in small babies. CS rates in preterms from high income countries have been reported at around 30%, although it should be noted that such rates should not be regarded as a benchmark for low resource settings without further considerations. [40,41] Moreover, we saw no change in mortality in these groups: 14% and 13% of multiples died in 2007 and 2013, respectively. [42]

As other studies from Tanzania, we observed lower CS rates in the poorest women and in those living furthest from a hospital.[3,5,22,43] We observed no changes of the association between CS and wealth and distance between 2007 and 2013 suggesting that geographical and economic inequalities in accesses to CS did not improve.

Strength and limitations

To the best of our knowledge, this is the first study using household survey data to evaluate trends in CS in obstetric risk groups similar to the Robson 10-group classification. The data set is large and representative of a rural population allowing disaggregation in relation to wealth and distance.

Our categorisation into obstetric risk group was constrained by the fact that we did not have data on previous CS, fetal lie and presentation,. This precluded a rigorous classification according to the Robson criteria.

CS in women with a previous CS has been identified as an important driver of overall CS.[12] We assume that about one-third to half of the CS rate in the group of multipara without induction of labour could have been due to repeat CS in our study. We believe this limitation does not invalidate the key results but limits the interpretation and comparisons with the Robson group 3. Similarly, we did not have information on fetal lie and presentation so that we could not compute Robson groups 6, 7 and 9 (breech presentation and transverse or oblique lie). Moreover, we also included in the group of women with induced labour those women whose labour was augmented, again because our questionnaire did not provide detailed information. Women's recall of induction and augmentation of labour is also subject to recall bias.[44] Finally, although many studies use birthweight to approximate gestational age in the absence of precise dating of the pregnancy[45] this approach does present an imperfect measurement.

Although population-based surveys as used by study are considered the gold standard to monitor progress in maternal and child health in low-income countries, they have limitations. We consider the women's reports of whether or not they had a CS as relatively reliable, particularly in the 2013 survey as we included check questions. Nevertheless, comparisons between hospitals-based and household-based estimations have indicated that CS rates reported in household surveys tend to be higher although within 95% confidence intervals .[46], We also cannot exclude recall bias in regard to other questions which is an inherent limitation of surveys.

Finally, we had a large number of births in 2007 where the size of the baby was not recorded, and we used the mothers' perception of the baby's size as a proxy for birthweight. We cannot exclude reverse causality between size of the baby and neonatal mortality, because mothers whose baby died might have been more likely to report their baby as having been smaller than usual.

Interpretation

While inequitable access to CS has been described in the literature, our study highlights not only wealth and education-related inequalities but also the failure to provide CS for high-risk women, particularly those with multiple pregnancies. Both the low CS rate and high mortality might be partly the result of inadequate risk screening and referral during antenatal care as proposed elsewhere.[4748]

In the context of revisions of antenatal care programmes in response to new WHO guidelines,[49] we believe that stronger attention to risk screening should be considered which need to include components to monitor the effect of such a policy change.

Efforts to improve quality of care and access to live-saving interventions should target hard-to-reach women in order to avoid widening existing geographic and wealth inequalities without increasing unnecessary CS.[6] Cross-sectional studies such as ours can indicate over- and under-provision of CS in relation to risk groups, but they do not allow casual inference between the CS and neonatal mortality.[14]

Attention to safety and efficient use of resources due to overuse of CS has only come lately on the agenda in low and middle income countries.[16,50] Raising staff awareness to CS rates in relation to obstetric risk groups and health determinants is only one strategy towards assuring that only those in need receive a CS. Ensuring providers skills and training to manage both normal vaginal birth and complications as well as respectful care are also necessary[51]

Lastly, although we believe that our analysis provides important information for clinical care and public health with the limited number of variables available in this setting, it is not intended to replace or amend the recommended Robson classification. Our categorization should be seen as a temporary tool in absence of information necessary for the Robson classification.

Conclusion

To our knowledge, this is the first attempt to analyse population-based CS rates in obstetric risk groups in a low income country. Our analysis in Tanzania highlights insufficient access to CS – particularly in women with multiple births, and poor rural women more generally – and relatively homogeneous increases between the two surveys.

In settings lacking the data needed for the use of the Robson classification, our construction of obstetric risk groups inspired by the Robson groups may serve as a first step to disentangle 'too many' or 'too few' CS, moving beyond the well-established equity analysis in countries where many women still deliver at home and population-based surveys present the only possibility to monitor progress and raise staff awareness of under- and overprovision.

Ethics

Ethical clearance was obtained from the institutional review boards of Ifakara Health Institute, the London School of Hygiene and Tropical Medicine, and the Ethics Commission of the Cantons of Basel-Stadt and Basel-Land, Switzerland. National clearance was through the Medical Research Coordinating Committee of the National Institute of Medical Research in Tanzania through the Tanzanian Commission of Science & Technology (COSTECH) (NIMR/HQ/R.8a/Vol.IX/861 of 3rd Dec 2012). Written consent to participate was obtained from household heads and verbal consent from women answering questions about pregnancy and childbirth.

Conflicts of interest

We declare that we have no conflicts of interest. Completed disclosure of interest forms are available to view online as supporting information.

Authors' contributions

CH, APB, GM and JS conceived the study. CH performed the statistical analysis with guidance from CO and JS. CO supported the multiple imputation work. CH wrote the first draft, all authors commented on the subsequent drafts. CH, EM, FM, and JS designed and supported the data collection. GM and FM supported the discussion and interpretation of findings. All authors read and approved the final version of the manuscript.

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Panel 1: The Robson classification of obstetric risk and adaptations used for this analysis

Original Robson classification		Obstetric risk classification used for this study
1	Nulliparous, singleton, cephalic, >37 weeks' gestational age, in spontaneous labour	Nulliparous, singleton, any fetal lie/presentation, categorised as normal in size or birthweight > 2500 [data from 2013], no induction / augmentation
2	Nulliparous, singleton, cephalic, >37 weeks' gestational age, induced labour or caesarean section before labour	Nulliparous, singleton, any fetal lie/presentation, categorised as normal in size or birthweight > 2500 [data from 2013], induction / augmentation
3	Multiparous (excluding previous caesarean section), singleton, cephalic, >37 weeks' gestation, in spontaneous labour	Multiparous, singleton, any fetal lie/presentation, categorised as normal in size or birthweight > 2500 [data from 2013], no induction / augmentation
4	Multiparous without a previous uterine scar, with singleton, cephalic pregnancy, > 37 weeks' of gestation, induced or cesarean section before labour	Multiparous, singleton, any fetal lie/presentation, categorised as normal in size or birthweight > 2500 [data from 2013], induction / augmentation
5	Previous caesarean section, singleton, cephalic, > 37 weeks' gestation	Information not available
6	All nulliparous with a single breech	Information not available
7	All multiparous with a single breech (including previous caesarean section)	Information not available
8	All multiple pregnancies (including previous caesarean section)	Multiple birth
9	All women with a single pregnancy in transverse or oblique lie (including those with previous caesarean section)	Information not available
10	All singleton, cephalic, <37 weeks' gestation pregnancies (including previous caesarean section)	All babies categorised as small in size or with a birthweight <2500g [data from 2013], unless born as multiples

Table 1: Socio-demographic and obstetric risk factors in study population and change in CS-rates between surveys

	2007 (N=21,178)		2013 (13,796)		2007 (N=21,178)	2013 (13,772)	Increase between surveys	
	n	%	n	%	CS-rate (95% CI)^		PR*(95% CI)	Adj PR (95% CI)
Overall	816		884		4.0 (3.8-4.3)	6.4 (6.0-6.9)	1.59 (1.44-1.76)	1.51 (1.37-1.68)
Region								
Mtwara	8,120	40	6,659	51	4.0 (3.5-4.4)	6.3 (5.7-6.9)	1.59 (1.36-1.86)	1.52 (1.29-1.78)
Lindi	12,058	60	7,113	49	4.1 (3.8-4.5)	6.6 (6.0-7.2)	1.60 (1.41-1.82)	1.53 (1.34-1.75)
Wealth quintiles								
Most poor	3052	15	1798	13	3.3 (2.7-4.0)	5.1 (4.2-6.2)	1.54 (1.17-2.04)	1.53 (1.13-2.06)
Very poor	3618	18	2549	18	3.1 (2.5-3.7)	5.1 (4.4-6.1))	1.68 (1.31-2.15)	1.75 (1.33-2.30)
Poor	4242	21	2800	20	3.6 (3.1-4.2)	6.0 (5.2-7.0)	1.69 (1.36-2.09)	1.66 (1.32-2.07)
Less poor	4220	21	3014	22	3.6 (3.1-4.2)	6.3 (5.5-7.2)	1.73 (1.40-2.14)	1.60 (1.28-2.00)
Least poor	4267	21	3412	25	6.1 (5.4-6.8)	8.3 (7.4-9.4)	1.37 (1.15-1.62)	1.30 (1.09-1.55)
Missing	779	4	199	1	5.0 (3.7-6.8)	9.3 (6.0-14.3)		
Education#								
No education	8,806	44	4,304	31	3.3 (3.0-3.7)	5.3 (4.6-6.0)	1.58 (1.33-1.87)	1.74 (1.45-2.09)
Completed primary or higher	11,291	56	9,412	68	4.6 (4.2-5.0)	7.0 (6.5-7.5)	1.51 (1.34-1.70)	1.51 (1.33-1.71)
Mother's occupation								
Subsistence farmers	19,029	94	12,783	93	3.7 (3.4-4.0)	6.2 (5.7-6.6)	1.67 (1.50-1.85)	1.59 (1.42-1.77)
Other income	827	4	790	6	10.2 (8.3-12.3)	10.0 (7.9-12.4)	0.98 (0.73-1.32)	1.01 (0.73-1.38)
Missing	322	2	199	2				
Distance								
< 10km	3,876	19	2,704	20	6.2 (5.5-7.1)	9.5 (8.5-10.7)	1.53 (1.28-1.82)	1.50 (1.26-1.79)
10-15 km	3,321	17	2,672	19	3.9 (3.2-4.6)	6.1 (5.2-7.1)	1.48 (1.25-2.00)	1.49 (1.16-1.91)
15-25 km	6,480	32	5,084	37	3.7 (3.3-4.2)	5.9 (5.2-6.7)	1.59 (1.33-1.90)	1.49 (1.24-1.79)
> 25km	4500	22	3,124	23	2.8 (2.4-3.3)	4.8 (4.1-5.6)	1.70 (1.35-2.14	1.63 (1.27-2.08)
Missing	2,003	10	189	1				
Mother's Age								
13 – 19	3,073	15	2,679	20	5.9 (5.1-6.7)	7.4 (6.4-8.4)	1.26 (1.03-1.53)	1.33 (1.06-1.67)
20 – 34	13,367	66	8,231	60	3.9 (3.5-4.2)	6.3 (5.8-6.9)	1.64 (1.45-1.87)	1.54 (1.35-1.76)
35 – 49	3,738	19	2,862	21	3.3 (2.7-3.9)	5.9 (5.1-6.8)	1.80 (1.42-2.27)	1.60 (1.26-2.05)
Parity #								
1st birth	4,454	22	4,233	31	7.3 (6.5-8.1)	9.0 (8.1-9.9)	1.24 (1.07-1.43)	1.26 (1.07-1.49)

2nd to 5rd birth	13,383	66	8,442	61	3.3 (3.0-3.6)	5.4 (4.9-5.9)	1.64 (1.43-1.88)	1.57 (1.37-1.81)
6th or more birth	2,339	12	1,095	8	2.4 (1.8-3.1)	5.0 (3.8-6.5)	2.08 (1.43-3.02)	1.82 (1.22-2.71)
Number of babies								
Singleton	19,780	98	13,582	99	3.9 (3.7 -4.2)	6.4 (5.9-6.8)	1.60 (1.45-1.77)	1.52 (1.37-1.69)
Multiple	398	2	190	1	9.3 (6.7-12.5)	14.6(10.1-20.6)	1.58 (0.99-2.52)	1.72 (1.06-2.79)
Induction or augmentation#								
No	19,317	96	12,206	89	3.4 (3.2-3.7)	5.6 (5.2-6.0)	1.62 (1.45-1.80)	1.53 (1.36-1.71)
Yes	858	4	1,566	12	17.6(15.2-20.3)	13.1(11.5-14.9)	0.75 (0.61-0.91)	0.79 (0.63-0.98)
Small or premature baby								
No	14,884	74	12,791	93	4.8 (4.4-5.1)	6.5 (6.1-7.0)	1.36 (1.23-1.51)	1.32 (1.18-1.46)
Yes	1,226	6	967	7	4.2 (3.6-5.5)	5.3 (4.0-6.9)	1.24 (0.85-1.82)	1.31 (0.87-1.97)
Missing	4,068	20	14	0	1.3 (1.0-1.7)	7.8 (1.1-39.6)		

^adjusted for clustering, *PR Prevalence ratio, # missing < 1% of total: missing for education 81 (0.4%) in 2007& 56 (0.4%) in 2013, missing for parity 2 in 2007 and 2 in 2013, missing for induction or augmentation 3 missing in 2007.

Table 2: CS-rates, relative and absolute contribution to overall rates by obstetric risk groups in 2007 and 2013

Obstetric risk group		Relative size of obstetric population (%) (95% CI)		CS rate in Group (%) (95% CI)		Relative contribution to overall CS rate (%) (95% CI)		Absolute contribution to overall CS rate (%) (95% CI)		Neonatal mortality per 100 live births (proportion dying, 95% CI)	
		2007	2013	2007	2013	2007	2013	2007	2013	2007	2013
1 ~	Nulliparous, singleton, normal size, no induction or augmentation	18.5 (17.9-19.1)	22.5 (21.8-23.3)	6.2 (5.4-7.0)	8.5 (7.4-9.5)	28.6 (25.3-31.8)	29.6 (26.6-32.7)	1.2 (1.1-1.4)	1.9 (1.7-2.1)	2.9 (2.3-3.5)	2.9 (2.3-3.5)
2 ~	Nulliparous, singleton, normal size, induction or augmentation	2.3 (2.1-2.6)	5.1 (4.7-5.5)	12.4 (9.3-15.6)	14.7 (11.9-17.4)	7.1 (5.3-8.9)	11.7 (9.4-13.9)	0.3 (0.2-0.4)	0.8 (0.6-0.9)	4.7 (2.6-6.7)	5.2 (3.5-6.9)
3 ~ (incl. 5) #	Multiparous, singleton, normal size, no induction or augmentation	67.1 (66.4-67.9)	59.1 (58.2-60.0)	2.7 (2.4-3.0)	4.4 (3.9-4.9)	44.5 (40.9-48.0)	40.7 (37.3-44.0)	1.7 (1.5-1.8)	2.6 (2.3-2.9)	2.4 (2.2-2.7)	1.7 (1.4-2.0)
4 ~	Multiparous, singleton, normal size, induction or augmentation	2.8 (2.5-3.1)	5.4 (5.0-5.8)	13.6 (10.7-16.5)	12.3 (9.9-14.7)	9.3 (7.3-11.3)	10.4 (8.3-12.4)	0.4 (0.3-0.5)	0.7 (0.5-0.8)	4.9 (2.8-7.1)	4.0 (2.6-5.5)
8	Multiple pregnancies	2.3 (2.1-2.5)	1.4 (1.2-1.6)	8.1 (5.6-10.5)	14.6 (9.4-19.8)	4.6 (3.1-6.0)	3.2 (2.0-4.4)	0.2 (0.1-0.2)	0.2 (0.1-0.3)	13.9 (10.6-17.1)	13.0 (8.0-17.9)
10	Small in size, singleton	7.0 (6.6-7.3)	6.5 (6.0-6.9)	3.5 (2.5-4.4)	4.4 (3.1-5.8)	6.0 (4.3-7.6)	4.5 (3.1-5.8)	0.2 0.2-0.3)	0.3 (0.2-0.4)	10.4 (8.7-12.1)	13.5 (11.2-15.8)
	Total (overall)	100	100	4.0 (3.8-4.3)	6.4 (6.0-6.9)	100	100	4.0	6.5	3.5 (3.2-3.7)	3.2 (2.9-3.5)

Only 5 observations could not be imputed; ~Cases of breech/transverse lie could not be separated out as factor not assessed; # Women with a previous scar are rarely introduced because obstetric staff fears uterine rupture in this setting, thus we assume that cases of previous scar are found in the group 3.

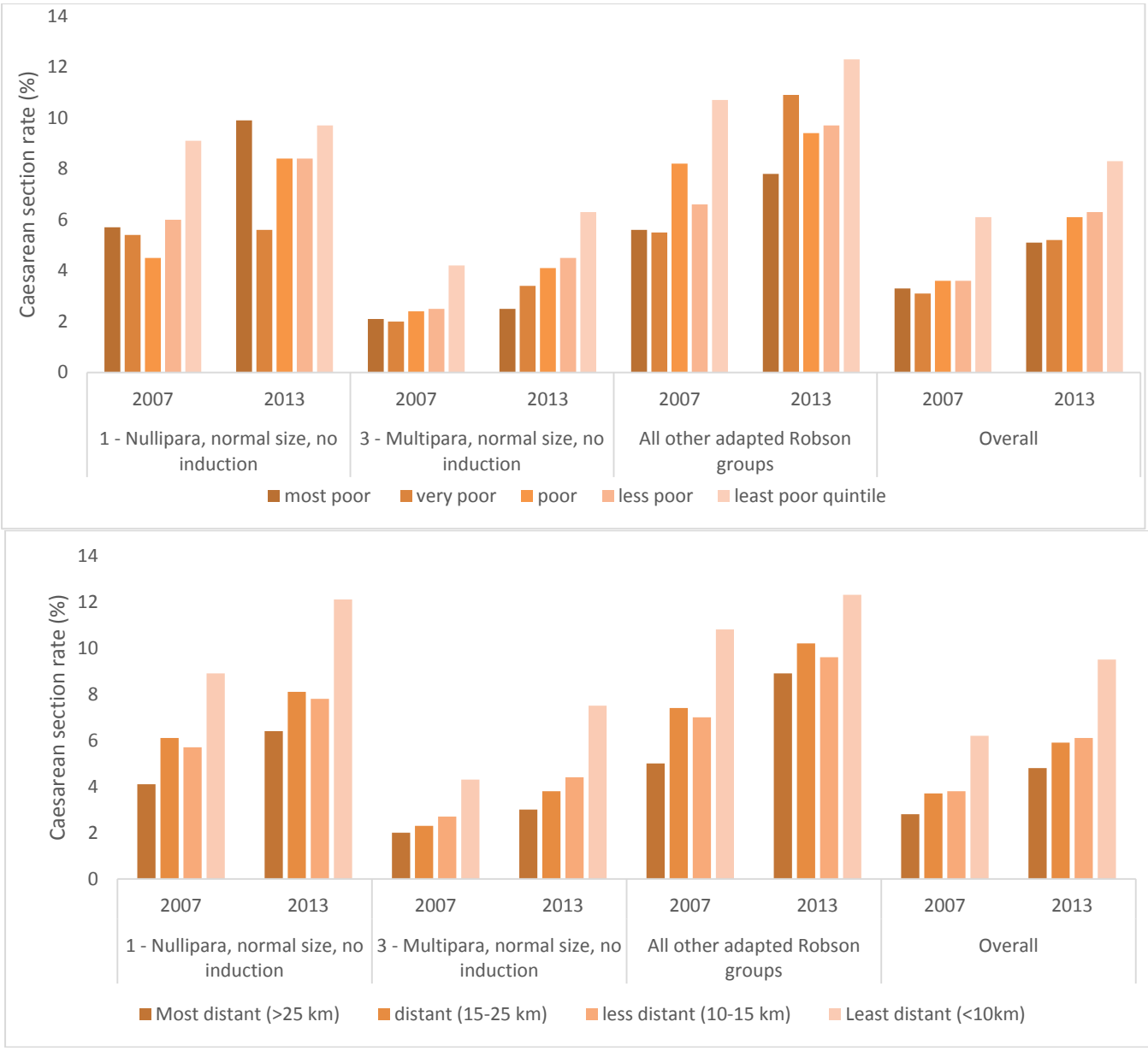

Figure 1: Caesarean section rates in A) wealth and B) distance groups, by survey period and obstetric risk group.