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Faculty of health sciences / Department of community medicine

Changing trends in caesarean section births in Murmansk County, Russia

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HEL-3950 Master's thesis in Public Health

March 2014

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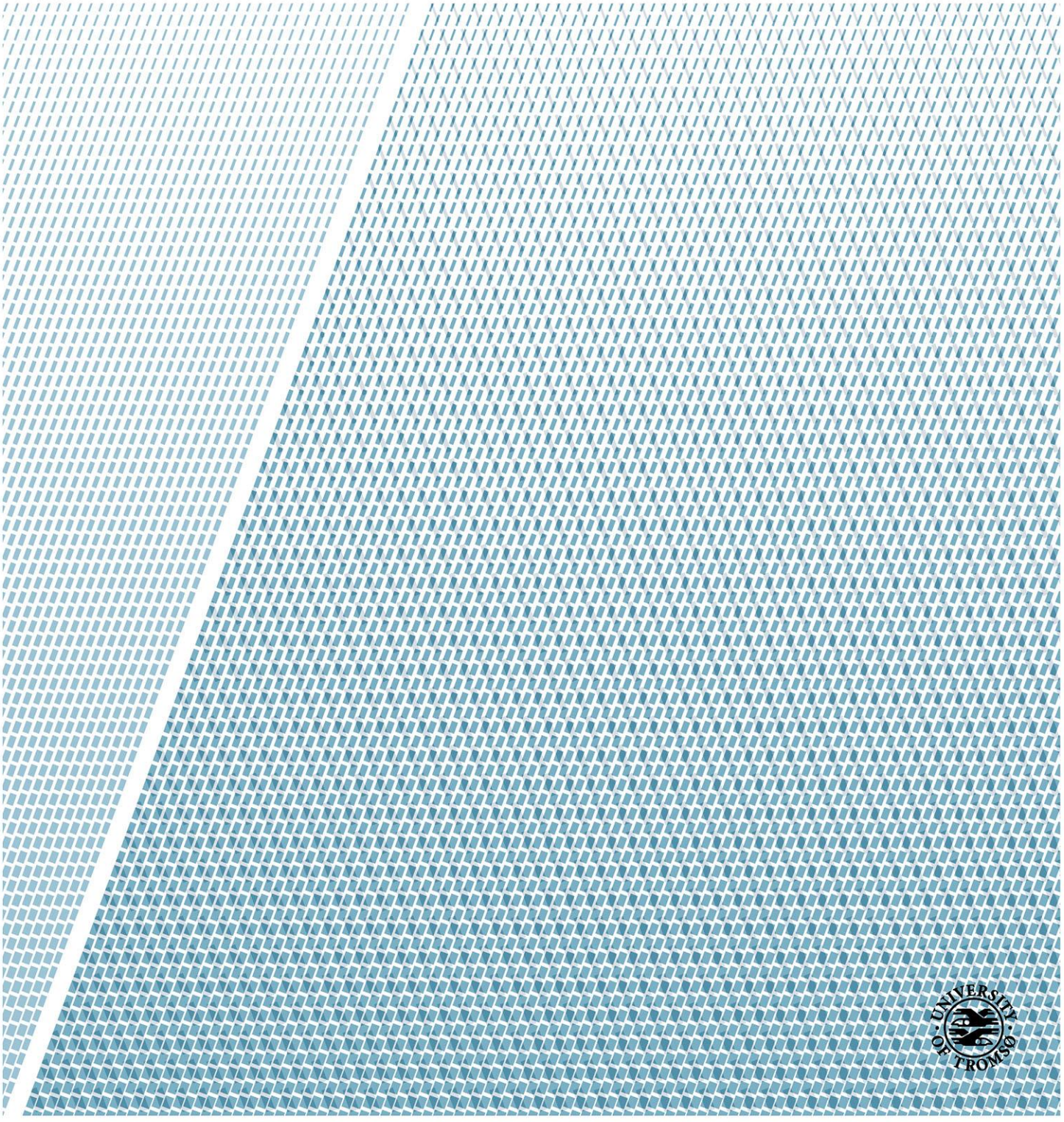

Acknowledgements

I would like to thank my supervisor Erik Eik Anda for his guidance, time, patience, support and constructive feedbacks, and giving me access to the Murmansk County Birth Registry (MCBR). I have gained valuable knowledge and experience during the process of master thesis. I would also like to thank my second supervisor Tonje Braaten for helping me with statistical analyses.

I am grateful for the finding I received from ISM to travel to Murmansk. I would like to express my gratitude to Yana Lapina and Anton Kovalenko for helping me to interpret the information in the MCBR and for the interesting discussions.

I would also like to thank my fellow students and friends for their support and memorable time in Tromsø. I would particularly like to thank Marko Lukic for the feedback on my draft.

Finally, I am grateful to my mother and her enormous support.

Abstract

Objective. To analyze changing trends of caesarean section (CS) birth rates in Murmansk County, Russia over a 5- year period (2006-2010) using the Robson 10-group classification system.

Design. A registry- based study.

Setting. The Murmansk County Birth Registry (MCBR).

Study population. All deliveries registered (N=44 267) in the MCBR between 1st of January 2006 and 31st of December 2010.

Methods. The study population comprises of data from the MCBR and selected perinatal health indicators designed by the Euro-Peristat. The Robson 10- group was applied to categorize all women into 8-modified groups by combining all nulliparous (Groups 1 and 2) and all multiparous (Groups 3 and 4) women with single cephalic pregnancies at ≥ 37 weeks of gestation. The CS rates were examined and described for each group, to identify the most important contributors to CS rates in this population.

Results. Maternal age, parity, maternal smoking, education, body mass index, birth weight changed significantly from 2006 to 2010, except gestational age and multiple births.
There was an increase in the overall CS proportion from 17.4% to 22.5% in Murmansk County between 2006 and 2010. Nulliparous women (Groups 1 and 2) and women with previous CS (Group 5), with single cephalic pregnancies at ≥ 37 gestational weeks were the greatest contributors at 39% and 31%, respectively, to the overall increase of CS rate from 2006 to 2010.

Conclusion: The observed increase in CS rate is mainly attributed to the increase of CS rate in Groups 1 and 2 (first-time CS), followed by Group 5 (repeated CS).

List of abbreviations

MCBR- Murmansk County Birth Registry

MA – Maternal Age

GA- Gestational Age

CS- Caesarean Section

LMP- Last Menstrual Period

WHO- World Health Organization

BW- Birth Weight

BMI- Body Mass Index

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1 Introduction

1.1 Caesarean section rate

Caesarean section (CS) is a surgical intervention aimed to prevent or treat adverse maternal and perinatal complications during pregnancy or birth (1). The rates of CSs have increased worldwide during the past decades and the variations in rates among developed countries are profound. In 2005-2011, the proportion of CS ranged from 16 % in Finland to 38% in Italy (2). The proportion of deliveries conducted by CS continue to rise despite recommendations by the WHO (3). In 1985, the WHO proposed that proportion of CS exceeding 15% reflects inappropriate levels of intervention. Factors contributing to the observed increase of CS rates are complex and many potential explanations have been proposed such as maternal request and fear of litigation (4, 5). Although, the CS can be a lifesaving procedure to both mother and baby, overuse of this obstetric intervention is not recommended. Any use without medical indication is associated with higher risk of adverse maternal and perinatal outcomes (6). These risks include excessive blood loss and infections in mothers and respiratory distress and hypoglycemia in infants.

The comparisons of CS rates between obstetric units are often confounded by variations in the delivering population, risk factors and medical practices among maternity hospitals (7, 8). To address this problem, the Robson 10-group classification system was designed to give an initial overview of CS rates and to permit comparison either between different units or one unit over time (7). The Robson 10-group classification is based upon the woman's characteristics and her pregnancy rather than on the medical indication. These groups are well defined, mutually exclusive, but totally inclusive which means that all women are categorized only once into a relevant group. The groups are particularly relevant for midwives and obstetricians because the assessment of a pregnant woman is carried out during the labor or

delivery in a clinical setting. The Robson 10-group classification system has been recognized by WHO (9) and has been applied by several international studies, which examine CS rates (10-13). The WHO reported an increase of overall CS proportion from 14.0% in 2000 to 22.1% in 2010 in Russia (14). A study of perinatal outcomes (15) found large variations, including CS rates among the 15 maternity hospitals in Murmansk County, Russia. In 2006, the proportion of CS births varied substantially between 9.8% and 23.4% in different delivery departments. Temporal trends of CS rates were not examined by the respective study. To the author's knowledge, there are no existing studies, which examine temporal trends of CS rates in Murmansk County by using the Robson 10-group classification system.

The main objective of this study is to examine trends of CS rates for the years 2006-2010 to detect temporal changes and identify groups of women who contributed most to the increased CS rates. The population characteristics will also be described by employing data from MCBR for 2006-2010 and some of the Euro-Peristat's core and recommended health indicators. Comparisons between the first and the last year will be made in order to detect important potential demographic changes.

2 Materials and Methods

2.1 Murmansk County Birth Registry

This study is registry based and employs data from the Murmansk County Birth Registry (MCBR) for 2006-2010. The MCBR annually registries over 98 % of all births in the region and has been evaluated as satisfactory in terms of quality (15). The registry was established in 2006 by researches from University of Tromsø in cooperation with the Health Department of Murmansk County, Russia. The MCBR was designed according to the Medical Birth Registry of Norway (16) for the purpose of monitoring maternal and perinatal health outcomes in Murmansk County.

2.2 Inclusion and exclusion criteria

The inclusion and exclusion criteria for this study are presented in Figure 1. The original dataset from the MCBR-database contained data on 44 267 deliveries, including live and stillbirths of all women of Murmansk County from 2006-2010. A fetus was considered live born when it was showing any of the important evidence of life (17) including breathing and heart beating, regardless of the gestational duration. A stillbirth or fetal death (18) is registered when the fetus is not showing any of the previously listed vital signs (17). Women with a registered maternal age (MA) below 10 years or above 50 years were excluded. Illogical values were removed such as MA of for example 9 or 64 or any other number with a minus in front. Women with missing MA values were not included in the final analyses.
For the purpose of description of the study population, all births regardless of gestational age (GA) from women aged 10-50 in Murmansk County between 2006 and 2010 were included (N=44 144). The population description was based on the following data: MA, parity (number of previous births), smoking during pregnancy, maternal educational level, GA, body mass

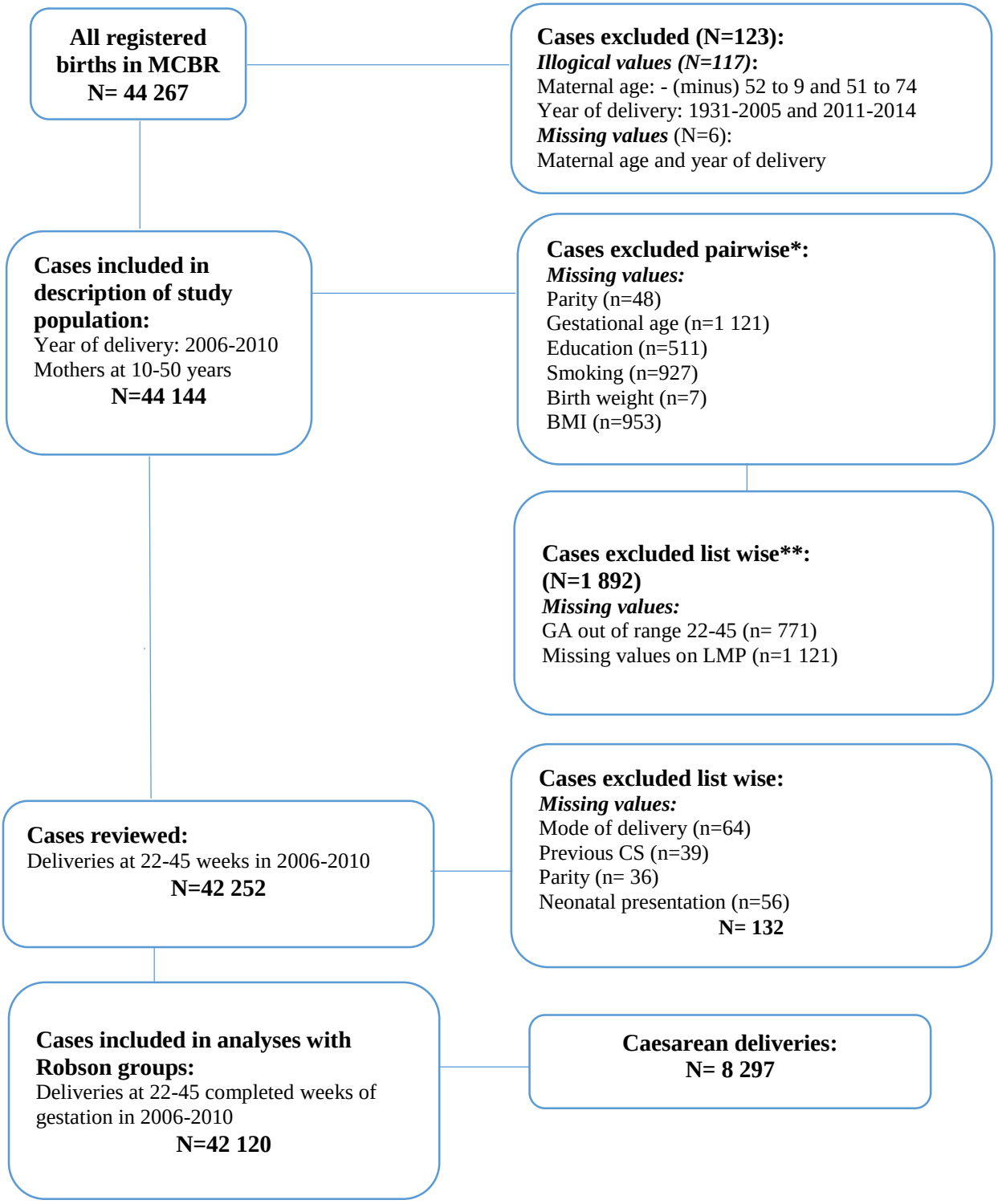
index (BMI), birth weight (BW) and plurality (number of fetuses). Pairwise deletion (a statistical method used to handle missing data), was applied to deal with missing values in displaying the population characteristics (19). The procedure of pairwise deletion excludes cases only if complete data is required for the specific analysis. In addition, only women with GA of 22 completed weeks of gestation or more were included in the analysis of calculating the mean GA, to ensure consistency with the definition of the perinatal period (20).

When the description of the study population was completed, additional exclusions were made for the Robson groups analyses, of which 42 120 women were considered eligible. Only deliveries between 22-45 completed weeks of gestation were included in the analyses with Robson groups, because GA below 22 weeks is not a part of the perinatal period (18, 20). The upper limit for GA was set at 45 completed weeks, to ensure consistency with a previous study (21) and because all deliveries are induced at 42 weeks in Murmansk. The following variables were used in the analyses with Robson groups: GA, parity, plurality, neonatal presentation, number of previous CS and mode of delivery. The Robson classification also prefers information on onset of labour, but this information is not available in the MCBR (described in section 2.4). Cases with missing values on the variables of interests were omitted from the analyses by using list wise deletion (19), because complete information was required for analyses. The procedure of list wise deletion excludes cases with missing values on any of the variables used in the analysis.

2.2.1 Missing values

There were some cases with missing values on the variables of interests (Figure 1). The variable with the information on women's LMP had the greatest number of missing values (2.5%). These excluded LMP- cases differed significantly from those retained in the analyses in terms of demographic composition. The 1 121 (2.5% of 44 144) cases excluded from the analyses for missing data on LMP differed somewhat by MA, smoking status and education

from those retained in the analyses. The excluded cases were younger, had lower education and more likely to smoke during pregnancy compared with included cases ($p<0.001$ for all). 16.3% of the excluded cases were below 20 years at delivery compared with 7.2% of the cases retained in the analysis. 43.6 % of the excluded cases smoked during pregnancy compared with 18.1% of the cases with complete information on LMP. Cases with primary and secondary educations consisted of 66.8% woman with missing information on LMP compared with 35.5% of women with complete data on LMP. Other missing values included parity (0.1%), education (1.2%), smoking during pregnancy (2.1%), BW (0.02%) and BMI (2.2%). The data used in the Robson groups analyses (N= 42 120) had the following missing values: mode of delivery (0.2%), number of previous CS (0.1%), parity (0.1%) and neonatal presentation (0.1%). The implications of these very limited missing values were not examined any further.



*Cases excluded only if the completeness of data was required by the analysis.
**Cases excluded if data were missing for any of the variables used in the analysis

Figure 1. Exclusion and inclusion criteria used in the study.

2.3 Study population

2.3.1 Perinatal health indicators

A summary set of perinatal health indicators suggested by Euro-Peristat, a project that aims to monitor and evaluate health and care of pregnant women in Europe (4), were chosen to describe the characteristics of the current study population (Table 1). These indicators include 5 core and 3 recommended indicators classified into 2 categories: i) fetal, neonatal and child health, and ii) population characteristics and risk factors (18). Core indicators are defined as those considered most important in monitoring perinatal health, while recommended indicators are considered eligible for an extended overview of perinatal health.

Table 1. Selected perinatal health indicators suggested by Euro-Peristat.

Category	Core	Recommended
Fetal, neonatal, and child health	• Birth weight distribution by vital status, gestational age and plurality • Gestational age distribution by vital status and plurality	
Population characteristics or risk factors	• Multiple birth rate by number of fetuses • Maternal age distribution • Parity distribution	• Percentage of women who smoked during pregnancy • Distribution of mother's education • Distribution of mother's BMI

2.3.2 Variables and definitions

The information on variables is presented in Table 2.

- **Maternal age distribution**

MA is defined as age of a mother in years at the time of delivery, according to Euro-Peristat (18) and calculated as the interval between the mother's date of births and the date of delivery (22). Four selected indicators specific to maternal age (15, 22) are presented as follows: mean maternal age at delivery, mean maternal age at first delivery, proportion of mothers below 20 years and proportion of mothers at 35 years or above. The mean maternal age at delivery estimates the average age in years of the mother at a time of delivery regardless of parity distribution. The mean maternal age at first delivery describes average age in years of the mother who gave birth for the first time. The proportions of mothers below 20 years and those at 35 years or above include percentage of mothers who were younger than 20 years or 35 years or older at the time of delivery.

- **Parity distribution**

Parity is defined according to Euro-Peristat (18) as the number of previous live or stillbirths (0, 1 ,2 or 3 or higher order births). Women who give birth for the first time are defined as nulliparous, while those who delivered at least one time before are defined as multiparous. Parity combines information on live and stillbirths from the birth registry and was estimated by summarizing number of live and stillbirths in the birth registry (Table 2). For example, women with no previous live birth, but one previous stillbirth were identified as nulliparous. On the other hand, women with both one previous live and stillbirth were considered as multiparous in the birth registry. Parity distribution is stratified into three different variables indicating 1^{st}, 2^{nd} and 3^{rd} deliveries, respectively (15).

- **Smoking during pregnancy**

Smoking during pregnancy is defined as proportion of mothers with live or stillbirths who smoked during pregnancy (18). The information on mothers who smoked during pregnancy was obtained from the original variable in the birth registry, indicating smoking during any trimester of pregnancy.

- **Mother's educational level**

The information on maternal education is obtained from the original variable in the birth registry, indicating the highest education completed (in years). This variable includes 6 categories in ascending order as follows: i) none, ii) primary (class 1-9), iii) secondary (class 10-11), iv) technical school, v) higher education, and vi) unknown. The women in the last category (unknown) were relocated into the category of missing values. The summary presentation of maternal education focused on the mothers with the higher education completed and is presented as a percentage.

- **Distribution of gestational age**

GA is defined as the duration of a pregnancy in days or completed weeks (23). The GA was measured as the interval between woman's first day of last bleeding (LMP) and the date of delivery. The Euro-Peristat defines this indicator as the number of live or stillbirths at each completed weeks of gestation, starting from 22 weeks (18). For example, if GA was 38 weeks and 4 days (38^{+4} weeks) from the LMP, it was recorded as 38 weeks rather than 39 weeks. The distribution of GA is categorized as follows: i) extremely preterm (22-27 weeks), ii) very preterm (28-31 weeks), iv) moderately preterm (32-36 weeks), v) term births (37-41 weeks), and vi) post-term births (42 weeks and above). In this study, the distribution of GA is presented as mean gestational age in completed weeks, commencing from week 22 of the perinatal period (20).

- **Distribution of maternal pregnancy Body Mass Index (BMI)**

Self-reported BMI refers to BMI calculated from woman's self-reported height and weight obtained before pregnancy (pre-pregnancy). The BMI was calculated as weight in kg divided by the square of the height in meters (kg/m2); (24) and presented as means.

- **Distribution of birth weight**

BW is defined as the weight of a fetus or infant at delivery (25). The original variable in the birth registry, indicating infant's BW (in grams) at delivery was used to calculate mean BW.

- **Multiple births**

The indicator of multiple birth is defined as the proportion of women with live or stillbirths by number of fetuses delivered in a multiple gestation pregnancy (18). The original variable in the birth registry included deliveries with twins (2 fetuses) or triplets (3 fetuses) in a multiple gestation delivery. This information was modified into a new variable, indicating single or multiple births (twins or triplets) and presented as proportions.

Table 2. The variables used in the study and their codes

Variable	MCBR code	Code used in the analysis	
Year of delivery[1] (YOBCHILD) (years)	Continuous: 1931-2014	Continuous 2006-2010	
Birth weight (BW) (grams)	Continuous: 290- 5630	Continuous: 290- 5630	
Gestational age[2] (GA) (completed weeks)	Continuous : -4080-4161	Continuous: GA 22-45	
Multiple births (number of fetuses)	Categorical FirstBORNTOTAL 2= twin 3=triplet	Categorical MBTH <2=single ≥2=multiple	
Maternal age[3] (years)	Continuous : MA -52-74	Continuous MA 10- 50 Categorical MA1: <20 = less than 20 ≥20 = 20 or more	 Categorical MA2 ≥35 = equal or greater 35 <35 = less than 35
Parity distribution (PAR)[4] (number of prev. births)	Categorical Live births + Stillbirths=PAR 0-20	3 categorical PAR1 (1st delivery): <1= yes ≥1=no PAR2 (2nd delivery): 1=yes 0 =no	PAR3 (3rd delivery): 2=yes (<2 or ≥3)=no
Smoking during pregnancy (at any trimester)	Categorical 0= not smoking 1= smoking	Categorical 0=not smoking 1= smoking	
Mother's educational level	Categorical 1= none 2= primary (class 1-9) 3= secondary(class 10-11) 4= technical school 5= higher education 6= unknown	Categorical (mother's with higher education): 5= higher education 1-5= less than higher education 6= missing values	
Neonatal presentation	Categorical BTHNP 0= Occipital/normal 1= Breech 2= Transverse 3=Abnormal cephalic 4= Other	Categorical NEOPRE 0=1=normal 1=2= breech ≥2=3 abnormal lies	
Previous CS (Number)	Categorical CAESDEL 0-4; 10-11	Categorical CAESDEL 0= without prev. CS ≥1= with prev. CS	
Mode of delivery	Categorical BTHDTYPE 0=spontaneous 1= induced 2=caesarean	Categorical CS ≤1 = spontaneous or induced delivery 2= caesarean delivery	

[1] Year of delivery was extracted from the variable date of delivery.
[2] Gestational age in completed weeks was estimated from women's last menstrual period.
[3] Maternal age was calculated by using mother's date of birth and delivery date.
[4] Parity was estimated from the number of previous live or stillbirths.

2.4 The Robson 10-group classification system

The Robson groups are constructed to give a more comprehensive picture of the relative contribution of CS proportions among women with different delivery histories in a population. The Robson 10-groups classification system categorizes women into 10 different groups according to a woman's characteristics and her pregnancy (7). These characteristics include number of fetuses (single or multiple), neonatal presentation (normal, breech or abnormal), parity (nulliparous or multiparous), history of a previous CS (Yes/No), course of labour (spontaneous, induced or caesarean section) and gestational duration in completed weeks at the time of delivery. The Robson groups are applied to examine CS proportions in relatively homogenous groups of women and to compare CS proportions in these groups over time (2006-2010).

The original Robson 10-group classification system, illustrated in Table 11 (see Appendix, section 7) was modified into 8 groups (Table 3) in order to apply this classification to births registered in the MCBR-database. The reason for the modification is incomplete information on the onset of labour in the database, which completeness is required in order to categorize women into 10 groups. Three different obstetric concepts, including their parameters, which are based on obstetric characteristics of a woman and her pregnancy, were chosen to categorize women into 8 different groups (Table 4). These concepts include the following information: i) category of the pregnancy (number of fetuses and neonatal presentation), ii) previous record of the pregnancy (parity and number of previous CS), and iii) gestation of the pregnancy. Groups 1 and 2 were aggregated together in order to work out the CS rates for all nulliparous women with single cephalic pregnancies at ≥ 37 weeks of gestation, as suggested by Robson (7). Similarly, Groups 3 and 4 were combined to estimate the CS rates for all multiparous women with single cephalic pregnancies at ≥ 37 weeks of gestation.

Table 3. Modified Robson 8-group classification system applied in this study.

Group	Definition
1 and 2	Nulliparous women, single cephalic pregnancy at ≥ 37 completed weeks of gestation
3 and 4	Multiparous women, without a previous CS, with single cephalic pregnancy at ≥37 completed weeks of gestation
5	All multiparous women, with at least one previous CS, single cephalic pregnancy at ≥ 37 completed weeks of gestation
6	All nulliparous women with a single breech pregnancy
7	All multiparous women with a single breech pregnancy, including previous CS
8	All multiple pregnancies, including previous CS
9	All abnormal lies, including previous CS
10	All women with a single cephalic pregnancy at ≤ 36 completed weeks of gestation, including previous CS

Table 4. Concepts and their parameters included in the modified Robson 8- group classification system.

Concept	Parameter
Category of pregnancy	Single cephalic pregnancy Single breech pregnancy Single abnormal lie pregnancy Multiple pregnancy
Previous obstetric record	Nulliparous Multiparous (without a previous CS) Multiparous (with a previous CS)
Gestation	Gestational age in completed weeks at the time of delivery
Course of labour and delivery*	Spontaneous labour Induced labour Caesarean section before labour (emergency or elective)

* Information not included due to incomplete data on the onset of labour in the registry.

2.4.1 Variables and definitions

Variables used to create 8-modified Robson groups are presented in Tables 2 and 5. Fetal or neonatal presentation is the position of the fetus during the delivery (26). Robson stratifies

neonatal presentation into three categories: i) cephalic/normal, ii) breech, and iii) abnormal lie (5). Cephalic position is defined as the position of a baby with the head first (26) and was identified as normal presentation from the birth registry. Breech presentation is considered when baby presents with the buttocks first (27) and was identified as breech presentation in the registry. The last possible position to be included in the Robson groups is abnormal lie (5), which refers to abnormal positions or other than those listed above (cephalic/normal and breech). All remaining categories of the variable representing neonatal position (transverse, abnormal or "other") in the birth registry are indicated by the abnormal lie category (Table 2). Parity was calculated from the number of previous live or stillbirths in the registry, as described earlier (see section 2.3.2). The variable (PAR1), indicating nulliparous or multiparous women was applied in the analyses with Robson groups. The information on number of fetuses was derived from the multiple births variable (MBTH) indicating twins (2 fetuses) or triplets (3 fetuses) in a multiple gestation pregnancy. Cases with no indication of a multiple pregnancy and no information on the second fetus were considered singleton pregnancies. The information on previous CS was collected from the original variable (CAESDEL), indicating number of previous CS in the MCBR-database. Women with at least one previous caesarean delivery were considered to have a uterine scar, indicating a cut on the uterus following CS procedure (28), as suggested by Robson (5). GA was calculated as described previously (see section 2.3.2). The GA was categorized as $\leq$36 weeks or $\geq$ 37 weeks, indicating pregnancies at 22-36 or 37-45 completed weeks of gestation.

Table 5. Variables and their composition used to classify women into modified 8 groups by Robson.

Group	Definition	Variable used in the analysis	Code
1 & 2	Nulliparous, single cephalic pregnancy, ≥ 37 weeks	PAR1 MBTH NEOPRE GA	<1=nulliparous <2= single 1= normal ≥37
3 & 4	Multiparous (without prev. CS), single cephalic pregnancy, ≥ 37 weeks	PAR1 CAESDEL MBTH NEOPRE GA	≥1= multiparous 0=without prev. CS <2=single 1= normal ≥37
5	All multiparous (with prev. CS), single cephalic pregnancy, ≥ 37 weeks	PAR1 CAESDEL MBTH NEOPRE GA	≥1=multiparous ≥1= with prev. CS <2=single 1=normal ≥37
6	All nulliparous women, single breech pregnancy	PAR1 MBTH NEOPRE	<1= nulliparous <2= single 2= breech
7	All multiparous (incl. prev. CS), single breech pregnancy	PAR1 MBTH NEOPRE	≥1=multiparous <2=single 2= breech
8	All women (incl. prev. CS) with multiple pregnancy	MBTH	≥2= multiple
9	All women (incl. prev. CS) single abnormal lies	MBTH NEOPRE	<2= single 3=abnormal lie
10	All women (incl. prev. CS), single cephalic pregnancies, ≤ 36 weeks	MBTH NEOPRE GA	<2= single 1= normal ≤36

Each Robson group was analyzed by the relative group size, CS proportion and relative contribution to the overall CS according to Robson (7). The relative group size was calculated by dividing the number of deliveries in each group by the total number of all deliveries (Table 8). The CS proportion was calculated by dividing the number of CS in each group by the total number of deliveries in this group (Table 9). The relative contribution to the overall CS proportion was calculated by dividing the number of CS in each group by the total number of caesarean deliveries (Table 10). The relative contribution to the total increase of CS in 2006-2010 was estimated by dividing the difference in the increase of CS proportion in each group, between the last and the first period, by the total number of the increase in CS proportion. The outcome was multiplied by 100 to obtain the percentage, and rounded to the nearest whole

percent. The relative contribution of each group to increased proportions of CS from 2006 to 2010 is illustrated by Figure 2.

2.4.2 Statistical analyses

Different statistical tests were performed to describe population characteristics of the current study population, both in terms of means and percentages. One-way ANOVA analysis was used to describe the mean values of dependent variables measured on a continuous scale (MA, GA, BW and BMI) with 95% confidence intervals. The data was obtained for each individual year of 2006-2010 from the categorical variable indicating year of delivery. An Independent sample t-test was applied to these data to compare the first period to the last and to test whether there was a significant difference. P-values less than 0.05 indicated significant difference for all tests. The assumptions of homogeneity of variance, and normality were examined for continuous variables. The appropriate p-value was reported based on the results from Levene's test for equality of variances (29). A significance value greater than 0.05 indicated that the assumption of homogeneity was met. In a situation where the assumption of homogeneity was violated ($p< 0.05$), the corrected p-value was reported. The assumption of normality was examined by requesting a histogram whereas a bell-shaped curve indicted that this assumption was met. Pearson chi-square test was used to describe categorical data as proportions. The proportion of each variable was compared between the first and the last period to detect potential significant changes. For these analyses no expected frequencies counted less than 5 which is an indicative that the assumption of the chi-square test for 2 by 2 table was met (29). All analyses were conducted by using SPSS (Statistical Package for the Social Sciences) Version 19.

3 Results

3.1 Population characteristics

Table 6 presents the population characteristics of mothers and their newborns for 44 144 deliveries in Murmansk County during the study period 2006- 2010. The number of annual births increased from 8 399 in 2006 to 9 062 in 2010 (Table 6). The mean maternal age at delivery increased from 26.0 in 2006 to 27.3 years in 2010 ($p<0.001$). The mean maternal age increased from 23.7 years in 2006 to 24.7 years in 2010 ($p<0.001$) for women experiencing their 1st delivery (nulliparous women). In 2010, 5.4 % of the women in the study population were younger than 20 years of age compared with 9.8% in 2006 ($p<0.001$). The proportion of mothers at 35 years or older increased significantly from 6.7% in 2006 to 10.2% in 2010 ($p < 0.001$). The proportion of nulliparous women decreased from 60.2% in 2006 to 52.3 % in 2010 ($p<0.001$). The proportion of women with 2nd and 3rd deliveries (multiparous women) increased, respectively, from 32.8% and 5.5% in 2006 to 39.1% and 6.6% in 2010 ($p<0.001$ and $p=0.002$). The percentage of mothers who smoked during pregnancy rose from 16.1% in 2006 to 21.4 % in 2010 ($p<0.001$). The proportion of mothers who had completed a higher education increased from 24.8% in 2006 to 37.4% in 2010 ($p<0.001$). The mean BMI changed significantly from 23.2 in 2006 to 24.1 in 2010 ($p=0.001$). The mean birth weight increased from 3330.2 to 3364.9 grams, from 2006 to 2010 ($p<0.001$). A significant change was not found in the mean gestational age ($p=0.49$) and the proportion of multiple births ($p=0.34$).

Table 6. Population characteristics of the delivering women and their children (2006-2010)

Indicator	2006 (N=8 399)	2007 (N= 8 755)	2008 (N=8 967)	2009 (N=8 961)	2010 (N= 9 062)	P-value [5]
Mean maternal age (years)	26.0	26.3	26.7	27.0	27.3	p<0.001
(95%CI)	(25.9-26.1)	(26.2-26.4)	(26.6-26-8)	(26.9-27.1)	(27.2-27.4)	
N	8 399	8 755	8 967	8 961	9 062	
Mean maternal age at first delivery (years)	23.7	23.9	24.1	24.5	24.7	p<0.001
(95% CI)	(23.6-23.8)	(23.8-24.0)	(24.0-24.2)	(24.4-24.6)	(24.6-24.8)	
N	5 052	5 017	4 903	4 860	4 731	
Maternal age < 20 years	9.8%	8.3%	7.2%	6.6%	5.4%	p<0.001
N	8 399	8 755	8 967	8 961	9 062	
Maternal age ≥ 35 years	6.7%	7.5%	8.2%	9.6%	10.2%	p<0.001
N	8 399	8 755	8 967	8 961	9 062	
1st delivery (parity distribution)	60.2	57.3	54.7	54.3	52.3	p<0.001
N	8 388	8 750	8 958	8 958	9 042	
2nd delivery (parity distribution)	32.8%	34.6%	36.8%	37.0%	39.1%	p<0.001
N	8 388	8 750	8 958	8 958	9 042	
3rd delivery (parity distribution)	5.5%	6.3%	6.8%	6.9%	6.6%	p=0.002
N	8 388	8 750	8 958	8 958	9 042	
Smoking during pregnancy	16.1%	18.5%	20.8%	19.9%	21.4%	p<0.001
N	8 169	8 728	8 469	8 888	8 963	
Mothers with higher education	24.8%	29.2 %	31.3%	33.8%	37.4%	p<0.001
N	8 358	8 713	8 740	8 808	9 014	
Mean GA (22-45 weeks)	39.0	39.1	39.0	39.0	39.0	p=0.49
(95% CI)	(39.0 -39.1)	(39.0-39.1)	(38.9-39.0)	(39.0- 39.1)	(39.0- 39.1)	
N	8 045	8 404	8 583	8 558	8 662	
Mean BMI	23.2	23.4	23.6	23.7	24.1	p=0.001
95% CI	(23.1-23.3)	(23.3-23.5)	(23.5- 23.7)	(23.5-23.8)	(23.6-24.6)	
N	8 041	8 609	8 817	8 837	8 887	
Mean BW (gram)	3330.2	3354.0	3343.7	3360.2	3364.9	p<0.001
(95% CI)	(3318.4-3342.0)	(3342.7-3365.3)	(3332.0-3355.3)	(3348.6-3371.7)	(3353.6-3376.1)	
N	8 399	8 755	8 965	8 958	9 060	
Multiple births (%)	0.8	0.8	0.9	0.9	0.9	p=0.34
N	8 399	8 755	8 967	8 961	9 062	

[5] The p-values were calculated by chi-square (percentages) or t-test (averages) and the changes were estimated from 2006 to 2010.

3.2 Robson Groups

The overall proportion of CS was 19.7% in 2006-2010 (Table 9). This estimate was based on 8 297 caesarean deliveries within the population (N= 42 120) considered eligible for the inclusion in Robson groups (Figure 1). The definition of each group of the modified Robson 8-group is presented in Table 7 below. The relative group size, proportion of CS and contribution of each group to the overall proportion of CS are presented in Tables 8-10. The contribution of each group to the increased proportion of CS from 2006 to 2010 is illustrated by Figure 2.

In this study, nulliparous women (Groups 1 and 2) accounted for the largest proportion (49.4%) of all deliveries in 2006-2010 (Table 8). Although, the relative proportion of CS in these groups was only 16.5% (Table 9), they accounted for 41.3% of all CSs in 2006-2010 (Table 10). The second largest proportion (34.3%) of all deliveries was attributed to multiparous women (Groups 3 and 4). Although, groups 3 and 4 combined accounted for a small relative proportion of CS (7.4%), these groups contributed 13.0% to the overall proportion of CS. Women with previous CS (Group 5) included only 4.3% of all deliveries (Table 8). Women in this group accounted for the largest proportion of CS (93.2%) in 2006-2010 (Table 9). At the same time, this group made up the second largest contribution (20.5%) to the overall proportion of CS (Table 10).

The remaining Robson groups consisted of all nulliparous women with single breech pregnancies (Group 6), all multiparous women with single breech pregnancies (Group 7), all women with multiple pregnancies (Group 8), all women with single abnormal pregnancies (Group 9) and all women with single normal pregnancies at pre-term (Group 10). Groups 6-10 included only 11.9% of all deliveries (Table 8). Although, the proportion of CSs in these

groups differed between 21.5% and 81.3% (Table 9), these groups together only accounted for 25.2% of all CSs in 2006-2010 (Table 10).

Temporal trends by Robson group

There was a significant temporal increase in the overall proportion of CS from 17.4% to 22.5% between 2006 and 2010 ($p<0.001$; Table 9). The proportion of nulliparous women (Groups 1 and 2) decreased significantly from 53.1% to 45.9% ($p<0.001$), but the proportion of CS in these women increased significantly from 13.9% to 20.4% ($p<0.001$). Groups 1 and 2 combined contributed 39% of the increase in proportion of CS from 2006 to 2010 (Figure 2), and was the largest contributor to the increased proportion of CS. The proportion of multiparous women (Groups 3 and 4) increased significantly from 30.9% to 37.3% ($p<0.001$), but the proportion of CS in these groups remained stable ($p=0.39$) during the period. Groups 3 and 4 combined contributed 11% of the increase in proportion of CS from 2006 to 2010 (Figure 2). The proportion of women with previous CS (Group 5) increased significantly from 2.9% to 4.7% between 2006 and 2010 ($p<0.001$). At the same time, the proportion of CS in these women increased from 91.5% to 96.0% ($p=0.004$). In addition, the contribution from this group to the overall proportion of CS increased significantly from 15.5% to 19.9% ($p=0.004$). Group 5 alone contributed 31% of the increase in proportion of CS from 2006 to 2010 (Figure 2).

Significant increases in the proportions of CS between 2006 and 2010 were also observed in nulliparous women with single breech pregnancies (Group 6; $p=0.002$), all women with single abnormal lie pregnancies (Group 9; $p=0.03$), and all women with single normal pregnancies at pre-term (Group 10; $p<0.001$). Significant increase in the relative group size was observed in all multiparous women with single breech pregnancies (Group 7; $p=0.03$). Groups 6-10 accounted for 18% of the increase in proportion of CS from 2006 to 2010.

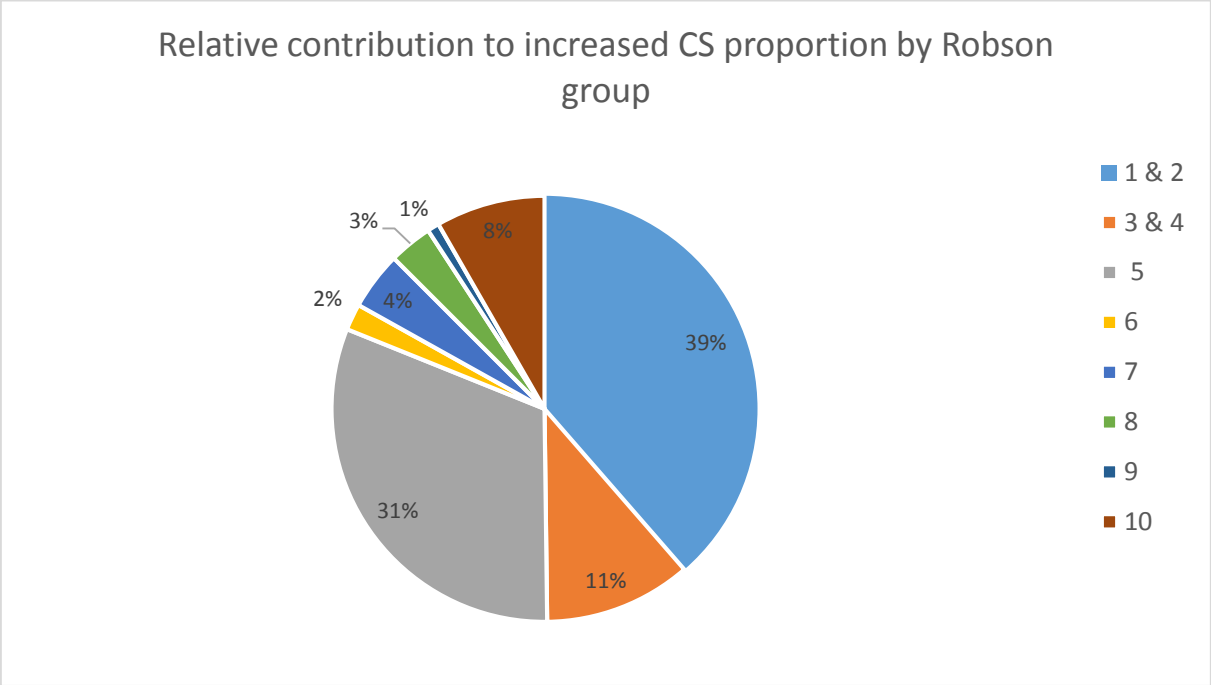


Figure 2. Relative contribution of each Robson group to increased proportion of CS from 2006 to 2010.

Table 7. The modified Robson 8- group.

Group	Definition
1& 2	Nulliparous women with single normal pregnancies at term (≥ 37 gestational weeks)
3&4	Multiparous women (without previous CS), with single normal pregnancies at term
5	All multiparous women (with previous CS), with single normal pregnancies at term
6	All nulliparous women with single breech pregnancies
7	All multiparous women with single breech pregnancies
8	All women with multiple pregnancies
9	All women with single abnormal lie pregnancies
10	All women with single normal pregnancies at pre-term (≤ 36 gestational duration)

Table 8. Relative size of each Robson group, 2006-2010.

Relative size of each Robson group N (%)							
Group	Overall (%)	2006	2007	2008	2009	2010	Chi-square for trend
1&2	20 805/42 120 (49.4)	4266/8031 (53.1)	4306/8393 (51.3)	4163/8557 (48.7)	4116/8530 (48.3)	3954/8609 (45.9)	p < 0.001 downward
3&4	14 460/42 120 (34.3)	2481/8031 (30.9)	2797/8393 (33.3)	2967/8557 (34.7)	3006/8530 (35.2)	3209/8609 (37.3)	p < 0.001 upward
5	1 826/42 120 (4.3)	236/8031 (2.9)	354/8393 (4.2)	408/8557 (4.8)	426/8530 (5.0)	402/8609 (4.7)	p < 0.001 upward
6	814/42 120 (1.9)	176/8031 (2.2)	151/8393 (1.8)	164/8557 (1.9)	157/8530 (1.8)	166/8609 (1.9)	p=0.33
7	457/42 120 (1.1)	88/8031 (1.1)	70/8393 (0.8)	85/8557 (1.0)	103/8530 (1.2)	111/8609 (1.3)	p=0.03
8	362/42 120 (0.9)	65/8031 (0.8)	68/8393 (0.8)	73/8557 (0.9)	74/8530 (0.9)	82/8609 (1.0)	p=0.28
9	351/42 120 (0.8)	85/8031 (1.1)	62/8393 (0.7)	68/8557 (0.8)	59/8530 (0.7)	77/8 8609 (0.9)	p=0.26
10	3 045/42 120 (7.2)	634/8031 (7.9)	585/8393 (7.0)	629/8557 (7.4)	589/8530 (6.9)	608/8609 (7.1)	p=0.06
Total	42 120/42 120 (100.0)	8 031/8 031 (100.0)	8 393/8 393 (100.0)	8 557/8 557 (100.0)	8 530/8 530 (100.0)	8 609/8 609 (100.0)	

Table 9. Proportion of CS in each Robson group, 2006-2010.

CSs in each Robson group N (%)							
Group	Overall (%)	2006	2007	2008	2009	2010	Chi-square for trend
1&2	3 426/20 805 (16.5)	595/4266 (13.9)	642/4306 (14.9)	701/4163 (16.8)	683/4116 (16.6)	805/3954 (20.4)	p< 0.001 upward
3&4	1 077/14 460 (7.4)	201/2481 (8.1)	182/2797 (6.5)	210/2967 (7.1)	222/3006 (7.4)	262/3209 (8.2)	p=0.39
5	1 701/1 826 (93.2)	216/236 (91.5)	321/354 (90.7)	379/408 (92.9)	399/426 (93.7)	386/402 (96.0)	p=0.004 upward
6	662/814	136/176	116/151	131/164	132/157	147/166	p=0.002

	(81.3)	(77.3)	(76.8)	(79.9)	(84.1)	(88.6)	upward
7	327/457 (71.6)	58/88 (65.9)	54/70 (77.1)	60/85 (70.6)	73/103 (70.9)	82/111 (73.9)	p=0.45
8	173/362 (47.8)	25/65 (38.5)	32/68 (47.1)	34/73 (46.6)	39/74 (52.7)	43/82 (52.4)	p=0.08
9	275/351 (78.3)	59/85 (69.4)	48/62 (77.4)	48/59 (81.4)	48/59 (81.4)	64/77 (83.1)	p=0.03
10	656/3 045 (21.5)	107/634 (16.9)	122/585 (20.9)	137/629 (21.8)	138/589 (23.4)	152/608 (25.0)	p< 0.001 upward
Total	8 297/42 120 (19.7)	1 397/8 031 (17.4)	1 517/8 393 (18.1)	1 708/8 557 (20.0)	1 734/8 530 (20.3)	1 941/8 609 (22.5)	p<0.001 upward

Table 10. Relative contribution of each Robson group to the overall proportion of CS, 2006-2010.

Relative contribution of each Robson group to overall proportion of CS N (%)							
Group	Overall (%)	2006	2007	2008	2009	2010	Chi-square for trend
1 & 2	3 426/8 297 (41.3)	595/1 397 (42.6)	642/1 517 (42.3)	701/1 708 (41.0)	683/1 734 (39.4)	805/1 941 (41.5)	p=0.22
3 & 4	1 077/8 297 (13.0)	201/1 397 (14.4)	182/1 517 (12.0)	210/1 708 (12.3)	222/1 734 (12.8)	262/1 941 (13.5)	p=0.86
5	1 701/8 297 (20.5)	216/1 397 (15.5)	321/1 517 (21.2)	379/1 708 (22.2)	399/1 734 (23.0)	386/1 941 (19.9)	p=0.004 upward
6	662/8 297 (8.0)	136/1 397 (9.7)	116/1 517 (7.6)	131/1 708 (7.7)	132/1 734 (7.6)	147/1 941 (7.6)	p=0.06
7	327/8 297 (3.9)	58/1 397 (4.2)	54/1 517 (3.6)	60/1 708 (3.5)	73/1 734 (4.2)	82/1 941 (4.2)	p=0.53
8	173/8 297 (2.1)	25/1 397 (1.8)	32/1 517 (2.1)	34/1 708 (2.0)	39/1 734 (2.2)	43/1 941 (2.2)	p=0.39
9	275/8 297 (3.3)	59/1 397 (4.2)	48/1 517 (3.2)	56/1 708 (3.3)	48/1 734 (2.8)	64/1 941 (3.3)	p=0.15
10	656/8 297 (7.9)	107/1 397 (7.7)	122/1 517 (8.0)	137/1 708 (8.0)	138/1 734 (8.0)	152/1 941 (7.8)	p=0.94
Total	8 297/8 297 (100.0)	1 397/1 397 (100.0)	1 517/1 517 (100.0)	1 708/1 708 (100.0)	1 734/1 734 (100.0)	1 941/1 941 (100.0)	

4 Discussion

4.1 Summary

The overall combined proportion of CS was 19.7% for 2006-2010. The annual proportion of CS increased significantly from 17.4% to 22.5% during the period. The increase in the total number of CS is largely attributed to an increased number of CS in nulliparous women with single normal pregnancies at term (39%; Groups 1 and 2), followed by multiparous women with previous CS births (31%; Group 5). In addition, the relative contribution from Group 5 to the overall proportion of CS increased significantly by 28 % between the first and the last period. Some characteristics of the delivering population of Murmansk County have changed from 2006 to 2010. The greatest changes were observed in distribution of age, parity, smoking during pregnancy and educational attainment in mothers.

4.2 Population Characteristics

The Russian Federation has experienced a major decline in the general population during the past decades. The population decreased from 148.6 million in 1993 to 143.0 million in 2012 (30). Falling fertility and rising mortalities, particularly among the population of working age, have challenged Russia for decades (31), although a slight increase in the population has been observed for the last two years. Because of improved standard of living, Russia has achieved public health improvements in recent years (32). These improvements include increase in life expectancy at birth and decline in mortality rates. The former is a measure of the average number of years that a person is expected to live, and the latter is a crude measure of death rate in a population (33). The fertility rate (25), an indicator of the average number of children born to one woman of reproductive age, has increased during the last decade (34). These

changes may be partly explained by factors such as increased income, reduced alcohol consumption, improved quality of health care and maternity subsidies (32). Maternity subsidies was introduced by the Russian government in 2007 as an attempt to boost the fertility level by offering so-called maternity capital to families who chose to have a second child. Although, public health in Russia has improved in recent years, mortality rates remain high, while life expectancies are relatively low compared with EU countries (32).

The situation for Murmansk County is similar to that of Russia as a whole. The annual number of births has increased, but the high mortality rates are slowing down the population growth (35). Although there was a slight increase in the population of Murmansk County in 2012, the population has decreased from 1 164 600 in 1989 to 787 900 in 2012 (35). The life expectancy at birth increased from 57.4 to 63.9 for men and from 70.2 to 75.3 for women from 2002 to 2012 (36, 37). Although, the life expectancy increased for both genders, women on average, live longer than men as shown elsewhere in Russia (37). The total fertility rate has increased from 1.3 in 2002 to 1.5 in 2011 (36, 37).

According to the data collected by MCBR, the annual number of births has increased from 2006 to 2010 (Table 4). Some characteristics of the delivering population of Murmansk County have changed during the same period (Table 4). The average maternal age has changed, as well as the average age for nulliparous women. Although the increases were small, they were significant, a not unexpected result from the large number of women included in the study, since the Independent sample t-test was used (38). Although, Unpaired z-tests, which are similar to t-tests are recommended in analyses with large sample sizes ($n \geq 100$), this test is neither available in SPSS nor commonly used in clinical research. However, both Unpaired z-test and Independent sample t-test are considered appropriate for the analyses when comparing mean values of two groups and with a normal distribution. However, the latter is usually not a problem in a large sample (19). According to Euro- Peristat, a

proportion of teenage mothers of more than 5% is considered high (4). Although, the proportion of teenage mothers exceeded 5% in 2010, it has declined significantly by 45% from 2006. The decrease of teenage mothers may reflect better economic situation for these women, because teenage pregnancies are associated with lower social status (39). On the other hand, the proportion of older mothers has increased by 52% during the same period. Since more women gave birth to their second and third child in 2010 compared with 2006, this may explain the increase in proportion of older mothers. Moreover, the findings are supported by the increased fertility rate in Murmansk County, described earlier on in this thesis. The proportion of women who reported smoking increased by 33%. Increasing economic growth may explain the increased proportion of mothers with completed higher education, since higher education reflects higher socio-economic status (40). On the other hand, the increased proportion of women with higher education is not surprising since maternal age has increased over the study period. Neither average GA nor proportion of multiple births changed significantly. Since variations in GA distribution is partly determined by the changes in multiple birth rates (4), these results were expected. The average BMI has increased significantly and this change may be explained by economic growth and corresponding dietary changes. The average BW increased minimally, but significantly mainly because of the large sample size, as explained before.

4.3 Robson groups

A significant temporal increase in the overall proportion of CS was found in this study. The proportion of CS increased by 29% from 17.4% to 22.5% between 2006 and 2010. These results were comparable to those reported from other countries (14, 16) , including Russia. WHO reported that the proportion of CS in Russia increased from 18.0% to 22.1%, from 2006

to 2010. In most other countries, the CS rates continue to increase and there are wide variations between different countries. In this study, the proportion of CS in 2010 was higher than in Finland (14.9%) and Norway (17.1%), similar to the Baltic states of Estonia (20.3%), Lithuania (21.4%) and Latvia (23.6%), and UK (23.8%), but lower than in Austria (28.2%), Italy (38.8%) and Turkey (46.7%).

Reasons for increasing CS rates are complex and several factors have been suggested to account for the increase. Factors such as obesity (41) and increasing maternal age at first birth (42) have been attributed to the rising rate. Although, wide differences in CS rates between countries cannot be explained merely by clinical risk factors and maternal characteristics. In contrast, social, cultural and health system factors have been proposed to contribute for the rising CS rates in developed countries (43). Both short and long-term adverse perinatal and maternal consequences are associated with unnecessary CS. The short- term consequences include excessive bleeding, infections, thrombosis and injury to the uterus in mothers, and accidental damage to the fetus during the CS procedure and neonatal respiratory problems (6, 44, 45). The long-term consequences are associated with higher risks of ectopic pregnancy, a pregnancy that develops outside a woman's uterus (46), and CS in subsequent pregnancies (47, 48). In addition, unnecessary CS have the potential to divert human and physical resources from other health care areas (3), since CS procedure is more costly than other delivery methods (49). In contrast, maternal and perinatal adverse outcomes are associated with vaginal delivery in women with a history of CS, although the risks are small (50).

In this study, the increase of CS births in groups 1 and 2, and group 5 contributed largely to the increase in CS proportion, as was shown elsewhere (11, 51). These groups included pregnancies at 37 completed weeks of gestation or more from nulliparous women (Groups 1 and 2) and women with previous CS (Group 5). Dr. Robson has proposed some rules in interpretation of the Robson groups which are based on his experience (13). In this study,

groups 1 and 2, and group 5 accounted for two-thirds (61.8%) of all CS births in 2006-2010, as expected by Robson (13).

Robson groups 1 and 2

The total proportion of primary CS or first- time CS (Groups 1 and 2) was lower (16.5%) than in some other developed countries (12, 13, 52), but it has increased significantly, despite the decline of these women. The proportion of nulliparous woman in groups 1 and 2, exceeded the expected (by Robson) range of 35-40% (49.4%) of all deliveries, but the number of these women has declined significantly between 2006 and 2010. While, the number of nulliparous woman declined, the number of multiparous woman (Groups 3 and 4) has increased during the period. These results are consistent with the increasing birth rate and fertility rate in Murmansk County, as well as the findings obtained earlier on in this study on parity distribution.

Robson group 5

According to Robson, group 5 is the highest contributor to the overall CS proportion in most obstetric populations (7). Group 5 was the second highest in this study (31%), following groups 1 and 2. However, the contribution of group 5 towards the total CS proportion has increased significantly by 28 % during the study period. Of note, this group showed the only significant proportional variation of all Robson groups during the period. The increased contribution of group 5 towards the overall proportion of CS may be partly explained by the sharp increase of women with previous CS and small increase in repeated CS. The proportion of women with previous CS births was within the expected range of 10% (13) of all deliveries, and lower than in other studies (11, 51). However, the proportion of these women has increased by more than 60%. The overall proportion of repeated CS was much higher than

suggested by Robson (13), but similar to that of USA (53). The proportion of repeated CS has increased by 5%. The increase of CS in women with a history of CS may be partly attributed to increase in primary CS (Groups 1 and 2), since the risk of CS is higher in these women (54). One of the reasons is increased risk of maternal and perinatal adverse complications associated with uterine rupture, following CS, in women who attempt natural birth in subsequent pregnancies (55).

4.4 Limitations

The current study has several limitations. One of the limitations of this study is missing information on onset of labour, which completeness is required to categorize women into 10 groups by Robson. In order to apply the Robson 10-group classification system, groups 1 and 2, and groups 3 and 4 were combined, thereby modifying Robson classification into 8 groups. Consequently, individual contribution of groups 1-4 to the overall increase in CS rate could not be derived. However, Robson suggests to combine groups 1 and 2 to obtain CS rates for all nulliparous women with normal pregnancies at term (13), as demonstrated in other studies (10). Likewise, groups 3 and 4 were combined to obtain the CS rates for all multiparous women with normal pregnancies at term. Another limitations is that 1 253 women could not be classified into Robson groups because of missing information. While some studies remove these women from the analyses (51), other studies retain them due to the high percentage of CS in these women (13). Although, excluding these women from the analyses does change the relative size and contribution of each group to the overall CS rate, the overall results are expected to be unaffected (13). Furthermore, significant changes in the relative size and contribution of any group to the overall CS rate are partly determined by the changes in the relative size and/or CS rate in other groups (7, 13). Another important limitation is the use of

LMP as the method to estimate GA. Although, LMP is a commonly used approach to estimate gestational duration, this method is considered less accurate than ultrasound (23, 56). The latter is a clinical estimate, which predicts duration of pregnancy by comparing fetal size to the reference level. The LMP-based method is associated with possible introduction of bias (33). These biases may result from erroneous recall of LMP (recall bias), irregular menses, delayed ovulations and early pregnancy bleedings (23). When compared with ultrasound, the method based on LMP tends to systematically overestimate the gestational duration on an average by approximately 1 day (56, 57). Hence, the mean GA is most likely, slightly overestimated in this study. Another limitation was the exclusion of women with incomplete data on self-reported LMP. Although, the proportion of missing values was relatively small (2.5%), women with missing data on LMP differed significantly from those with complete data. Women with missing LMP information were younger, had lower education and smoked more often during pregnancy, as demonstrated elsewhere (58).

4.5 Privacy and ethics

This study was approved by Regional Committees for Medical and Health Research Ethics (REC). All patient related data were anonymized for comparative and statistical purposes.

5 Conclusions

There was a greater than 29% increase from 17.4% in 2006 to 22.5% in 2010 in the overall proportion of CS. The CS rates are also increasing internationally and variations between different countries are large. In this study, the observed increase in CS proportion was highly attributed to the increased CS proportion in nulliparous women with single normal pregnancies at term (Groups 1 and 2), followed by women with previous CS births (Group 5). The proportion of primary CS rose markedly by 47%, despite a decline in the proportion of nulliparous women, and correspondingly, the number of women with previous CS increased greatly, by 62%.

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7 Appendix

Table 11. The Robson 10-group classification of caesarean section

1.	Nulliparous women with a single cephalic pregnancy, at greater than or equal to 37 weeks gestation in spontaneous labour.
2.	Nulliparous women with a single cephalic pregnancy, at greater than or equal to 37 weeks of gestation who either had labour induced or were delivered by caesarean section before labour.
3.	Multiparous women, without a previous uterine scar, with a single cephalic pregnancy at greater than or equal to 37 weeks in spontaneous labour
4.	Multiparous women, without a previous uterine scar, with a single cephalic pregnancy at greater than or equal to 37 weeks gestation who either had labour induced or were delivered by caesarean section
5.	All multiparous women, with at least one previous uterine scar and a single cephalic pregnancy at greater than or equal to 37 weeks of gestation
6.	All nulliparous women with a single breech pregnancy
7.	All nulliparous women with a single breech pregnancy including, women with previous uterine scars
8.	All women with multiple pregnancies, including women with previous uterine scars
9.	All women with a single pregnancy with a transverse or oblique lie, including women with previous uterine scars
10.	All women with a single cephalic pregnancy at less than or equal to 36 weeks gestation, including women with previous scars