HOSPITAL VARIATION IN QUALITY OF BIRTH CARE IN DENMARK

A nationwide study

by

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ABSTRACT

Background: The rate of caesarean section, CS, has increased worldwide (Betran AP, 2021). This raises health concerns for birthing women, due to the complications CS can contribute with, such as bleeding, infections, risk for the child, and risk for complications of future pregnancy and birth (Burmester, 2021) (Haerskjold A, 2012).

Aim: To estimate the variation in use of acute CS between Danish hospitals

Methods: Risk factors for acute CS was discovered through literature, and a Directed Acyclic Graph, correcting for potential confounding, was made. Data from 65,996 women of Robson group 1 or 2a was sourced from DNQDB and BEF. Unadjusted and adjusted IRR values for regions and hospitals were estimated, and corresponding forest plots were made. Furthermore, an exploratory analysis excluding women with medical conditions and smokers was made, and adjusted IRR was estimated for this study subpopulation.

Results: This study concludes that a variation in use of acute CS between Danish hospitals can be observed. It was observed that less hospitals varied statistically from Rigshospitalet, when adjustments for maternal age, BMI, and socioeconomic measures, was made. It was thereby observed that there is a difference in risk of acute CS according to hospital where birth is given among nulliparous women with a singleton pregnancy at 37 weeks or above, intendent to delivery vaginally. The variation was not observed to be due to medical conditions.

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Abbreviations

CS: Cesarean section

WHO: World Health Organization

DNQDB: The Danish National Quality Database for Births

NTSH: nulliparous women term singleton in head position

QPM: Quality performance measures

DAG: Directed Acyclic Graph

IRR: Incidence rate ratio

95% CI: 95% confidence interval

RC: Region Capital of Denmark

RZ: Region Zealand

RN: Region North Denmark

RCD: Region Central Denmark

RS: Region Southern Denmark

CHAPTER 1. BACKGROUND

1.1. INTRODUCTION

The rate of caesarean section, CS, has increased worldwide (Betran AP, 2021). The increase is observed in both low-, middle-, and high-income countries, and is assumed to continue throughout the current decade. A study collecting data from 2010 to 2018, covering 94,5 % of the World populations live births, found that 21.1 % of women delivered by CS. The same study estimated that by year 2030, the global proportion of births by CS would be 28.5%. The proportion varied between the countries from 5.0% to 42.8%, with the lowest average frequency being at 8.2% for low-income countries, creating a potential inequality in healthcare, considering CS can be provided as emergency surgery (Betran AP, 2021).

The World Health Organising, WHO, has since year 1985 considered a CS rate between 10% to 15% adequate, indicating a global overuse (Betran, 2016).

This puts a spark to health concerns for birthing women, due to the complications CS can contribute with, such as bleeding, infections, tissue damage and risk for the child. Moreover, women who has delivered by CS, are at greater risk of complications during future labor and birth, which is why it is of interest to avoid unnecessary CS to first-time mothers, who were intendent to birth vaginally (Burmester, 2021) (Haerskjold A, 2012) .

CS can be provided due to a vast number of reasons, meaning the population of birthing delivering by CS can carry many properties, which can affect hospitals on different levels, and therefore affect the proportion of performed CS (Wehberg S, 2018).

The following section will describe key numbers: Frequencies of CS for the entire birth population in Denmark, and for a subgroup of uncomplicated pregnancies.

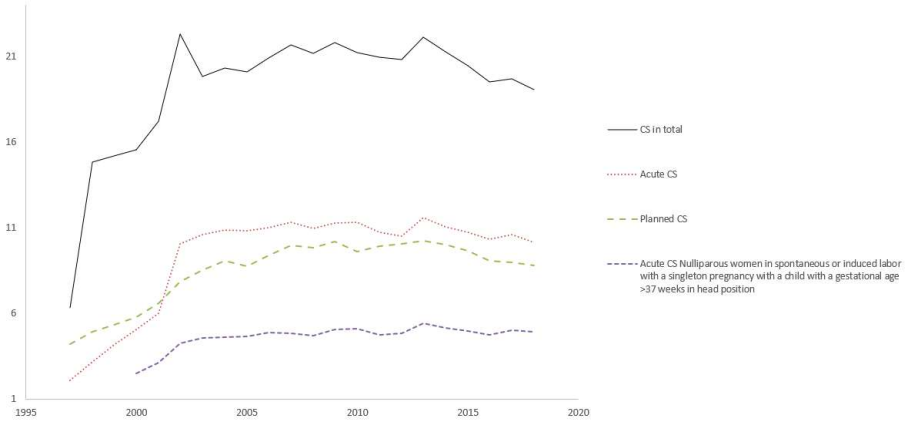
1.2. KEY NUMBERS

Figure 1.2.1 presents the proportion of CS of all births in Denmark. It can on the figure be observed that CS has increased since 1997. Proportions of both planned and acute CS has increased

Numbers from the annual reports by The Danish National Quality Database for Births, DNQDB, show that approximately 15% of nulliparous women, at term with singleton pregnancy head position, *NTSH*, intendent to deliver vaginally, received acute CS in the year medio 2013-2014 (Fødsler, 2014).

In the year 2017-2018, the number was 13.2 % (DKF, 2019)

Figure 1.2.1: Graph of the percentage of CS out of the total number of births in Denmark from 1997-2018. The proportion of respectively total number of CS, acute CS, planned CS, and acute CS for NTSH women in spontaneous or induced labor, can be seen. The graph is based on data from The Medical Births Registry (Sundhedsdatastyrelsen).



1.3. LABOR AND BIRTH

The course of birth has three stages: the first stage, the second stage and the third stage.

The first stage consists of a latent phase and an active phase. The latent phase starts from the beginning of labor, where the woman first experiences contractions. This phase stretches until orificium is dilatated about 4 centimeters. The active phase starts when orificium is dilatated more than 4 centimeters.

The second stage starts when orificium is fully dilatated and terminates with the delivery of a child. During this state, there is a phase of descendance of the child towards the pelvic floor, followed by a phase with strong contractions and an urge to push.

The third stage is from the birth of the child to the delivery of placenta (Sørensen, 2012).

Successful labor is described as the result of maternal effort, uterine contractions, characteristics of the fetus, and pelvic anatomy (Hutchison J, 2022).

The latent phase of labor is described in literature to have a duration of >20 hours for nulliparous and > 14 hours for multiparous women (Eiberg).

Labor is often a spontaneous process, where women will self-present to the facility with indications of labor such as contractions, vaginal bleeding and/or leakage of the amniotic fluid (Hutchison J, 2022).

The labor can be interrupted by complications, as beforementioned. These can be fetus, maternal or combined related complications, and they can vary in severeness. Examples of complications can be maternal bleeding, cardiotocography showing signs of asphyxia, lack of progression of labor or worsening of preeclampsia (Sandbjerg, 2009) (Sørensen, 2012).

In DNQDB's documentalist report from 2017, an uncomplicated birth is defined to not include CS, cup, forceps, vacuum, episiotomy, postpartum bleeding at 1000 ml or more, and 3. or 4. degree vaginal tears. Also the children these women birth must have a 5-minute APGAR-score at 9 or 10 in order to be of an uncomplicated nature (DANSK KVALITETSDATABASE FOR FØDSLER, 2017) (DKF, 2019).

The annual report for year 2018 from DNQDB, showed that 63.1 % of NTSH, had an uncomplicated labor and birth, corresponding to the above-mentioned standards (DKF, 2019).

Numbers from the report also showed that 13.2% of NTSH intendent to deliver vaginally, received acute CS. Previous years the frequency was 12.6% in respectively both 2016 and 2017 (DKF, 2019).

The Finnish Institute for Health and Welfare carries an inventory of the proportion of CS in all nulliparous women for countries being members of The Nordic Federation of Societies of Obstetrics and Gynecology. Here it can be found that Denmark had a frequency ranging from 20.0 % to 21.2 % in the years 2016 to 2018. Finland had a range from 21.0 % to 21.5 %, Iceland 16.6 % to 18.7 %, Sweden 18.6 % to 19.3 %, and Norway had a constant proportion of 18.2 % throughout the three years (NFOG, 22).

It can be difficult to compare births, and the use of CS, since there are several factors that can differentiate between the women, these being singleton contra twin-pregnancies, nulliparous contra multiparous

women, fetal presentation, spontaneous contra induced labor, complications at previous births, and gestational age of the fetus. These factors can give rise to complications in varying degrees, and it is therefore essential to be able to categorize the births according to the estimated complexity (World Health Organization, 2017).

1.4. ROBSON CLASSIFICATION

Robson classification is a method which enables comparison of births. By dividing birthing women into groups, it becomes possible to analyse tendencies in processes and outcomes during deliveries. This classification consists of 10 groups and is also mentioned as the TGCS-ten Groups Classification System in literature. The system was designed to describe who, why, and when a delivery by CS is performed. Hereby clinically relevant groups can be defined, and CS rates within these groups can be monitored. The classification system includes all women birthing at a facility, no matter method of delivery. The grouping can be applied prospectively using information collected by the clinicians (World Health Organization, 2017).

Table 1.4.1: The 10 groups of the Robson classification (World Health Organization, 2017).

Robson group	**Characteristics of the population**

1	Nulliparous women in spontaneous labor with a singleton pregnancy at gestational age 37 weeks or above in head position
2 2a 2b	Nulliparous women in induced labor (2a) or pre-labor delivery by cesarean section (2b) with a singleton pregnancy at gestational age 37 weeks or above in head position
3	Multiparous women in spontaneous labor with a singleton pregnancy at gestational age 37 weeks or above in head position, without previous cesarean section
4 4a 4b	Multiparous women in induced labor (4a) or pre-labor delivery by cesarean section (4b) with a singleton pregnancy at gestational age 37 weeks or above in head position, without previous cesarean section
5 5a 5b	Multiparous women with one (5a) or more (5b) previous cesarean section(s) with a singleton pregnancy at gestational age 37 weeks or above in head position
6	Nulliparous women with a singleton breech pregnancy
7	Multiparous women with a singleton breech pregnancy with previous cesarean section(s)

8	All women with multiple pregnancies
9	All women with a singleton pregnancy with a child with a gestational age at 37 weeks or above in transverse or oblique position
10	All women with a singleton pregnancy with a child with a gestational age under 37 weeks in head position

Besides the birth- and pregancy related variables of the Robsons groups, there are additional factors that may contribute to the risk of CS, this can be found in section *1.7 RISK FACTORS FOR CESAREAN SECTION*.

The section below will describe CS; The indications and the complications following the intervention will be elabortaed.

1.5. CESAREAN SECTION

CS is a method of delivery by incision through the abdominal wall and uterus (Sung S, 2022). CS is performed when it is assessed that the risk is too high for the mother or the child if the birth is performed by vaginal delivery, or a vaginal delivery is not possible. Decision making about acute CS, is based on maternal-, fetal-, or combined indications. (Sørensen, 2012)

CS can be performed planned or acute. A section can be planned before onset of labor due to medical reasons, such as previous births by CS, multiparous pregnancy, fetal presentation or disproportion, or placenta previa. A planned CS can also be due to maternal request (Sørensen, 2012).

Acute CS is classified into three groups: first degree, second degree and third degree.

First degree is performed when the mother or the child is in imminent danger of death. The section is performed at soon as possible and should be completed within 15 minutes. Indications can be uterus rupture or life-threatening maternal bleedings.

A second-degree CS should be performed within 30 minutes and is ordered when there is a great risk for mother or child, but with no immediate risk of death. Indications can be fetal distress or failed attempt to argument labor with cup.

A third-degree CS is ordered at an unstable situation, but with no great risk of severe outcomes. Reasons for this procedure can be a lack of progression in the labor or a severe case of preeclampsia (Sørensen, 2012) (Burmester, 2021).

Before a CS, informed consent must be conducted. The general risks when undergoing a CS include infections, bleeding, damage on uterus and the area surrounding such a bladder, intestine, or blood vessels. CS also poses risk for the child to have difficulty breathing. Furthermore,

CS can increase the risk of complications in future pregnancies and deliveries, such a rupture of uterus scar from the procedure (Burmester, 2021) (Knight, 2014) .

This project will focus on acute CS. The following section will describe the database of which this project origin.

1.6. THE DANISH NATIONAL QUALITY DATABASE FOR BIRTHS

DNQDB was created in 2010 as part of a national program for clinical quality databases in Denmark. The database consists of quality performance measures, QPM's, for the provided care during labor and childbirth (RKKP, 2022)

The aim of DNQDB is to measure the quality of care during labor and birth, to ensure a high and homogentisic quality of care within the Danish hospitals, and to deliver evidence for care to be based upon. Furthermore, the database aims to ensure that the quality of care during labor and birth adds up to the quality of care provided internationally (RKKP, 2022). Each year, DNQDB publishes a report on the findings of the collected data. These reports deliver information concerning tendencies for all QPM's and discusses recommendations on how to improve care further (DKF, 2019) (DANSK KVALITETSDATABASE FOR FØDSLER, 2017).

Data for QPM's is collected from the Danish National Patient Register, and CPR-registry. The population includes all births taking place at a Danish hospital (Andersson, 2016).
Some of the QPM's are measured on specific subpopulations, such as the QPM for uncomplicated births or the one concerning acute CS. The subgroup for acute CS is defined as Robson group 1 and 2a, excluding cases with planned CS (DKF, 2019).

Creating these subgroups, does remove some differences in characteristic the women receiving acute CS may have, which removes some of the bias contributing to variation in CS frequencies between hospital departments (Andersson, 2016). Besides these, more characteristics can contribute to bias in variation, so to make the study population as homogeneous as possible, a literature search exploring the risk factors for acute CS, for a woman of Robson group 1 or 2a, has been carried out.

1.7 RISK FACTORS FOR CESAREAN SECTION

A literature search was performed with a pragmatic approach to explore well-established risk factors for unplanned CS, for women of Robson group 1 and 2a. The process and documentation for the literature search can be found in Appendix A. The investigation for explanatory factors, was not limited to the systematic literature search. Table 1.7.1 present factors that may affect a hospital and possibly create a visitation bias on population level.

Table 1.7.1: Results of literature search. The table shows maternal and fetal related risk factors for acute AC.

Maternal related risk factors	
	Maternal age (Eva Rydahl, 2019) (Wehberg S, 2018) (Andrikopoulou M., 2021)
	Ethnicity (Rasmussen, 2019)
	Maternal height (Mogren, 2018) (Wehberg S, 2018)
	Socioeconomic factors, educational level (Eva Rydahl, 2019) (Essex, 2013)
	High BMI prior to pregnancy (Crequit, 2020) (Kwon, 2016) (Wehberg S, 2018) (Andrikopoulou M., 2021)
	Medical conditions
	Respiratory condition (DSOG, 2018)
	Thyroid condition (Männistö, 2013)
	Gastrointestinal condition (Burke, 2017)

	Polycystic ovarian syndrome (Boomsma CM, 2006)
	Mental health https://pubmed.ncbi.nlm.nih.gov/31213056/ (Ryding EL, 1998)
	Hypertension, eclampsia, preeclampsia (Wehberg S, 2018)
	Insulin dependent diabetes mellitus (Wehberg S, 2018)
	Gestational diabetes mellitus (Eid, 2021)
	Smoking (Wehberg S, 2018)
	Anemia (Drukker L, 2015)
Fetal related risk factors	
	Macrosomia https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4871932/ (Wehberg S, 2018)

1.8 VARIATION IN HEALTHCARE

According to Dr. Wennberg, care can be categorized into three groups: effective care, preference sensitive care, and supply sensitive care. Effective care is provided when the benefit of the applied intervention exceeds the associated risk. Preferred sensitive care is defined as more than one available established treatment. Different from the two other groups of care, which both focuses on willingness or ability to provide a treatment, supply sensitive care is dependent on the capacity of the system. This is things such as doctors' appointments, hospital admissions and laboratory tests (E, 2011).

In the beforementioned groups, underuse or overuse can occur. If care is categorized as effective care, unwarranted variation would be expressed as underuse of the intervention. Opposite to this, is care supply sensitive, unwarranted variation is typically seen as overuse (E, 2011).

Variation can be caused by the fact that some hospitals have more patients of a certain group, than other hospitals. This can for example be due to specialization of the department or differences in patients' demographics or the illness of them (E, 2011) . This variation can be controlled by correction of visitation bias and is therefore not understood as unwarranted variation. Is the variation on the other hand caused by the service and practice of a medical staff, it can be seen as unwarranted variation. Factors that can contribute to this can be culture,

environment, education, and training of the medical staff (Birkmeyer JD, 2013) (E, 2011).

When looking at CS, WHO has stated that an acceptable rate of CS lies at 10% to 15%, indicating that Denmark has an overuse of this (Betran, 2016). An acute CS can be understood as effective care, since it is applied when the mother or child is assumed to be in risk of an unreasonable outcome, and Denmark's high rate can therefore be argued as adequate use, and not overuse (Sørensen, 2012) In practice, it could be opposite, which is highly unfavorable considering the outcomes an overuse of acute CS could bring. Moreover, Denmark's high rate of CS can possibly be reduced by reducing the rate of provided acute CS. To investigate if there is an unwarranted variation in the use of acute CS in Denmark, and a possible overuse, a more in-depth analysis of data from DNQDB is warranted

2 AIM

Aim of this project is to estimate the variation in use of acute CS between Danish hospitals.

The project will be based on, that there is no difference in risk of acute CS according to the hospital where birth is given among, nulliparous woman in labor at gestational age 37 weeks or above, with one child in head position.

3 METHODS

Data source of this study was the database DNQDB linked with the data source BEF, which includes data about the Danish population. Data from year 2016, 2017, and 2018 were used in this study. All data is pseudo anonymized.

The study population consisted of 65,996 women intended to have a vaginal spontaneous birth, meaning they was categorized by Robson group 1 and 2a and were not planned to deliver by CS. Therefore, women carrying other properties were excluded. The outcome was acute CS. All unplanned CS were considered acute CS. SKS-codes were used to register the course and facility of birth

3.1 COVARIATES

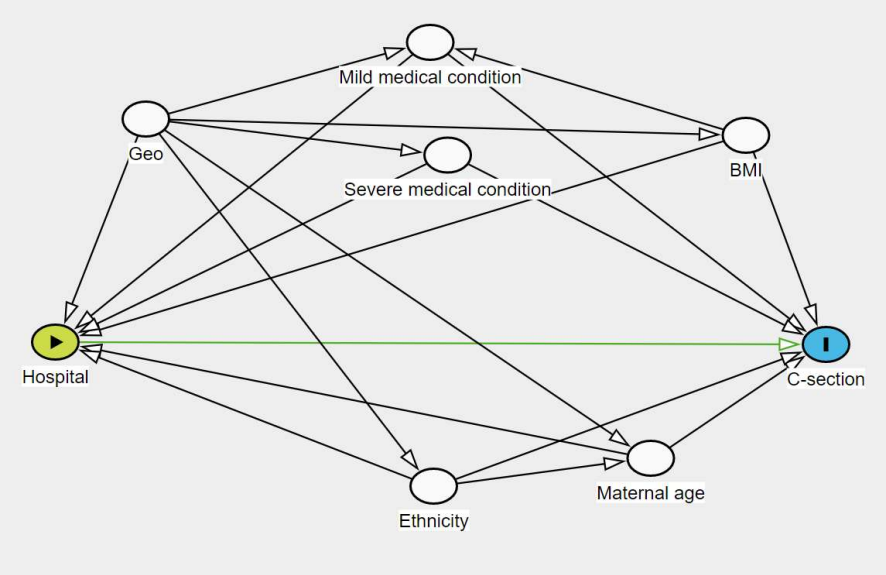
To correct for potential confounding a Directed Acyclic Graph, *DAG* using the result of the litterature search, was made. Seen on figure 3.1.1. The litterature search can be found in appendix A.

The covariate “Geo” refers to a measure where municipalities get classified into five groups based on the size of the biggest city in the municipality and the job availability. These two factors are used as a reflection of the size of the municipality and its placement (central or distant). Also, by adding the aspect of job availability, the method indirect reflects economic activity, and can therefore be used as a sort of expression for socioeconomic factors (Danmarks Statistik, 2018).

Mild medical condition refers to respiratory-, thyroid-, and gastrointestinal- conditions, anemia and polycystic ovarian syndrome.

Severe medical condition refers to hypertension, eclampsia, preeclampsia, insulin dependent diabetes mellitus and gestational diabetes mellitus.

Figure 3.1.1: DAG presenting explanatory variables. The DAG is created using DAGitty Development Version 3.0 (Johannes Textor, 2016).



3.2 STATISTICAL ANALYSES

All results for this project were generated using STATA/MP 17.0.

3.2.1 UNADJUSTED ANALYSIS

To make the unadjusted analysis, an incidence rate ratio, IRR, was calculated for each region and hospital, with the exposed group being the birthing at a certain location, and the reference being Rigshospitalet. IRR was estimated with a Poisson regression.

3.2.2 ADJUSTED ANALYSIS

A data inspection of demographics of the study population, for the covariates explained through the DAG, was made, to eliminate the number of explanatory variables in the adjusted analyses. Following this, a check for "change in estimate" was done, meaning if adjustment with a variable made little to no change in the effect measure risk ratio, the variable would be excluded. For this project, the lower limit of change in risk ratio was set to be at least 5% for ¼ of the hospitals.

To adjust the analysis, the covariates BMI, maternal age, and geo was used. IRR was calculated, using Poisson regression, resulting in the relative incident rate for acute CS at a location compared with a reference. The reference used was Rigshospitalet.

3.2.3 EXPLORATORY ANALYSIS

An exploratory analysis was made were the restriction also included medical conditions, and smoking, meaning cases including these were excluded from the study population, resulting in a study subpopulation.

An adjusted analysis, like the description above, was made using this study subpopulation.

3.3 FOREST PLOTS

For each of the analyses, there were made a forest plot, to present the relative risk and rates with 95% CI.

The forest plot was made in Excel using the IRR for the analyses, and their respected 95% CI.

4 RESULTS

4.1 DEMOGRAPHICS OF THE REGIONS AND HOSPITALS

Table 4.1.1 shows the demographic characteristics of the study population. It can here be seen that the largest birthplace for the study population was Region Capital of Denmark, RC, meaning the biggest part of the study populations births took place there. Second largest birthplace was Region Central Denmark, RCD, followed by respectively Region Southern, RS, Region Zealand, RZ. Region North Denmark, RN, was in this study the smallest birthplace.

In the RC, 19.7 % of the study population is another ethnicity than Danish. The region with the lowest percentage was the RN with 13.1% followed by RZ with 13.8%.

RC and RS had the highest frequency of mild medical conditions, at 9.3% and 8.2%, whereas RN and RC had the lowest at 5.2%. RZ and RN had the highest frequencies of severe medical conditions, at respectably 12.6 and 12.0%, and RC and RCD had the lowest both at 9.5%.

At table 4.1.2 the total number of births at the hospitals of Denmark are seen. The hospitals are order by regions, and within the regions, by how many births of the study population, that took place there. At the table, it is seen that the largest birthing place in the study population was

Hvidovre with 8,703 births. The second, third and fourth largest birthplace of all hospitals were Herlev, Rigshospitalet and Aarhus. The smallest birth places where Bornholm, Thy- Mors, and Nykøbing Falster with less than 1000 births.

Table 4.1.1: Demographics of regions study population n= 65,996 2016-2018

	Denmark	**Region Capital of Denmark**	**Region Zealand**	**Region North Denmark**	**Region Central Denmark**	**Region Southern Denmark**
Births in total, n	65.996	25,487	7,484	6,148	16,317	10,560
Acute cesarean section, (%)	13.4	12.8	14.6	14.0	12.6	14.5
Demographics of study populatin (%) BMI, (%)						
<20	15.9	17.7	13.9	13.4	15,6	14,6
20-25	52.8	58.0	46.1	48.1	51.7	49.3
25-30	20.2	16.7	23.9	23.6	20.9	22.5
30-35	7.6	5.4	10.1	9.9	8.1	9.0
35-40	2.3	1.4	3.6	3.2	2.4	2.8
>40	1.3	0.7	2.4	1.7	1.4	1.7
Age, (%)						

12-19	2.2	1.0	4.5	2.9	2.1	3.0
20-25	27.7	19.1	36.2	35.2	29.8	34.8
26-30	43.3	44.3	38.1	42.1	45.2	42.6
31-35	19.4	25.3	14.9	14.1	17.3	14.2
36-40	5.9	8.2	4.9	4.0	4.6	4.3
>40	1.4	2.1	1.3	0.8	1.0	1.1
Ethnicity (yes), (%)	16.5	19.7	13.8	13.1	14.0	16.3
Medical condition (yes), (%)						
Mild	11.1	9.3	7.2	5.2	5.2	8.2
Servere	10.2	9.5	12.6	12.0	9.5	10.4

Table 4.1.2: Proportion of study population births and acute CS for regions and hospitals. The regions are arranged as in figure 1, but the hospitals are ordered by the number of births, meaning the largest birthplace is placed in the top of the belonging region, and the smallest in the bottom.

Regions and hospitals	**Total number of births, study population (n)**	**Exposed risk (%)**
Region Capital of Denmark	25,487	12.8%
Hvidovre	8,703	14.0%
Herlev	6,727	12.4%
Rigshospitalet	6,326	10.9%
Hillerød	3,536	14.1%

Bornholm	195	14.9%
Region Zealand	7,484	14.6%
Roskilde	2,781	13.2%
Næsved/Slagelse	2,126	15.4%
Holbæk	1,619	15.7%
Nykøbing Falster	953	15.0%
Region North Denmark	6,148	14.0%
Aalborg	4,201	13.4%
Vendsyssel	1,314	16.1%
Thy- Mors	633	13.9%
Region Central Denmark	16,317	12.6%
Aarhus	6,258	13.5%
Holstebro/Herning	3,266	10.6 %
Viborg	2,332	11.9 %
Horsens	2,238	12.3 %
Randers	2,223	14.0 %
Region Southern Denmark	10,560	14.5 %
Odense/Svendborg	4,091	14.4 %
Kolding	3,365	15.9%

Esbjerg	1,749	14.9 %
Aabenraa	1,355	10.6%

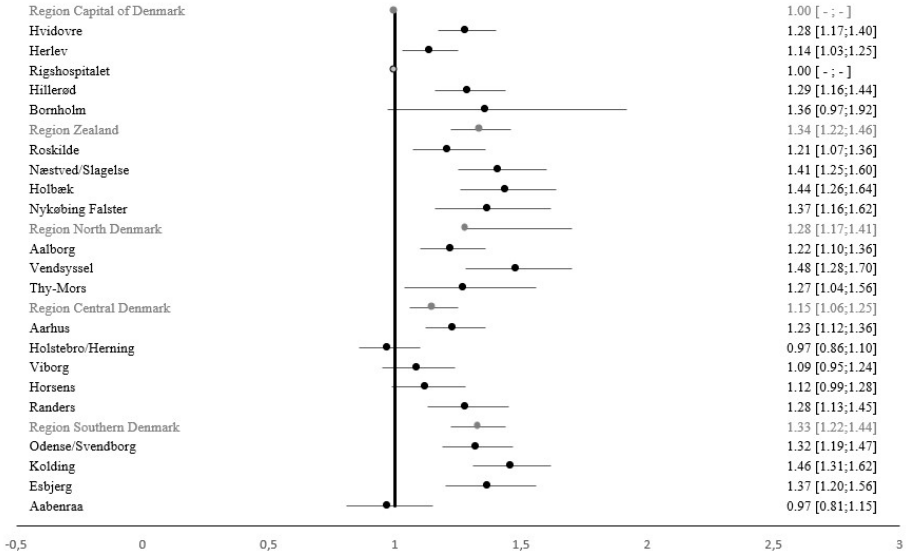
4.2 INCIDENCE RATE FOR ACUTE CS

On figure 4.2.1 a forest plot of IRR for acute CS for regions and hospitals, with Rigshospitalet as a reference, with an IRR being 1, is seen.

RC had an IRR at 1. All other regions had an IRR and belonging 95% CI above 1.

All hospitals had an IRR and belonging 95% CI above 1, except for Holstebro/Herning and Aabenraa both having an IRR below 1, with 95% CI crossing 1. The 95% for Viborg also cross 1.

Figure 4.2.1. forest plot of unadjusted IRR, with Rigshospitalet as reference, marked with a gray and black outline. Regions are marked with gray. The black vertical line presents a value of 1.



4.3 ADJUSTED INCIDENCE RATE FOR ACUTE CS

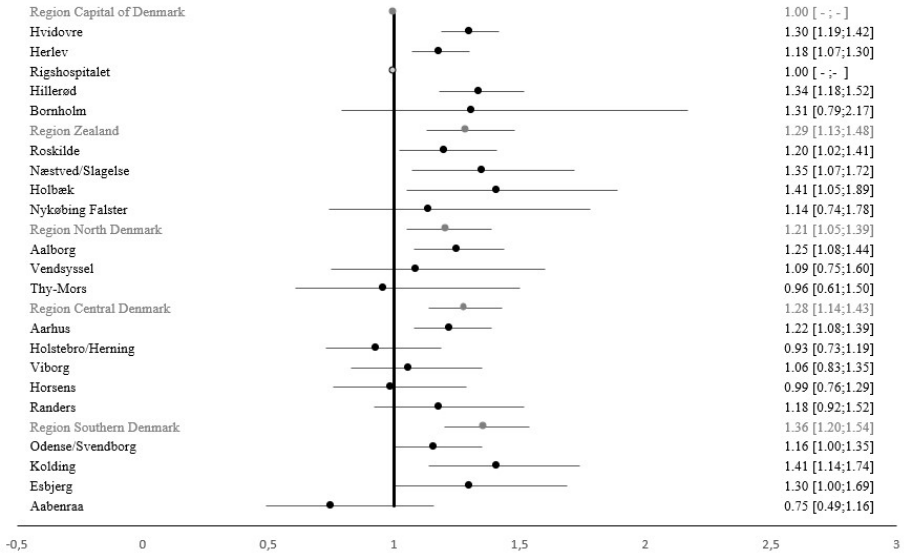
The result of adjusted values was generated through a multivariable analysis of IRR, adjusting for BMI, maternal age, and an indirect measure for socioeconomic geographic differences between the municipalities of Denmark, referred to as geo.

The adjusted IRR forest plot seen on figure 4.3.1, present the IRR and 95% CI for the regions and hospitals, when compared to Rigshospitalet.

All regions had IRR-values with 95% CI above 1, except the Region Capital of Denmark.

The hospitals Thy- Mors, Hostebro/Herning, Horsens, and Aabenraa had a RR below 1, with Horsens IRR being 0.99. Hvidovre, Herlev, Roskilde, Næstved/Slagelse, Holbæk, Aalborg, Aarhus, and Kolding all had a IRR and 95% CI above 1. Bornholm, Nykøbing Falster, Thy-Mors, Holstebro/Herning, Viborg, Horsens, Randers, and Aabenraa had a 95% CI crossing 1.

Figure 4.3.1 Forest plot of adjusted IRR, with Rigshospitalet as reference marked with a gray and black outline. Regions are marked with gray. The black vertical line presents a value of 1.



4.4 EXPLORATORY ANALYSIS

The exploratory analysis excluded women with medical conditions, and women who smoked during pregnancy. A total of 50,166 women was included in the exploratory study subpopulation.

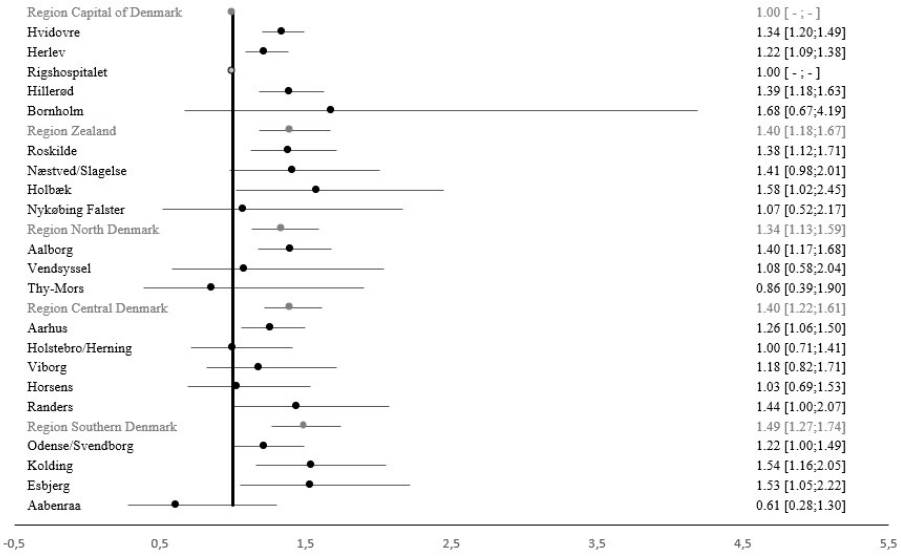
Table 4.4.1 presents the number of excluded women from the study population, for each medical condition and for smoking. Here it is seen that the major causes for exclusion based on medical conditions is hypertension and preeclampsia, mental illness, and thyroid disease. 2889 cases were excluded based on smoking. 24.0 % of the study population was excluded.

Table 4.4.1: Number of excluded cases from study population, based on medical conditions and smoking

Medical condition	**Excluded cases in numbers, n**
Respiratory disease	960
Thyroide disease	2,072
Gastrointestinal disease	446
PCO	498
Anemia	1,235
SMI/MMI	2,776
Hypertension+preeclampsia	4,476
IDDM	314
GDM	2,391
Other	
Smoking	3,787

Total proportion of study population excluded	24.0 %

Figure 4.4.1 Forest plot for exploratory analysis, of adjusted IRR, with Rigshospitalet as reference marked with a gray and black outline. Regions are marked with gray. The black vertical line presents a value of 1.



The forest plot seen on figure 4.4.1 is the result of an adjusted analysis, adjusting for BMI, maternal age, and geo, using Rigshospitalet as reference.

On figure 4.4.1 it is seen that IRR and belonging 95% CI for regions all are above 1, except RC's IRR being at 1. IRR for Thy- Mors and Aabenraa is below 1, with their belonging 95% CI crossing 1. Holstebro/Herning have an IRR at 1, and Horsens has an IRR at 1.03. All other IRR values for the hospitals are above 1. 95% CI for Bornholm, Nykøbing Falster is crossing 1.

5 DISCUSSION

5.1 RESUME OF RESULTS

The proportion of births with acute CS ranged was 10.6% to 16.1% across the Danish hospitals in the period 2016 to 2017, for respectively Holstebro/Herning, Aabenraa and Vendsyssel.

All hospitals and regions, except Bornholm, Holstebro/Herning, Viborg, Horsens and Aabenraa, varied statistically significantly from Rigshospitalet in use of acute CS. All hospitals and regions had a higher risk than Rigshospitalet, except for Holstebro/Herning and Aabenraa.

When adjusting for BMI, maternal age, and the measure for socioeconomic factors, it could be observed that Bornholm, Nykøbing Falster, Vendsyssel, Thy- Mors, Holstebro/Herning, Viborg, Horsens, Randers and Aabenraa did not vary from Rigshospitalet. Furthermore, IRR for Thy -Mors, Holstebro/Herning, Horsens and Aabenraa was lower, when compared with Rigshospitalet. The hospitals in RN and RCD were observed to vary the least from Rigshospitalet. All hospitals of RN and RCD did not vary, except Aalborg and Aarhus, which both were the biggest birthplaces within the regions, for the study population.

5.2 DISCUSSION OF ADJUSTMENTS

An exploratory analysis was carried out, excluding women with medical conditions and women who smoked, resulting in exclusion of 24% of the study population. An adjusted analysis was performed, adjusting for BMI, maternal age, and geo. At the forest plot it could be observed that the same hospitals, as for the adjusted plot in figure 4.3.1 did not vary from Rigshospitalet. Aalborgs and Aarhus' IRR increased posing a higher risk for acute CS, than at Rigshospitalet.

This study adjusted for BMI, maternal age, and geo. Before this, it was tested whether mild and severe medical conditions also should be used when adjusting IRR. These were found to not affect the relative risk adequately and were therefore not used for the estimation. The exploratory analysis can be used to confirm that medical conditions probably did not count for most of the variation observed between the hospitals, since no additional hospitals' 95% CI crossed 1. IRR did generally increase when removing cases with medical conditions or smoking. Only Nykøbing Falster, Vendsyssel, Thy- Mors, and Aabenraa decreased. Opposite, smoking has not been checked for change in estimate, meaning smoking could have confounding effect.

Besides this, a study investigating risk factors for CS for NTSH, concluded that high BMI and maternal age were highly associated increased risk for CS, and posed a higher risk for CS than the medical conditions marked as severe in this study (Andrikopoulou M., 2021).

5.3 DISCUSSION OF RESULTS

On figure 4.3.1 it is observed that hospitals of RN and RCD did not vary significantly from Rigshospitalet. A possible explanation for this could be that they were hospitals with an average population, considering they also generally were placed closer to 1, in the unadjusted analysis, seen on figure 4.2.1

It could be speculated that there is a cultural difference between the hospitals. This could for example be a difference in when acute CS due to prolonged birth or exhaustion is offered. These different thresholds could be dependent on feelings and beliefs towards CS, and thereby affect the frequency of acute CS. A study found that NTSH could have up to 30% increased risk of receiving CS, if they delivered at a hospital with a high rate of CS. The study did not differentiate between planned and unplanned CS (Ebott, 2020)

Studies has suggested that the size of the birth facility can affect the risk for acute CS (Wehberg S, 2018) In this study it cannot be concluded whether this is an explanation for hospital variation, but generally it can be observed in figure 4.3.1 that the larger birthplaces, nationally and within regions, had higher IRR.

A decrease in national variation in acute CS, could result in a lower frequency of CS, decreasing the risk of overuse, in terms of WHO's 10% to 15 % standard (Betran, 2016) A question that can be raised, is whether the standard is appropriate, considering acute CS as both

effective care, and preferred sensitive care. Critics has over time argued that the standard does not take complex population into account (Betran, 2016). The results of this study could indicate that there is unwarranted variation in the procedures. A possible way to decrease this, is to investigate the maternal, and child related outcomes following acute CS, and thereby provide better evidence for the use of unplanned sections (Birkmeyer JD, 2013).

6 CONCLUSION

This study concludes that a variation in use of acute CS between Danish hospitals can be observed. It was observed that less hospitals varied statistically from Rigshospitalet, when adjustments for maternal age, BMI and socioeconomic measures, was made. It was thereby observed that there is a difference in risk of acute CS according to hospital where birth is given among NTSH, intendent to delivery vaginally.

The variation was not observed to be due to medical conditions.

Further studies should focus on variation in outcome for NTSH following acute CS, to provide evidence for further discussion of variation between Danish hospitals.

7 BIBLIOGRAFI

Andersson, C. B. (2016). The Danish National Quality Database for Births. *Clinical epidemiology*, s. 595-599. doi:https://doi.org/10.2147/CLEP.S99492

Andrikopoulou M., W. O.-J. (2021). 188 Risk factors for nulliparous, term, singleton, vertex cesarean birth. *American Journal of Obstetrics and Gynecology, 224*, s. S126-S127. doi:https://doi.org/10.1016/j.ajog.2020.12.210

Betran AP, Y. J. (2021). Trends and projections of caesarean section rates: global and regional estimates. *BMJ Global Health;6:e005671*.

Betran, A. T. (2016). WHO Statement on Caesarean Section Rates. *BJOG; 123: 667–670*.

Birkmeyer JD, R. B. (28. Sep 2013). Understanding of regional variation in the use of surgery. *Lancet*. doi:10.1016/S0140-6736(13)61215-5

Boomsma CM, E. M. (Nov-Dec 2006). A meta-analysis of pregnancy outcomes in women with polycystic ovary syndrome. *the European society of human reproduction and embryology(Eshre)*. doi:10.1093/humupd/dml036

Burke, K. E. (03. 05 2017). Indications for Mode of Delivery in Pregnant Women with Inflammatory Bowel Disease. Inflammatory bowel diseases. s. 721–726. doi:10.1097/MIB.0000000000001113

Burmester, L. W. (25. 08 2021). *Region Nordjylland:Regionshospital Nordjylland:Afdeling for Gynækologi, Graviditet og Fødsel Hjørring.* Hentet fra pri.rn.dk: https://pri.rn.dk/Sider/33611.aspx

Crequit, S. K. (2020). Use of the Robson classification to understand the increased risk of cesarean section in case of maternal obesity. *BMC Pregnancy Childbirth*(738). doi:https://doi.org/10.1186/s12884-020-03410-z

Danmarks Statistik. (2018). *Inddeling af Danmarks kommuner.* Dokumentation-af-Kommunegrupper.pdf.

DANSK KVALITETSDATABASE FOR FØDSLER. (2017). *Dokumentalistrapport.* Hentet 31. 05 2022 fra https://www.rkkp.dk/siteassets/de-kliniske-kvalitetsdatabaser/databaser/fodsler/ny_fodsler/dokumentalistrap_dkf_okt2017.pdf

DKF, D. K. (2019). *Årsrapport 2018.* RKKP. Hentet fra https://www.sundhed.dk/content/cms/66/4666_aarsrapport-dkf-2017-2018-hovedrapport-samt-bilag-12.pdf

Drukker L, H. Y.-G. (DEC 2015). Iron deficiency anemia at admission for labor and delivery is associated with an increased risk for Cesarean section and adverse maternal and neonatal outcomes. *Transfusion*. doi:10.1111/trf.13252

DSOG. (19. 01 2018). Lungesygdomme og graviditet. *Sandbjerg* (1. version).

E, W. J. (17. March 2011). Time to tackle unwarranted variations in practice. *BMJ*(342 :d1513). doi:10.1136/bmj.d1513

Ebott, J. A. (01. Jan 2020). 356: Maternal care matters: An analysis of hospital Cesarean delivery rates in Michigan. *AJOG, 222*(1), s. S237-S238. doi:https://doi.org/10.1016/j.ajog.2019.11.372

Eiberg, M. P. (u.d.). *Partus normalis, den normale fødsel.* Hentet 31. 05 2022 fra https://www.nordsjaellandshospital.dk/afdelinger-og-klinikker/gynaekologisk-obstetrisk-afdeling/for-sundhedsfaglige/Documents/PartusNormalis_DenNormaleFoedsel.pdf

Eid, J. M.-J. (2021). Risk factors for nulliparous, term, singleton, vertex cesarean birth among deliveries complicated by pregestational diabetes. *AJOG*. doi:https://doi.org/10.1016/j.ajog.2021.11.1170

Essex, H. G. (20. March 2013). Which women are at an increased risk of a caesarean section or an instrumental vaginal birth in the UK: an exploration within the Millennium Cohort Study. *BJOG, 120*(6), s. 732-743. doi:https://doi.org/10.1111/1471-0528.12177

Eva Rydahl, E. D. (24. Jan 2019). Cesarean section on a rise—Does advanced maternal age explain the increase? A population register-based study. *PLOS ONE*. doi:https://doi.org/10.1371/journal.pone.0210655

Fødsler, D. K. (2014). *Årsrapport 2014.* Hentet fra https://jordemoderforeningen.dk/fileadmin/Nyheder/Foedsler_aarsrapport_2014_NY.pdf

Haerskjold A, H. H. (Aug;32(6):543-7 2012). Emergency caesarean section in low risk nulliparous women. *J Obstet Gynaecol*. doi:10.3109/01443615.2012.689027

Hutchison J, M. H. (26. Feb 2022). Stages of Labor. *StatPearls Publishing*. Hentet fra https://www.ncbi.nlm.nih.gov/books/NBK544290/

Johannes Textor, B. v. (2016). Robust causal inference using directed acyclic graphs: the R package 'dagitty'. *International Journal of Epidemiology 45(6)*, 1887-1894.

Knight, H. G.-U. (2014). Vaginal birth after caesarean section: a cohort study investigating factors associated with its uptake and success. *BJOG, 121*, s. 183-192. doi:https://doi.org/10.1111/1471-0528.12508

Kwon, H. Y. (May 2016). The risk of emergency cesarean section after failure of vaginal delivery according to prepregnancy body mass index or gestational weight gain by the 2009 Institute of Medicine guidelines. *Obstetrics & gynecology science*, s. 169-177. doi:10.5468/ogs.2016.59.3.169

Männistö, T. M. (Jul 2013). Thyroid diseases and adverse pregnancy outcomes in a contemporary US cohort. *The Journal of clinical endocrinology and metabolism*, s. 2725-2733. doi:10.1210/jc.2012-4233

Mogren, I. L. (29. May 2018). Maternal height and risk of caesarean section in singleton births in Sweden-A population-based study using data from the Swedish Pregnancy Register. *PloS one*, s. 13(5): e0198124. doi:10.1371/journal.pone.0198124

NFOG. (31. 05 22). *Finnish institue for health and welfare.* Hentet fra The Nordic perinatal statistics 2020: https://thl.fi/documents/189940/1449591/Nordic_perinatal_appendix_tables.pdf/cf90da41-cfd0-33e2-7497-e60b85fce18a?t=1649754636241

Rasmussen, T. V. (04. Jun. 2019). Ethnic differences in the risk of caesarean section: a Danish population-based register study 2004–2015. *BMC Pregnancy Childbirth 19*(194). doi:https://doi.org/10.1186/s12884-019-2331-6

RKKP. (2022). *regionernes kvalitetsudviklingsprogram*. Hentet 31. 05 2022 fra rkkp.dk: https://www.rkkp.dk/kvalitetsdatabaser/databaser/dansk-kvalitetsdatabase-for-foedsler/om-databasen/

Ryding EL, W. B. (1998). Fear of childbirth during pregnancy may increase the risk of emergency cesarean section. *Acta Obstet Gynecol Scand.* Hentet 31. 05 2022 fra https://pubmed.ncbi.nlm.nih.gov/9654177/

Sandbjerg. (2009). *http://gynobsguideline.dk/.* Hentet 31. 05 2022 fra http://gynobsguideline.dk/sandbjerg/090405%20Guideline%20Akut%20sectio%20-%20klassifikation%20%20Sandbjerg%202009.pdf

Sørensen, J. L. (2012). Ars Pariendi - håndgreb og akut behandling ved fødsler. København: Munksgaard.

Sundhedsdatastyrelsen. (u.d.). Fødte og fødsler (1997-). *esundhed.dk*. Hentet 31. 05 2022 fra https://www.esundhed.dk/Emner/Graviditet-foedsler-og-boern/Foedte-og-foedsler-1997-#tabpanel61119A72216248AC86DB508579760DED

Sung S, M. H. (21. Jan 2022). Cesarean Section. I H. M. Sharon Sung, *Cesarean Section* (s. Excerpt). Hentet fra https://pubmed.ncbi.nlm.nih.gov/31536313/

Wehberg S, G. R. (2018). Risk factors and between-hospital variation of caesarean section in Denmark: a cohort study. *BMJ Open, 8*. doi:10.1136/bmjopen-2017-019120

World Health Organization. (2017). *Robson Classification: Implementation Manual.* Hentet 2022 fra https://www.who.int/publications/i/item/9789241513197

Appendix A. Systematic literature search

A systematic literature search was performed to investigate the risk factors for acute CS.

The literature search was performed in Embase 2021 Elsevier.

The search terms used was 1) caesarean section 2) risk factors and 3) maternal-, fetal-, or labor-related. The search words were validated in Embases Emtree. Alle searches were carried out in title and abstract.

The terms resulted in the following search blocks:

1) 'caesarean section':ti OR 'caesarean delivery':ti OR 'caesarean birth':ti OR 'cesarean section':ti OR 'cesarean delivery':ti OR 'cesarean birth':ti OR 'caesarian section':ti OR 'caesarian birth':ti OR 'caesarian delivery':ti OR 'c section':ti OR sectio:ti OR 'surgical birth':ti OR 'surgical delivery':ti OR 'abdominal birth':ti OR 'abdominal delivery':ti OR hysterotomy:ti
2) 'determinant condition':ab,ti OR 'determinant conditions':ab,ti OR 'predisposing factor':ab,ti OR 'predisposing factors':ab,ti OR 'risk factor'/de OR 'risk'/de
3) 'maternal':ti OR 'maternal related':ti OR fetal:ti OR 'fetal related':ti OR labour:ti OR 'labour related':ti OR 'labor related':ti OR 'labor'/exp

The three search blocks were combined using the operator “and” resulting in 812 hits.

Limitations were added to the search, these being language and study type being human. The language limited for were Danish, English, Norwegian, and Swedish. This resulted in 733 hits.

The articles were added to ProQuest Refworks, where the process of exclusion took place, transferring from Embase to Reworks, where the exclusion took place.

The articles were excluded primarily based on title followed by information in abstract. Articles were first excluded based on the following:

1. Does not fit the theme of being an article about risk factors for CS
2. The article focuses on a study population of irrelevant characteristics, e.g., non-inclusion of women of Robson group 1 or 2a
3. Too individual based

Out of these, systematics reviews and registry studies from NFOG-countries were prioritized when selecting the final sources of information. 77 articles were included in the search for covariates. Some covariates for table 1.7.1. were discovered in studies that not directly investigated them, and they were therefore explored beyond the search.