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Explanatory factors of the variation in caesarean section rates and financial implications for NHS hospitals

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EXPLANATORY FACTORS OF THE VARIATION IN CAESAREAN SECTION RATES AND FINANCIAL IMPLICATIONS FOR NHS HOSPITALS

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Abstract

The increasing trend in caesarean section (C-section) rate has become a global health challenge. In addition to the adverse effects that C-sections may cause to the mother/child, the increasing rate of this procedure may trigger other problems, including an economic impact on national health systems (NHS). In Portugal, with the purpose of consolidating the reduction in the rate of C-sections, targets were defined with repercussions on hospital financing.

In the present study, a sample of 4523 deliveries between 2018 and 2020 was selected in which caesarean section rates were analysed, financial losses were calculated, and risk factors that allow explaining and estimating the variation in caesarean section rates at the Entre Douro e Vouga Hospital Centre were determined. To this end, a binary dependent variable model (Probit model) was developed to analyse the socio-demographic and clinical factors of the mother/newborn that affect the caesarean section rate.

The main findings of this study indicate the determinants of caesarean section rate are high maternal age, high body mass index, nulliparity, high head circumference perimeter, multiple pregnancies, and smoking habits.

This study aims to complement the scarce literature in Portugal on the topic. In addition, the work developed has the potential to develop a prediction model for caesarean sections, with a view to performing interventions that reduce the risk of these surgeries.

JEL codes: I10; I18; I19

Keywords: Caesarean rate; Caesarean section; Electronic register; Financial impacts; Financial penalties; Indicators; ObsCare.

Resumo

A tendência crescente da taxa de cesarianas tornou-se um desafio global de saúde. Além dos efeitos adversos que a cesariana pode causar na mãe/ filho, o aumento da taxa deste procedimento pode desencadear outros problemas, incluído o impacto económico nos sistemas nacionais de saúde (SNS). Em Portugal, com o objetivo de consolidar a redução da taxa de cesarianas, foram definidas metas com repercussões no financiamento hospitalar.

No presente estudo, foi selecionada uma amostra de 4523 partos entre 2018 e 2020 em que foram analisadas as taxas de cesariana, calculadas as perdas financeiras e determinados os fatores de risco que permitem explicar e estimar a variação das taxas de cesarianas no Centro Hospitalar de Entre Douro e Vouga. Para tal foi desenvolvido um modelo de escolha binária para variável dependente (Modelo Probit) para analisar os fatores sociodemográficos e clínicos da mãe/recém-nascido que afetam a taxa de cesariana.

As principais conclusões deste estudo indicam que os fatores determinantes na taxa de cesarianas são a idade maternal elevada, índice de massa corporal elevado, nuliparidade, grande perímetro da circunferência da cabeça, gravidezes múltiplas e hábitos tabágicos.

Este estudo visa complementar a escassa literatura em Portugal sobre o tema. Além disso, o trabalho desenvolvido tem potencial para vir a desenvolver um modelo de previsão para cesarianas, com vista a realizar intervenções que reduzam o risco destas cirurgias.

Códigos JEL: I10; I18; I19

Palavras-chave: Cesarianas; Impactos financeiros; Indicadores; ObsCare; Penalidades financeiras; Registo eletrónico; Taxa de cesarianas.

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Abbreviations

AGE_M	Maternal age
APPSH	Average price effectively paid for each episode of surgical hospitalisation
BMI	Body Mass Index
BMI_M	Maternal BMI
BPHG	Base Price of the Hospital Group
BW	Birth weight
C-section	Caesarean section
CESAR	Caesarean section
CHTN	Chronic hypertension
CMI	Case-Mix Index
CNRTC	Comissão Nacional para a Redução da Taxa de Cesarianas" (
DRG	Diagnoses Related Groups
EDU	Education level
ENP	Equivalent number of patients
G_DIAB	Gestational diabetes
HC	Head circumference
MEDCIDS	Department of Community Medicine, Health Information and Decision of the Faculty of Medicine of the University of Porto
N_NB	Number of newborn babies
N_PREG	Number of pregnancies
NHS	National health systems
NSH	Number of surgical hospitalisations
SMOK_HAB	Smoking habits
TAP	Total amount paid for surgical hospitalisations
WHO	World Health Organization

1. Introduction

Caesarean section (C-section) is defined as the delivery of a fetus through an abdominal (laparotomy) and uterine (hysterotomy) incision (Gabert & Bey, 1988). The rate of C-sections is considered internationally as the main indicator of the quality of obstetric care and, consequently, it is crucial that this rate is low in order to guarantee a higher quality (Long, Kempas, Madede, Klemetti, & Hemminki, 2015; WHO, UNFPA, & UNICEF, 2009). However, studies reveal that the use of C-sections has been increasing worldwide and is estimated to rise over the coming decade (World Health, 2021). Apart from the detrimental effects C-sections can cause on the mother/newborn, the increased rate of this procedure can trigger other problems such as the economic impact on national health systems (NHS). In Portugal, it has been no different, and in order to consolidate the reduction in the C-section rate, some targets have been set with repercussions on hospital funding if they are not achieved.

Therefore, the main purposes of this work are to account for the financial losses of a hospital due to penalties associated with caesarean rates above the stipulated in the programme contracts and to determine some possible risk factors in mothers/newborns that explain and allow estimating the variation in caesarean rates.

In order to achieve these purposes, this study will be divided into six parts, the first of which is composed of the present introduction. The second part presents the literature review, which will provide a framework for the topic through studies that analysed the main factors leading to an increase in C-section rates. The research methodology will be described in section 3, which refers to the estimation method considered, and explanation of the variables used. Section 4 presents the results of the empirical analysis and discussion. Section 5 presents the conclusions and, finally, the bibliographical references that served to support the writing of this study.

2. Literature review

This second chapter is based on the contextualisation of the topic, which is crucial to understanding the study. It focuses on the definition of c-section, the rates of c-sections around the world and why they are increasing, the risk factors that can lead to an increase in c-sections, the political measures adopted in Portugal, and the payment of hospitals.

2.1 Definition of caesarean section

C-section is a surgical procedure that was introduced in medicine in order to prevent or treat potentially fatal situations for the mother/fetus (Gibbons et al., 2010). According to the protocol of the Obstetrics Service of the Hospital de S. João, the use of caesarean delivery can only be justified in the following situations: maternal pathology that contraindicates eutocic delivery (pregnant with HIV infection, active genital herpes, psychopathy, etc.); severe pathology associated or associated with pregnancy (placenta previa, eclampsia, etc.); fetal abnormality contradicting eutocic delivery; unsuccessful attempt to induce labor; previous C-section (two or more previous C-sections, 41-week gestation with unfavourable Bishop's indice); fetal state not reassuring; abnormal fetal situation or presentation; suspected feto-pelvic incompatibility; stationary labor (mechanical or dynamic dystocia); multiple pregnancy; among others (maternal refusal of eutocic delivery, etc.)(Campos, 2004).

Historical registers reveal that the first authenticated report of a child who survived C-section is a document describing the birth of Gorgias in Sicily in 508 BC (Boley, 1991). Since then the procedure has evolved massively and become increasingly common in both developed and developing countries (Ye, Betrán, Guerrero Vela, Souza, & Zhang, 2014). Nowadays, concerns on the rise in the numbers of C-section and the possible negative consequences for maternal and child health have been expressed (Byamugisha & Adroma, 2020; Mi & Liu, 2014). Nonetheless, assessing the acceptable C-section rate at the population level, while avoiding medically unnecessary operations is a challenging assignment (Byamugisha & Adroma, 2020).

2.2 Caesarean section rates and why the increase over the decades

A C-section may bring unambiguous health benefits to the pregnant woman and her child but its misuse without clinical reasons carries increased risks for both. According to the World Health Organization (WHO), in 1985, the rate of C-sections should not exceed between 10 and 15% in any region of the world (Betrán, Torloni, Zhang, & Gülmezoglu, 2016; WHO, 2015). Nevertheless, the rate of C-sections has been increasing systematically and unequally worldwide. It is estimated that currently, worldwide, one in five births (21%) are C-sections and that this number will continue to rise over the next decade to almost a third (29%) (World Health, 2021)(Figure 1 – A). Based on studies, if

this trend continues, by 2030, countries in East Asia, Latin America and the Caribbean, West Asia, North Africa, and Southern Europe will report the highest C-section rates (63%, 54%, 50%, 48% and 47% respectively) (Figure 1 – B, C, D, and E).

Women's access to C-sections varies depending on their geographical location (Betran, Ye, Moller, Souza, & Zhang, 2021). According to the data in Table 1, the percentage of C-sections performed in the least developed countries is 8%, which indicates a worrying lack of access to this type of surgery due to the excessive poverty of these countries. In sub-Saharan Africa they continue to struggle to give mothers access to C-sections, with a slight variation in the rate since 2000. In this region, the C-section rate has fluctuated around 5% (Byamugisha & Adroma, 2020).

In contrast, there are countries in Latin America and the Caribbean which have a percentage of 42.8, which is considered to be significantly higher than that recommended by the WHO.

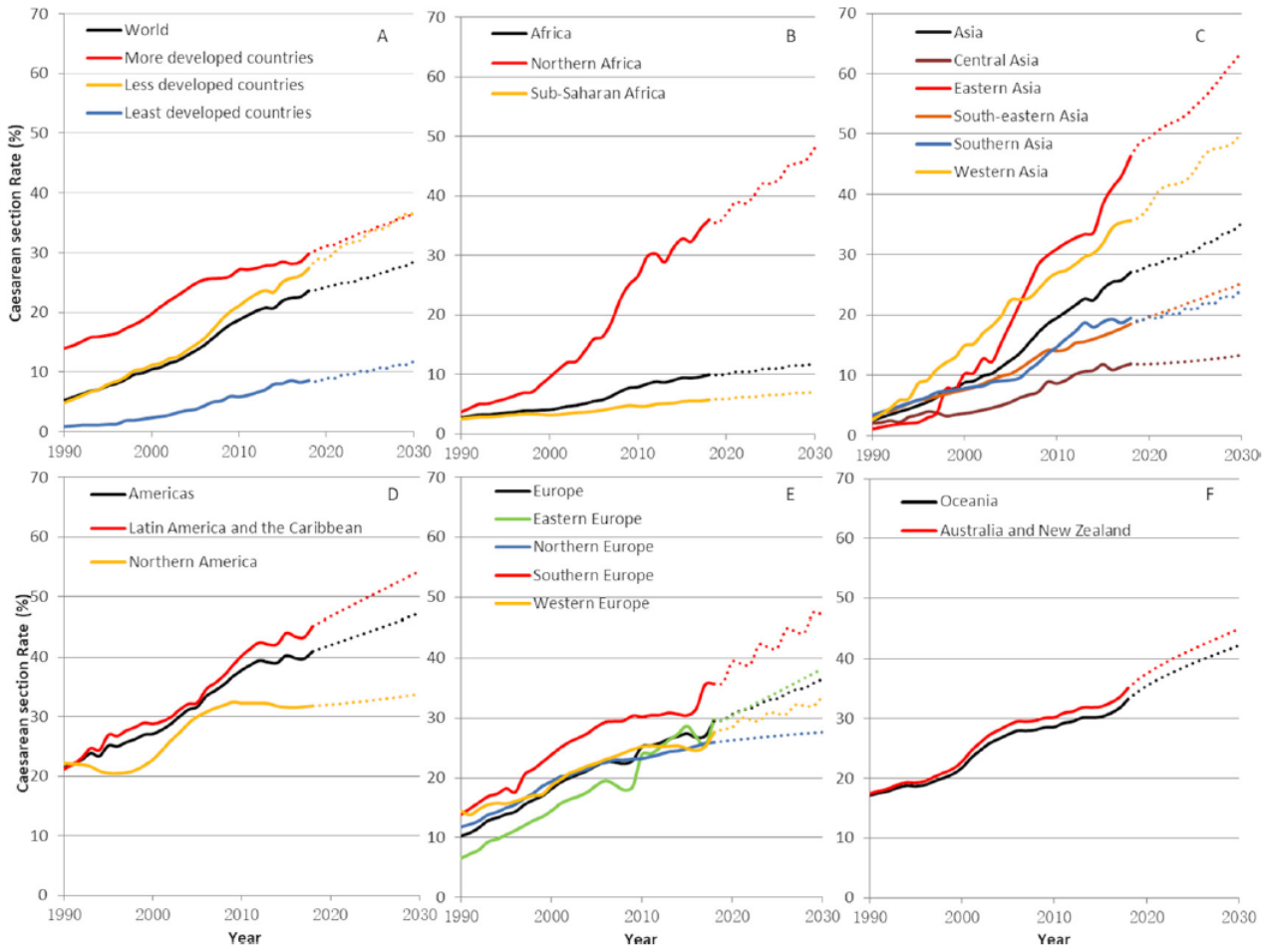


Figure 1: Trends (1990–2018) and projections (2030) in global, regional, and subregional estimates of CS rates. Solid lines are trend estimates and dotted lines are projections. (A) World; (B) Africa; (C) Asia; (D) Americas; (E) Europe; (F) Oceania (Betran et al., 2021).

Table 1: C-section rates according to United Nations geographical grouping in 2018 (World Health, 2021).

Region/subregion	Estimated C-section rate (% 95% CI)
Africa (n=44)	9.2 (5.2, 13.2)
Northern Africa (n=5)	32.0 (5.9, 58.2)
Sub-Saharan Africa (n=39)	5.0 (3.5, 6.6)
Asia (n=40)	23.1 (19.9, 26.3)
Central Asia (n=5)	12.5 (6.5, 18.4)
Eastern Asia (n=5)	33.7 (27.3, 40.1)
South-eastern Asia (n=8)	15.9 (9.6, 22.3)
Southern Asia (n=7)	19.0 (13.7, 24.3)
Western Asia (n=15)	31.7 (22.7, 40.6)
Europe (n=38)	25.7 (23.4, 28.0)
Eastern Europe (n=10)	25.0 (18.7, 31.3)
Northern Europe (n=10)	25.3 (21.5, 29.1)
Southern Europe (n=11)	30.1 (27.5, 32.7)
Western Europe (n=7)	24.2 (18.3, 30.2)
Americas (n=25)	39.3 (34.6, 44.0)
Latin America and the Caribbean (n=23)	42.8 (37.6, 48.0)
Northern America (n=2)	31.6 (20.5, 42.8)
Oceania (n=7)	21.4 (6.6, 36.2)
Australia and New Zealand (n=2)	33.5 (1.9, 65.1)
Melanesia, Micronesia, and Polynesia (n=5)	3.6 (0.7, 6.6)
World total (n=154)	21.1 (18.8, 23.3)
More developed countries (n=45)	27.1 (25.2, 29.2)
Less developed countries (n=70)	24.2 (20.9, 27.5)
Least developed countries (n=39)	8.2 (5.2, 11.2)

The increasing trend of C-section in childbirth has become a global health challenge (A. P. Betrán et al., 2016). The causes for this increase are not well-understood (Ana Pilar Betrán et al., 2016). According to the literature, several factors can contribute to this increase, namely: changes in maternal characteristics and professional practice styles,

economic, organizational, social and cultural aspects (Lin & Xirasagar, 2004; Linton, Peterson, & Williams, 2004; Mi & Liu, 2014; Zwecker, Azoulay, & Abenhaim, 2011).

Unnecessary caesarean deliveries increase maternal and neonatal morbidity (Lin & Xirasagar, 2004) with many associated short-term and long-term risks, such as, increased risk of uterine rupture, abnormal placentation, placenta previa, ectopic pregnancy, and preterm birth for mothers and increased risk of likelihood of allergy, atopy, asthma, and obesity in children (Keag, Norman, & Stock, 2018; Sandall et al., 2018; Yu et al., 2019). Additionally, the high rates of C-sections present economic concerns since they represent a heavy burden on health resources thus affecting equity in access to healthcare (Ana Pilar Betrán et al., 2016; Boatin et al., 2018; Gibbons et al., 2010; Ronsmans, Holtz, & Stanton, 2006; Yu et al., 2019).

2.3 Factors that increase the risk of caesarean sections

In the literature, there are several significant factors for the increase in the rate of C-sections, from patients, institutions, health professionals and social factors (Byamugisha & Adroma, 2020). One of the most mentioned factors is the average maternal age, which has been gradually increasing. Therefore, older women, especially nulliparous women, have a higher risk of caesarean delivery (Al Busaidi, Al-Farsi, Ganguly, & Gowri, 2012; Al Rifai, 2017; Amjad et al., 2018; Manyeh, Amu, Akpakli, Williams, & Gyapong, 2018; Patel, Peters, Murphy, & the, 2005; Suzuki & Nakata, 2013).

Another important determinant is the maternal obesity, which corresponds to a risk of caesarean delivery, and which unfortunately has been reaching large epidemic proportions (Al Busaidi et al., 2012; Al Rifai, 2017).

Socio-demographic factors (e.g., higher education level, occupation), were found as significant aspects associated with C-section delivery (Al Rifai, 2017; Amjad et al., 2018; Manyeh et al., 2018; A. R. Oliveira, 2013). Other behavioral/cultural considerations (e.g., the fear of childbirth and labor pains) and some beliefs (e.g., C-section prevents possible trauma and damage to the pelvic; C-section is less traumatic for the baby; birth date can be lucky for the future/destiny) are also considered significant factors (Byamugisha & Adroma, 2020).

Witt et al., Suzuki & Nakata and Al Busaidi et al. found evidence that prior C-section is a strong factor for an increased risk of C-sections (Al Busaidi et al., 2012; Suzuki & Nakata, 2013; Witt et al., 2015). Factors such as financial incentives, pregnancy in the private sector, maternal solicitation and the lack of regulation may also be contributing significantly to the increase in this rate (Tadevosyan et al., 2019).

Table 2 presents a summary of the empirical studies that analyse possible factors responsible for the increase in the rate of C-section over time.

Table 2: Summary of empirical studies on the factors contributing to the increase in C-sections.

Country	**Purpose of the study**	**Methodology**	**Main Conclusions**	**References**
Armenia	The mains' purpose of this study was to explore potential aspects contributing to the increasing rates of C-section and determine the actual costs of C-section and vaginal birth.	Partially mixed quantitative-qualitative equal status study.	The study demonstrated that financial incentives (reimbursement and out of pocket payments), maternal request and lack of clear regulations could be contributing to increasing the CS rates.	(Tadevosyan et al., 2019)
Bangladesh	The work identifies the prevalence of C-section and socio-economic and health care seeking related determinants of C-section.	A cross-sectional survey was conducted using a structured questionnaire.	The prevalence of C-section was significantly associated with women who gave birth in private units and who had complications during the last delivery. Socio-demographic factors (e.g., women's religion, education, and occupation), husband's education, household's wealth quintile, and obstetric factors were not significantly associated with C-section.	(Karim et al., 2020)

Brazil	To identify the indicators associated with C-sections in southern Brazil.	Cross-sectional study	The category of hospitalization (private/health insurance plan), cervix dilation and its characteristics, fetal presentation, and uterine dynamics, at the time of admission, were statistically related to C-section.	(Saraiva, Gouveia, & Gonçalves, 2017)
Egypt	The study evaluated the trend and factors associated with increased c-sections in Egyptian mothers.	This study utilized the Egypt Demographic and Health Surveys (DHS).	In the results, childbearing at ≤18 years or ≥35 years, living in high socioeconomic status, maternal overweight/obesity, pregnancy with high-risk birth weight or multiple babies, delivery in a private sector were found as significant aspects associated with C-section delivery.	(Al Rifai, 2017)
England	To identify the risk factors for the increasing rates of C-section and the marked variation between institutions.	Longitudinal cohort study.	The highest odds ratios of C-section in this study were for previous C-section and non-cephalic fetal presentation. Increasing maternal age, neonatal head circumference, birthweight, diabetes mellitus and either no previous pregnancy or a poor outcome of the last pregnancy were also associated with increased odds of C- section.	(Patel et al., 2005)

Ghana	This study searched to identify the rate of C-section and associated factors in two districts in southern Ghana.	The associations between the exposure variables and the outcome of interest were explored in an adjusted logistic regression model.	Maternal age, educational level, parity, household socioeconomic status, district of residence, and level of education of household head are related with C-section delivery.	(Manyeh et al., 2018)
Italy	This study aims to identify risk factors for C-section and suggests strategies to counteract the increase.	Caesarean section rates and odds ratios were assessed for each variable and applied logistic regression to investigate possible confounding factors.	The results demonstrated significantly higher odds ratios in women who delivered in Niguarda, who underwent six or less antenatal consultations, who received antenatal care from obstetricians working in a hospital and were explicitly asked by the doctor whether they wanted a C-section (offer of C-section).	(Signorelli, Cattaruzza, & Osborn, 1995)
Japan	To assess the factors associated with C-sections over a 10-year period at a Japanese Perinatal Center	Logistic regression modeling was used to estimate C-section rate over time and for each factor.	The prevalence of C-section was significantly associated with the prevalence of advanced maternal age (≥35 years) and the cases of nulliparity, preterm delivery, low birth weight, previous C-section deliveries, and breech presentation.	(Suzuki & Nakata, 2013)

Oman	This study explored the risk factors, profiles and neonatal outcomes of C-sections in Oman.	Case control from the Maternal Health Card and through personal interview of the selected women.	The factors associated with increased risk of C-section were advancing age, prior C-section, increased body mass index, extremes of neonatal birth weight, and pre-pregnancy diabetes. On the other hand, increased parity and history of the use of birth spacing methods were associated with decreased risk of C-section.	(Al Busaidi et al., 2012)
Pakistan	To assess the determinants associated with C-sections among child-bearing women aged 15 and 49 years in Pakistan.	Cross-sectional survey data from the Pakistan Demographic and Health Survey	The likelihood of caesarean deliveries was related with mothers aged more than 24 years, residing in Punjab province, belonging to the richest class, with higher education, employed at professional/managerial/technical level, and residing in an urban setting.	(Amjad et al., 2018)

Portugal	The main purpose of this study was to determine whether sociodemographic, cultural and economic factors are associated with the practice of C-section.	Case control study	Higher maternal educational level, nulliparity, follow-up of pregnancy in the private sector, hypertension, previous C-section, the use of formula at discharge, and post-partum infection were associated with C-section.	(A. R. Oliveira, 2013)
USA	This study aims at an approach to understand the factors that contribute to delivery methods in the USA.	Using multinomial logistic regression, they examined the role of sociodemographic, health, healthcare, stressful life events, pregnancy complications, and history of C-section on the odds of medically indicated and non-medically indicated C-sections, compared to vaginal delivery.	The results verified that prior C-section was the main factor of both medically indicated and non-medically indicated C-sections.	(Witt et al., 2015)

In this study, it is important to further analyse the most relevant determinants for the increase in caesarean rates. As previously mentioned, the reasons for the increased risk of C-sections are multifactorial, but the literature suggests that the increase is predominantly a result of advanced maternal age (Rydahl, Declercq, Juhl, & Maimburg, 2019). Maternal age appears to have an important impact on the decision for a C-section, as more and more motherhood is postponed leading to an increase in the average maternal age. Increased age entails a deterioration in the physiological functions of the genital tract, the uterine musculature, and the hormonal system (Cohen, 2014). There is evidence to support a continued decline in the physical capacity to perform sufficient uterine contractions, increasing a potential risk of labour dystocia (Herstad et al., 2015; Waldenström & Ekéus, 2017). Thus, the higher rate of C-sections may also be a result of concomitant comorbidities related to advanced maternal age (Klemetti, Gissler, Sainio, & Hemminki, 2016; Vaughan, Cleary, & Murphy, 2014).

Body Mass Index (BMI) is also a factor considered and it is estimated that the risk of a c-section is approximately 2-3 times higher, respectively, among obese and severely obese women compared to normal weight pregnant women (Chu et al., 2007). According to the literature, obesity may increase maternal pelvic soft tissue, which reduces birth canal diameters and increases the risks related to dystocia (Crane, Wojtowycz, Dye, Aubry, & Artal, 1997; Kaiser & Kirby, 2001; Schmid, Stark, Berlin, Landais, & Lau, 2004; Young & Woodmansee, 2002), a macrosomic child, or cephalopelvic disproportion (Isaacs, Magann, Martin, Chauhan, & Morrison, 1994; Witter, Caulfield, & Stoltzfus, 1995). Another justification may be related to differences in the progression of labour among obese women or their response to oxytocin administration (Vahratian, Zhang, Troendle, Savitz, & Siega-Riz, 2004).

The current obesity epidemic is leading to an increase in gestational diabetes mellitus (Doi et al., 2020; Poobalan, Aucott, Gurung, Smith, & Bhattacharya, 2009). Lius et al. defines gestational diabetes mellitus as any degree of glucose intolerance with onset or first recognition during pregnancy and is considered one of the most common medical complications of pregnancy (Li et al., 2020). This disease presents multiple risks for the pregnant woman/newborn child, such as pre-eclampsia, macrosomia, and a consequential increase in obstetric interventions (Phaloprakarn & Tangjitgamol, 2020).

Another disease that is highly associated with an increased risk of C-sections is chronic hypertension (Panaitescu, Syngelaki, Prodan, Akolekar, & Nicolaides, 2017). Chronic hypertension in pregnancy is defined as a systolic blood pressure (SBP) ≥ 140

mmHg and/or a diastolic blood pressure (DBP) ≥ 90 mmHg, measured on two separate occasions (Agrawal & Wenger, 2020). Pregnant women with this disease have a higher occurrence of superimposed pre-eclampsia, c-section, pre-term delivery before 37 weeks' gestation, birth weight less than 2500 g, and perinatal death (Bramham et al., 2014).

Two factors that may influence pregnancy risk is the number of previous pregnancies and the number of fetuses. Studies suggest that nulliparous women (women with no previous deliveries) are at higher risk of delivery complications than multiparous women (women who have had at least one previous delivery) (Miranda, Edwards, & Myers, 2011). Regarding the number of fetuses, multiple pregnancies are high-risk pregnancies, which can cause complications such as prematurity, low birth weight babies, pre-eclampsia, anaemia, intrauterine growth restriction, among others. Therefore, the majority of multiple pregnancy cases are delivered by c-section (Kurdi, Mesleh, Al-Hakeem, Khashoggi, & Khalifa, 2004).

Head circumference and birth weight are also associated with an increase in C-sections (Patel et al., 2005). A study conducted by Elvander et al. indicates that a larger fetal head circumference is associated with increased odds of prolonged labour, fetal distress, maternal distress, extraction vacuum, and emergency caesarean delivery (Elvander, Hogberg, & Ekeus, 2012). According to Temerinac et al., a fetal birth weight below 2500 g and a birth weight above 4250 g are associated with some risks of C-section (Temerinac, Chen, Sütterlin, & Kehl, 2015). In turn, the study by Mpotora et al. reveals that newborns weighing more than 3.5 kg had a higher probability of C-section (Mpotora, Yahaya, Ngw'eshemi, & Mwampagatwa, 2021).

Many studies have focused on differences in the percentage of C-sections between socioeconomic groups, by salary, occupation or education, even after adjustment for clinical risk factors (Milcent & Zbiri, 2018). The literature indicates that women with a lower level of education have a higher risk of caesarean deliveries (Cesaroni, Forastiere, & Perucci, 2008; Guihard & Blondel, 2001; Lee, Khang, Yun, & Jo, 2005). The explanation for this higher rate of C-sections in the less educated groups is the higher preference for this type of delivery and the low access to obstetric services. However, there is no consensus on this explanation (Tollanes, Thompson, Daltveit, & Irgens, 2007).

Regarding smoking habits, Lurie et al. report that there is an increased risk of C-sections in women who smoke during pregnancy compared to non-smokers. Pregnant women who are exposed to tobacco may experience several pregnancy complications,

teratogenic effects and neonatal adverse effects, as well as paediatric problems (Lurie, Ribenzaft, Boaz, Golan, & Sadan, 2014)

To analyse the trends and determinants of C-sections in health care facilities, the Robson classification is commonly used. The purpose of this classification is to help institution-specific monitoring, as well as to obtain a standardised method of comparison across institutions, countries, and time points (Vogel et al., 2015). The system classifies pregnant women into 1 of 10 groups that are mutually exclusive and totally inclusive. The groups are based on six obstetric variables: parity (nulliparous or multiparous), previous C-section (yes (one or more) or no), onset of labour (spontaneous, induced or on labour (prelabour C-section)), number of foetuses (singleton or multiple), gestational age (preterm (less than 37 weeks) or term (37 weeks or more), and Foetal lie and presentation (cephalic presentation, breech presentation or transverse lie) (Byamugisha & Adroma, 2020) (Table 3).

Table 3: Obstetric variables for Robson's classification (Byamugisha & Adroma, 2020)

Group	Definition
1	Nulliparous women with a single cephalic pregnancy ≥37 weeks' gestation in spontaneous labour.
2	Nulliparous women with a single cephalic pregnancy, ≥37 weeks' gestation who either had labour induced or were delivered by C-section before labour.
3	Multiparous women without a previous uterine scar, with a single cephalic pregnancy ≥37 weeks' gestation in a spontaneous labour.
4	Multiparous women without a previous uterine scar, with a single cephalic pregnancy ≥37 weeks' gestation who either had labour induced or were delivered by C-section before labour.
5	All multiparous women with at least one previous uterine scar with a single cephalic pregnancy ≥37 weeks' gestation.
6	All nulliparous women with a single breech pregnancy.
7	All multiparous women with a single breech pregnancy, including women with previous uterine scar.
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 scar.
10	All women with a single cephalic pregnancy <37 weeks', including women with previous uterine scar.

2.4 Caesarean rates and political measures in Portugal

In Portugal, there is also a high and increasing percentage of C-sections. OECD data suggests that Portugal is the fourth country in Europe with the highest rate of C-sections (Figure 2). According to data from the Directorate-General of Health (DGS), in Portugal, the caesarean delivery rate rose from 26.8% in 1999 to 36.7% in 2009. Following this peak, the rate has trended slightly downward, and it was 34.1% in 2018 (Figure 3). This value is far above what is recommended by WHO.

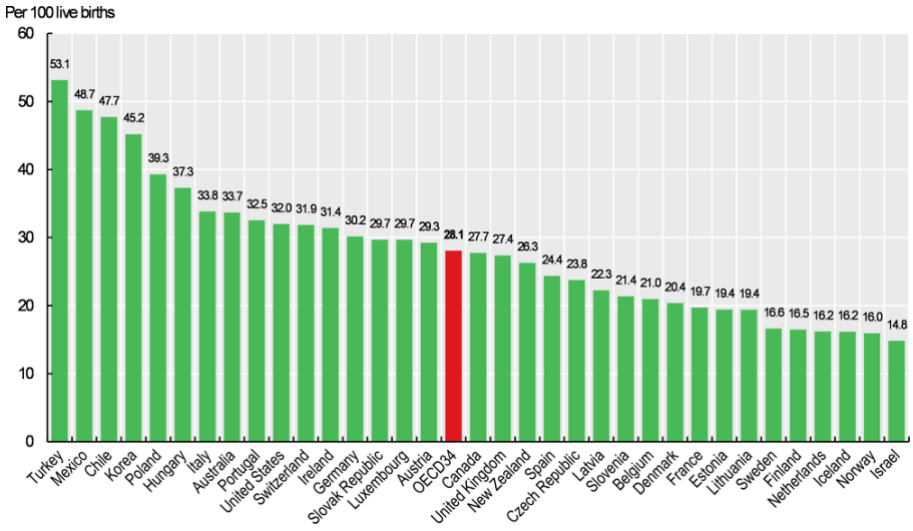


Figure 2: C-section rates, 2017 (or nearest year) (OECD, 2019)

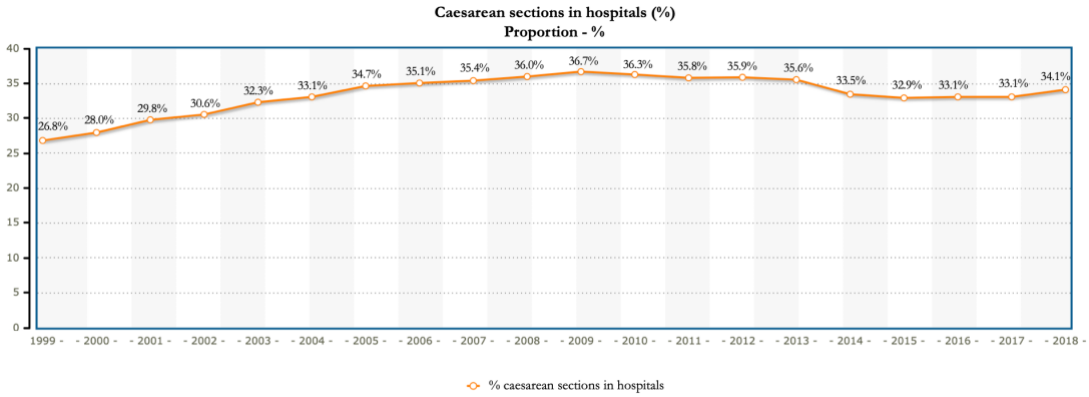


Figure 3: C-sections in hospitals (PORDATA, 2019)

To consolidate the reduction in the rate of C-sections in Portugal, the "Comissão Nacional para a Redução da Taxa de Cesarianas" (CNRTC) was created in 2013. This commission proposed several measures to reduce the C-section rate:

"1. The dissemination to health professionals and the general public of the risks of C-section, the risks of inducing labour and the benefits of vaginal delivery after C-section.

2. The implementation of a single computer program for hospital registration of perinatal data, with a uniform classification of the reasons for C-sections and allowing the automatic export of some indicators perinatal indicators to the ARS Norte.

3. Annual public dissemination by the ARS Norte of the C-section rate for each hospital centre, together with the rate of admission to neonatal intensive care units for "hypoxic ischaemic encephalopathy".

4. The revision of the price of the GDH associated with vaginal delivery to make it similar to that of C-section. The alteration of the basic price table of the Portuguese Medical Association in order to attribute a similar value to vaginal birth and C-section.

5. The implementation of fetal electrocardiography technique in different hospitals.

6. The promotion of measures in the different hospitals which allow the permanent availability of an operating room dedicated to Obstetrics in the proximity of the delivery room, that the external cephalic version is routinely advised to all pregnant women with the fetus in breech presentation at 36 weeks gestation, that no inductions of labour are carried out at term without health reasons before 41 weeks gestation, that vaginal delivery after C-section is considered a preferred option in well-defined situations that there is a regular internal audit of C-sections, carried out with the involvement of Neonatology.

7. The development of national clinical guidelines on the following topics: systematisation of reasons for C-section; definition of stationary labour and suspicion of foetal-pelvic incompatibility; analysis and clinical decision based on cardiotocography; collection of umbilical blood for blood gases; cephalic version by external manoeuvres; reasons for and methods of induction of labour; indications and care to be observed in attempted vaginal delivery after C-section.

8. The development of a medical remuneration policy that includes individual performance indicators, in which the rate of C-sections should be included. The existence of a more attractive remuneration policy, leading to greater retention of doctors in public institutions, thus reducing possible conflicts of interest with private medicine.

9. Implementation of regular training courses for health professionals in interpreting cardiotocographic and electrocardiographic tracings, performing the external cephalic version and resolving intrapartum obstetric emergencies (Comissão para a redução da taxa de cesarianas da ARS NORTE, 2010)."

The CNRTC also proposed the establishment of targets for the C-section rate in NHS hospitals, with an impact on hospital funding, without this measure leading to an increase in health risks for patients. In the hospitals' contract programme, penalties were

defined due to non-compliance with the rules associated with the programme to reduce the C-section rate (Termos de Referência para contratualização de cuidados de saúde no SNS para 2020 (2020)). Thus, it is defined that the payment for hospitalisation episodes with C-section (x) is indexed to the C-section rate with the penalties according to the following Table 4.

Table 4: Repercussions on hospital funding (adapted from Termos de Referência para contratualização de cuidados de saúde no SNS para 2020 (2020)).

Rate of Caesarean sections	
Perinatal support hospitals	Perinatal Differentiated Support Hospitals
< 25.0% = value x	< 27.0% = value x
25.0% - 26.4% = 0.75 value x	27.0% - 28.4% = 0.75 value x
26.5% - 27.9% = 0.50 value x	28.5% - 29.9% = 0.50 value x
28.0% - 29.4% = 0.25 value x	30.0% - 31.4% = 0.25 value x
> 29.5% = without funding	> 31.5% = without funding

Therefore, for hospitals, decreasing the rate of caesarean delivery is extremely important, not only for women's health issues, but also for the economic values that underlie that rate. In cases where the rate exceeds 29.5% perinatal support hospitals may not even receive any funding.

A C-section costs more than a vaginal birth, not only because it is a surgery but also because it can lead to clinical complications for both mother and baby, leading to their need for more health care.

2.5 Hospital Payments

The current payment method used to fund Portuguese public hospitals seeks to be prospective in nature and to consider hospital production. To achieve this, it uses information provided by DRG (Diagnoses Related Groups) to characterise the production profile of the institutions, in terms of the costs of their treated patients, and then funds them accordingly (Bentes, 1996). DRGs were developed by Fetter and Thompson and their main purpose is to group hospital admission episodes into homogeneous categories regarding resource consumption, considering the hospitalisation duration (Bentes, 1996; Urbano & Bentes, 1990). A relative weight is associated to each DRG, i.e., a weighting

coefficient that reflects the expected cost with the treatment of a typical patient grouped in that DRG, expressed in relative terms in face of the average cost of the typical patient at national level. The amount to be paid for financing hospitalisation in each hospital is calculated based on the equivalent number of patients for the year in question (ENP), the Case-Mix Index (CMI) by type of DRG (medical and surgical) and the base price defined by hospital group (BPHG) (Table 5).

Table 5: Methodology for payment of production (adapted from (Nunes, 2012)).

Production Line	**Quantity**	**Case mix index (CMI)**	**Price**	**Payment**
Internment (GDH)	Number of equivalent patients (ENP)	CMI for Inpatient Hospital	Base Price of the Hospital Group (BPHG)	ENP * CMI * BPHG

In Portugal, the information provided through DRGs granted the development of the current financing model, thus enabling the performance of public hospitals to be assessed. Therefore, this method allowed obtaining information on hospital practices at a national level and detecting possible deviations from the standards observed at a national level (type of care, quality, and effectiveness). However, DRGs have some disadvantages, such as, the incentive to under-provide care, for the same payment, to highly severely ill patients; lack of quality of care to reduce costs; promoting the selection/exclusion of patients with higher associated severity; discouraging the admission of patients with higher resource consumption, since these increase the price of production, among others (Nunes, 2012).

2.6 MEDCIDS

The study was carried out in collaboration with MEDCIDS group – Department of Community Medicine, Health Information and Decision of the Faculty of Medicine of the University of Porto. This group has as purpose the scientific, technological and humanistic training of physicians and other professionals involved and the transfer of knowledge to the community.

3. Methodology

This study aims to determine the risk factors that explain and allow estimating the variation in the rate of C-sections.

As intermediate purposes, this study aims to:

I. Contribute to the existing literature on C-section rates in Portugal;

II. Accounting for financial losses in hospitals due to penalties associated with caesarean rates above what is stipulated in the program contracts;

III. Analysis of socio-demographic and clinical data of the mother/newborn at Centro Hospitalar de Entre o Douro e Vouga and the influence that these characteristics may have on the probability of performing a C-section. In this work, a cross-sectional study of a data cohort was conducted, based on the data included in the obstetrics specific electronic register (ObsCare).

3.1 ObsCare Software

The Regional Health Administration of the North, an institution that administers health policies in the North region, has acquired for all its public hospitals the ObsCare system. ObsCare (VC ObsCare – VirtualCare - Systems for Life) software was created in 2003 and it was created to serve as a clinical record for health professionals, allowing for the prospective collection of quality data that can be used to analyse the current situation of obstetric interventions in the Portuguese population (e.g. prevalence and reasons for C-section)(Pereira, Maranhão, Silva-Costa, & Correia, 2019).

This system was developed with active support from specialists in the field of obstetrics who were based on the most recent obstetric guidelines to serve adequate support for clinical research. Currently, the system is operating in twelve public hospitals in mainland Portugal and it incorporates eight sections (Hospitalization/ Delivery and Abortion/ Surgery/ Appointment/ Urgency/ Indicators/ Newborn and Listings) (Figure 4)).

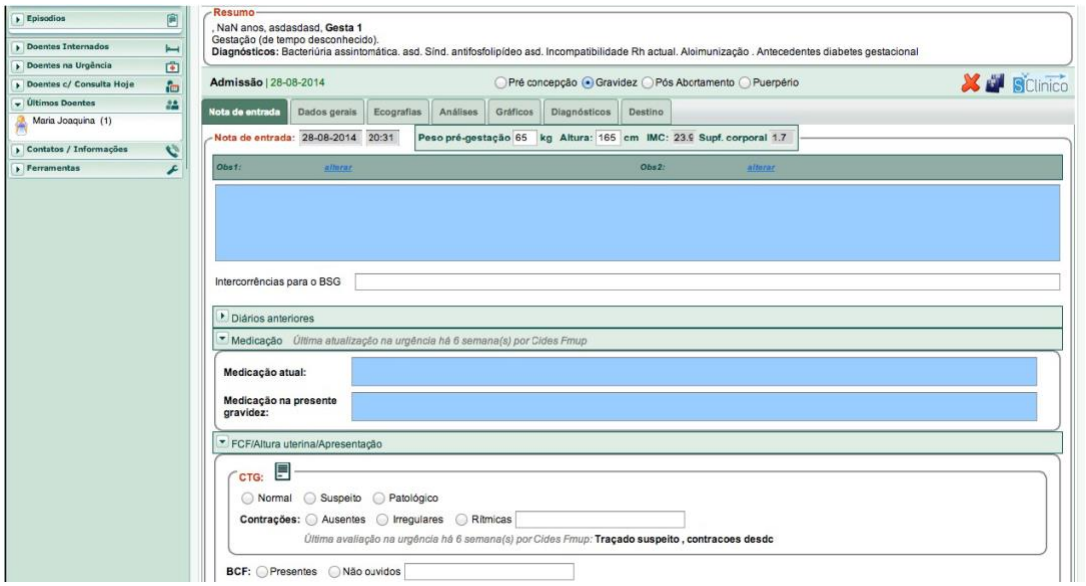


Figure 4: ObsCare system interface.

3.2 Ethical consideration

In October 2020, the project involved obtained a favourable opinion from the Ethics Committee, considering that the imperatives underlying Good Clinical Practice and the internationally recognised ethical and scientific quality precepts that must be respected in the design and conduct of clinical studies involving the participation of human beings have been observed (Appendix 1).

In the use of its own competencies as laid down in Decree-Law No. 97/95 of 10 May, and in the exercise of its functions in compliance with the deliberation of Law No. 21/2014 of 16 April, which approves the law on clinical research, in its current wording amended by Law No. 73/2015 of 27/07/15, complemented by Decree-Law No. 80/2018 (DR no. No. 198-2018, Series I of 2018/10/15) which reinforces the role of ethics committees in the context of the institution in which they are integrated, in their mission to contribute to the compliance with the principles of ethics and bioethics, in the provision of health care and in conducting clinical research, and also in harmony with the internal regulations of the FLN, with the codes of ethics, the conventions and recommendations contained in international declarations and guidelines, namely the Helsinki and Tokyo Declarations of the World Health Organization and the European Union, the Ethics Committee assessed the project, which it considers to comply with the fundamental ethical requirements that must be respected, reflecting the primacy of human dignity and integrity.

The right to moral and physical integrity of the participant is ensured, and essential precautions are taken, whose purpose is to minimise possible damage to their personality

rights, as well as the right to privacy and the protection of personal data concerning them, respecting the imperatives reflected in the General Data Protection Regulation (RGPD) entered into force on 25 May 2016 and fully applicable from 25 May 2018, (Regulation (EU) 2016/679 of the European Parliament and of the Council of 27/04/16) of 27 April, published in the Official Journal of the European Union on 4 May 2016, and in Law no. No. 58/2019, of 8 August.

In brief, the study respects all the ethical approval procedures of the ethics committee of each participating institution.

3.3 Data

The data cohort used for this study was obtained from the database of the Portuguese public hospital, Centro Hospitalar de Entre o Douro e Vouga. The sample was collected from 2018 to 2020. The sample period was based on data availability.

In this system there are several variables, such as socio-demographic factors and clinical parameters. These variables were selected according to the literature and the relevance of the data for the purpose of the study. The variables considered were the following: age, level of education, BMI, chronic hypertension, gestational diabetes, number of pregnancies, number of foetuses, head circumference, bird weight of the newborn, and smoking habits. All variables available in the system are shown in Appendix 2.

A database was created in EViews 10 and the association between variables and type of delivery was analysed through the binary model of dependent variables (Probit).

3.4 Binary dependent variable models

In this study, the aim was to determine the explanatory aspects that affect the risk of the pregnant woman having a C-section or not. Given the dichotomous nature, a qualitative response model is appropriate as they relate the probability of an event to multiple independent variables (M. Oliveira, Santos, & Fortuna, 2018; Uzunoz & Akcay, 2012).

To provide a detailed analysis of the determinants of the C-section rate, a Probit model was applied. The binary dependent variable (Y_i) assumes the value 1 if the patient had a C-section and the value 0 otherwise. The results of this variable are mutually exclusive and exhaustive. The variable Y is just the observable manifestation of an unobservable variable Y^* (latent variable) such that:

$$Y_i^* = \beta_1 + \beta_2 X_{2i} + \beta_3 X_{3i} + \ldots + \beta_k X_{ki} + u_i \qquad (1)$$

(where X_i is the $(1 \times k)$ vector of explanatory variables observed for individual i, β is the vector $(k \times 1)$ of regression coefficients, and u_i is a random disturbance).

And where a rule for determining Y as a function of Y^* is specified. This rule is typically of the form:

$$Y_i = \begin{cases} 1, & \text{if } Y_i^* > 0 \\ 0, & \text{if } Y_i^* \leq 0 \end{cases} \qquad (2)$$

Notice that, in this formulation, both the latent dependent variable and the random disturbance can be validly defined as continuous random variables and the discrete character is reserved only for the observable counterpart of the variable of interest (EViews, 2020).

3.5 Variables analysed in the model

In this study, a model was proposed that estimates the probability of a patient having a C-section as a function of the values of the explanatory variables. According to the literature, maternal factors such as age, education level, BMI, chronic hypertension, gestational diabetes and nulliparity are some of the conditions that influence the incidence rate of C-sections. Other clinical factors such as multiple pregnancies, head circumference and birth weight can also influence C-sections. For the analysis of this study, in addition to the variables mentioned above, smoking habits were also included. The following Table (Table 6) presents the nomenclature and definition of variables that were considered for the model.

Table 6: Nomenclature and definition of the variables considered.

Variables	Definition	Type of variable
CESAR (Ceasarean section)	Caesarean section = 1, non-caesarean section = 0	Binary
AGE_M (Maternal age)	Maternal age (years)	Numerical
EDU (Education level)	1 – Incomplete elementary school, 2 – Elementary school, 3 – Middle school, 4- Higher education	Ordinal
BMI_M (Maternal BMI)	Maternal body mass index (Kg/m^2)	Numerical
CHTN (Chronic hypertension)	Chronic hypertension = 1, otherwise = 0	Binary
G_DIAB (Gestational diabetes)	Gestational diabetes = 1, otherwise = 0	Binary
N_PREG (Number of pregnancies)	Number of pregnancies	Numerical
N_NB (Number of newborn babies)	Number of newborn babies (multiple pregnancies)	Numerical
HC (Head circumference)	Head circumference (cm)	Numerical
BW (Birth weight)	Birth weight (g)	Numerical
SMOK_HAB (smoking habits)	Yes = 1; No = 0	Binary

4. Results and discussion

4.1 Sample

From January 2018 to December 2020, a total of 4523 births were delivered at the Centro Hospitalar entre o Douro e Vouga, and 1302 (28.79%) of these births were delivered by C-section. As shown in Table 7, the c-section rate increased during the study period (26.63% in 2018 versus 30.53% in 2020).

Table 7: Information on the distribution of women according to the labour onset and mode of delivery, according to the year in which delivery occurred.

N(%)		Year		
	All	2018	2019	2020
All(%)	4523	1562 (34.54)	1556 (34.40)	1405 (31.06)
Mode of Delivery				
Vaginal eutocic	2303	817	809	677
Vaginal instrumental	917	329	289	299
Caesarean section (%/all)	1302	416 (26.63)	457 (29.37)	429 (30.53)

4.2 Accounting for financial losses in the hospital

Given the penalties defined in the programme contracts (Table 4, Methodologies), the hospital in 2018, was funded with 50% of the total C-section hospitalisations, in 2019, it was funded with 25% of the total C-section hospitalisations, and in 2020, it was not funded. This data indicates that despite the penalties imposed by the Government on NHS hospitals, the hospital is not containing the number of C-sections, on the contrary, it is increasing.

Considering the data from the " Acordo Modificativo ao Contrato-Programa- 2020 CHEDV, EPE" (Table 8) the average price effectively paid for each episode of surgical hospitalisation (APPSH) was calculated by applying the following formula: APPSH = TAP (Total amount paid for surgical hospitalisations) / NSH (Number of surgical hospitalisations). Then the APPSH was multiplied by the number of C-sections performed in the respective year (Table 9).

Table 8: Transcription of the "Acordo Modificativo ao Contrato-Programa- 2020 CHEDV, EPE.

		Doentes Equivalentes				
	ICM	N.º	%	Preço Unitário (€)	Quantidade	Valor (€)
2. Internamento:						
Doentes Saídos						
GDH Médicos	0,8268	9.821	97,73%	2.759,00 €	10.049	22.403.087,73 €
GDH Médicos Cuidados Paliativos	0,8268		97,73%	2.897,00 €		
GDH Médicos CRe	0,8268	110	97,73%	2.897,00 €	113	263.476,36 €
GDH Médicos CRI	0,8268	0	97,73%	2.897,00 €	0	0,00 €
GDH Cirúrgicos	0,8268	4.501	97,73%	2.759,00 €	4.606	10.267.416,54 €
GDH Cirúrgicos CRe	0,8268	50	97,73%	2.897,00 €	51	119.761,98 €
GDH Cirúrgicos CRI	0,8268	0	97,73%	2.897,00 €	0	0,00 €

Table 9: Total amount paid for surgical hospitalisations, Number of surgical hospitalisations, Average price effectively paid for each episode of surgical hospitalization, Number of C-sections, Amount to be paid to hospital for C-sections, Amount to be paid to hospital for C-sections with penalties, and total value of contract for each year. a – Acordo modificativo ao Contrato-Programa – 2018 – CHEDV, EPE; b– Acordo modificativo ao Contrato-Programa – 2019 – CHEDV, EPE; c– Acordo modificativo ao Contrato-Programa – 2020 – CHEDV, EPE.

	2018	2019	2020
Total amount paid for surgical hospitalisations (TAP) (€)	8 006 590.64	9 068 530.91	10 267 416.54
Number of surgical hospitalisations (NSH)	4 336	4 678	4 606
Average price effectively paid for each episode of surgical hospitalisation (APPSH)	1 846.54	1 938.55	2 229.14
Number of C-sections	429	457	416
Amount to be paid to hospital for C-sections (€)	792 164.99	885 916.77	927 322.03
Amount to be paid to hospital for C-sections with penalties (€)	396 082.50	221 479.19	0
Total Value of Contract (€)	79 555 428.52	84 947 975.99	101 964 255.48
Reference	a	b	c

Given the penalties defined by the programme contract, the hospital receives for C-sections the value of 396 082.50€ in 2018, 221 479.19€ in 2019 and 0€ in 2020. It can be noted that the Hospital had increasing financial repercussions over the last 3 years. With the penalties, the hospital lost 396 082.49€ in 2018, 664 437.58€ in 2019, and 927 322.03€ in 2020.

The reasons for this increase in c-sections over the years may be numerous. One of the concerns to be considered is the covid-19 pandemic. Studies suggest that pregnant women infected with covid-19 during pregnancy have a higher risk of C-section, a higher chance of postpartum complications and a higher incidence of placental thrombosis (Cruz, 2020; Jan, 2020). In addition, regular pretenatal check-ups have been affected by the pandemic, exposing pregnant women to a higher risk of poor perinatal health management and can lead to series of adverse pregnancy outcomes (Townsend et al., 2021; Zhang et al., 2020). Other factors that may be directly related to the increase in C-sections are pressure from pregnant women and inadequate organisation/ management of the obstetric and anaesthetic teams (Marques, 2017).

The reasons for this increase may be related to the mother/birth characteristics that influence the rate of C-sections. According to published data from the Gynaecology/Obstetrics Department of the S. João Hospital, the percentage of births by C-section increased when it concerned risk pregnancies: 36% in morbidly obese pregnant women and 37% in women over the age of 35 ("Taxa de cesarianas aumenta e atinge o maior valor desde 2010," 2021). This issue raises the question of whether it makes sense to impose penalties on the financing of hospitals that have a high rate of C-sections.

4.3 Sample characterization

For this work, data was accessed to determine the mother's socio-demographic position, and other patient and hospital characteristics (Table 10).

Table 10: Socio-demographic and maternal/ newborn health indicators.

Assessment parameters	Vaginal childbirth (n%)	Caesarean section (n%)	Sample (%)
Age			
≤19 years	83 (76.85)	25 (23.15)	2.39
20-24 years	449 (77.55)	130 (22.45)	12.80
25-29 years	871 (74.25)	302 (25.75)	25.94
30-34 years	1004 (70.65)	417 (29.35)	31.43
≥35 years	813 (65.51)	428 (34.49)	27.44

Education			
Incomplete elementary school	238 (71.26)	96 (28.74)	7.39
Elementary school	796 (72.76)	298 (27.24)	24.19
Middle school	1248 (71.52)	497 (28.48)	38.59
Higher education	760 (69.03)	341 (30.97)	24.35
Unknown	178 (71.77)	71 (28.23)	5.48
BMI			
<18.5 kg/m²	79 (72.48)	30 (27.52)	2.41
18.5-24.9 kg/m²	1425 (75.76)	456 (24.24)	41.60
25-29.9 kg/m²	658 (72.95)	244 (27.05)	19.95
≥30 kg/m²	336 (66.27)	171 (33.73)	11.21
Unknown	722 (64.29)	401 (35.71)	24.83
Chronic hypertension			
yes	66 (57.89)	48 (42.11)	2.52
no	3154 (71.55)	1254 (28.45)	97.48
Gestational diabetes			
yes	324 (68.49)	149 (31.50)	10.46
no	2896 (71.52)	1153 (29.48)	89.54
Parity			
Nulliparous	1327 (65.05)	713 (34.95)	45.11
Multiparous	1893 (76.27)	589 (23.73)	54.89
Number of newborn babies			
1	3167 (72.26)	1216 (27.74)	96.93
2	53 (38.13)	86 (61.87)	3.07
Head circumference			
<34 cm	732 (75.54)	237 (24.46)	21.43
34.0-34.9 cm	887 (75.88)	282 (24.12)	25.85
35-35.9 cm	838 (71.93)	327 (28.07)	25.76
>36 cm	573 (64.75)	312 (35.25)	19.57
Unknown	190 (56.89)	144 (43.11)	7.39
Birth weight			
<2500 g	203 (52.19)	186 (47.81)	8.60
25000-3999 g	2942 (73.92)	1038 (26.08)	88.01
≥4000 g	75 (49.34)	77 (50.66)	3.36
Unknown	0 (0.00)	1 (100,00)	0.02
Smoking habits			
yes	422 (70.69)	175 (29.31)	13.20
no	2798 (71.29)	1127 (28.71)	86.80

Considering the sociodemographic indicators (Table 9), it was verified that the most representative age groups in the hospital, were from 30 to 34 years (31.43%). It was also possible to notice that there is an increasing tendency in the percentage of C-section**s**

from 20 to 24 years old to those over 35 years old (22.45% versus 34.49%). Mothers aged over 35 years have the highest rate of C-sections compared to vaginal births (34.49% versus 65.51%).

Women with lower levels of education report lower rates of caesarean births: 28.74% for those who have not completed elementary education, while the most highly educated women (i.e., with higher education) have a ceasarean birth rate of 30.97%.

Regarding maternal BMI, it should be highlighted the fact that 31.16% of pregnant women whose BMI is known have this indicator above 25 kg/m^2, which is considered above what is acceptable as being healthy. Furthermore, pregnant women with BMI higher than or equal to 30 kg/m^2 have the highest percentage of C-sections (33.73%).

Obstetric morbidities such as hypertension and gestational diabetes were also considered, which showed a higher rate of C-sections when compared with the rate in the absence of these conditions (42.11% versus 28.45% and 31.50% versus 29.48%).

Considering pre-pregnancy reproductive factors, the percentage of multiparous pregnancies is higher than that of nulliparous (54.89% and 45.11%). As expected, nulliparous pregnancies have a higher C-section rate (34.95%) compared to multiparous pregnancies (23.73%) (Miranda et al., 2011).

In multiple pregnancies, the percentage of C-sections is much higher than that of vaginal deliveries (61.87% versus 38.13%). These values are in line with the literature, since timely C-sections have an important role to play in minimising the feto-maternal risks inherent to twin pregnancies (Onwuzuruike & Onah, 2004).

Regarding the newborn's clinical data, those with head circumference higher than 36 cm and weight higher or equal to 4000 g demonstrated a higher C-section rate (35.25% and 50.66% respectively) when compared to the cases considered normal (head circumference between 35 and 35.9 cm and birth weight between 2500g and 3999g) (28.07% and 26.08% respectively). These results are in agreement with the literature as it indicates that these clinical data are associated with an increase in C-sections (Patel et al., 2005).

Women with smoking habits, although not very significant, also have a higher rate of C-sections, with 29.31%, while non-smokers have a rate of 28.71%.

4.4 Econometric model

Prior to the development of the binary model, the independent variables were analysed in a table with descriptive statistics (Table 11).

Table 11: Descriptive analysis of socio-demographic factors and clinical data of the mother/newborn.

Variables	AGE_M	EDU	BMI_M	CHTN	G_DIAB	N_PREG	N_NB	HC	BW	SMOK_HAB
Mean	30.727	2.846	25.095	0.0252	0.105	1.946	1.031	34.211	3153.911	0.132
Median	31	3	24	0	0	2	1	34	3190	0
Maximum	45	4	45	1	1	9	2	50	4500	1
Minimum	16	1	16	0	0	1	1	0	700	0
Std. Dev.	5.660	0.896	6.290	0.157	0.306	1.093	0.173	1.667	523.684	0.338
Observations	4522	4275	3400	4522	4522	4522	4522	4189	4521	4522

To define the variables that may be significantly influencing the rate of C-sections in hospitals, a binary model of dependent variables (Probit) was developed. Before a final model was established, some models were tested.

In this study, caesarean delivery (dependent variable) was expected to be influenced by age, education, BMI, hypertension, gestational diabetes, parity (number of pregnancies), number of fetuses, head circumference, newborn weight, and smoking habits (independent variables). These sociodemographic variables and mother/newborn clinical data were included in the model, but the variables education, chronic hypertension and gestational diabetes were not statistically significant (p-value (EDU) = 0.6353; p-value (CHTN) = 0.3586; p-value (G_DIAB) = 0.1992). In other words, in contrast to what was expected, these variables have no statistically significant effect on C-section rates.

A possible explanation for the fact that the education variable is not a significant determinant is the fact that in Portugal selective C-section is not allowed in public hospitals. Despite this, studies suggest that women with higher levels of education, are more likely to have children at relatively late ages, and are therefore more susceptible to C-sections (Santas & Santas, 2018).

The model was then re-estimated without the education variables, chronic hypertension and gestational diabetes (Table 12).

Table 12: Estimates of the binary probit model.

Variable	Coefficient	Std. error	z-statistic	Prob.
Constant	-5.481792	0.745418	-7.353981	0.0000
AGE_M	0.027786	0.004771	5.824086	0.0000
BMI_M	0.029537	0.005070	5.825509	0.0000
N_PREG	-0.106685	0.024485	-4.357143	0.0000
N_NB	0.698521	0.155353	4.496356	0.0000
HC	0.094507	0.025296	3.736012	0.0002
BW	-0.000176	7.96E-05	-2.211973	0.0270
SMOK_HAB	0.174756	0.072919	2.396575	0.0165
McFadden R-squared	0.033379	Mean dependent var		0.251269
S.D. dependent var	0.433812	S.E. of regression		0.425253
Akaike info criterion	1.094893	Sum squared resid		568.5610
Schwarz criterion	1.110263	Log likelihood		-1717.551
Hannan-Quinn criter.	1.100407	Deviance		3435.101
Restr. deviance	3553.723	Restr. log likelihood		-1776.861
LR statistic	118.6212	Avg. log likelihood		-0.544908
Prob (LR statistic)	0.000000			
Obs with Dep = 0	2360	Total obs		3152
Obs with Dep = 1	792			

In a first analysis it is interesting to study the signs of the estimates of each coefficient, presented in Table 12.

Considering the model presented, the estimates of maternal age, BMI, number of fetuses (single or multiple), head circumference and smoking habits were positive, i.e., the increase in these factors leads to an increase in c-section rates. This signal is in accordance with what is expected *a priori* given what is presented in the literature (Chu et al., 2007; Elvander et al., 2012; Kurdi et al., 2004; Lurie et al., 2014; Rydahl et al., 2019) and analysed in section 2.3 of the literature review.

Conversely, estimates of parity (number of pregnancies) and birth weight show a negative sign. In this case, the signs of estimates are also consistent with the literature and with the section 2.3 of the literature review (Miranda et al., 2011; Temerinac et al., 2015).

4.5 Response probability curve

The results of the binary model were used to plot a response probability curve. Therefore, through the estimated coefficients, the variations of the predicted probabilities with an independent variable were analysed. The probability of Y =1 (C-section occurring) was estimated as a function of one variable with the others evaluated in the sample mean values.

Estimates of. the probabilities of C-section occurring were plotted as a function of age, BMI, number of pregnancies, number of newborns, head circumference and newborn weight. The tables with the probabilities are presented in Appendix 3.

Regarding maternal age, from 16 to 45 years there is a monotonous increase of 25.15 percentage points in the estimate of the probability of occurring a C-section (13.96% versus 39.11%) (Figure 5). The results are in conformity with the literature which indicates that the higher the age, the more complications may occur and there is a higher probability of performing a C-section to minimise risks (Mylonas & Friese, 2015) .

It was found that BMI is an important maternal clinical data for the estimates of the probability of occurrence of C-section, given its wide variation (Figure 6). The probability of C-section also demonstrated an upward trend with increasing BMI. According to model estimates, a woman with morbid obesity (e.g., 45 kg/m^2) is more than twice as likely to have a C-section compared to a woman considered healthy (e.g., 22 kg/m^2) (22.23% versus 46.61%). Similar to the findings of the present study, Siega-Riz et al. found that overweight and obese women are at higher risk of adverse reproductive health compared to normal weight women (Siega-Riz, Siega-Riz, & Laraia, 2006).

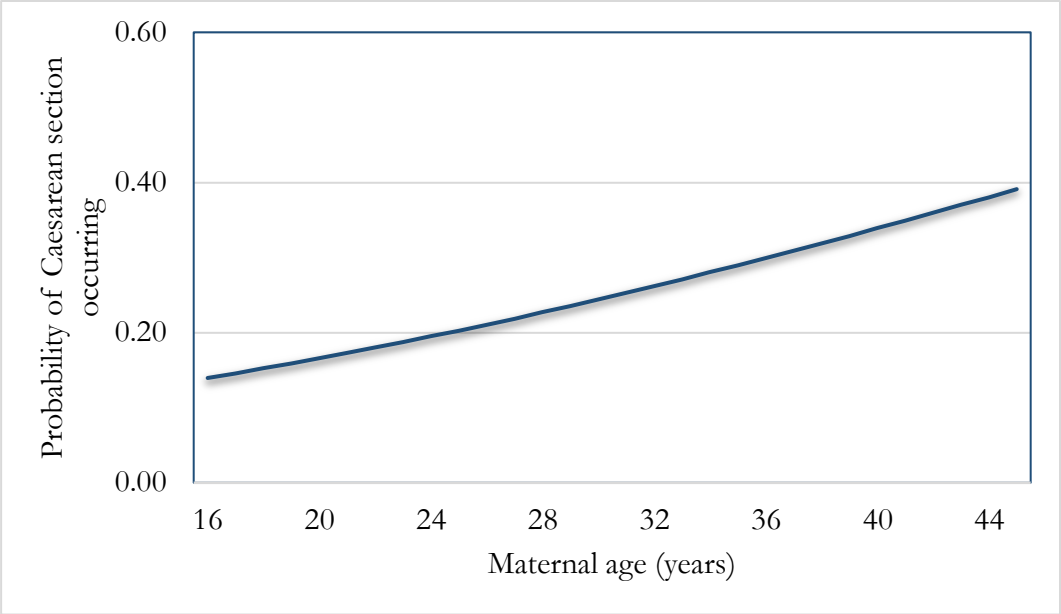


Figure 5: Probability of c-section as a function of maternal age.

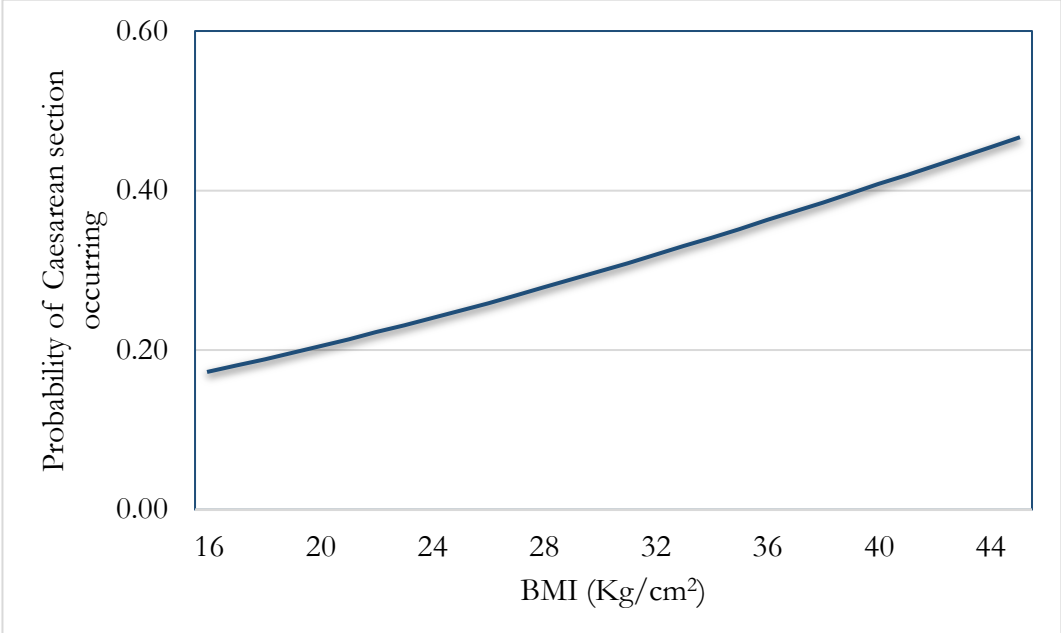


Figure 6: Probability of c-section as a function of BMI.

However, increasing parity and birth weight presented a negative trend in the probability of occurrence of C-sections (Figure 7 and 8). A nulliparous woman (number of pregnancies equal to 1) is estimated to be 3.5 percentage points more likely to have a caesarean section than a multiparous woman with a previous pregnancy (28.36% versus 24.86%). Studies have shown that nulliparous women are at higher risk of complications in childbirth than multiparous women (Miranda et al., 2011). The higher probability of

caesarean section for smaller newborns may be explained by the contribution of breech presentation and gestation of twins (Poma, 1999).

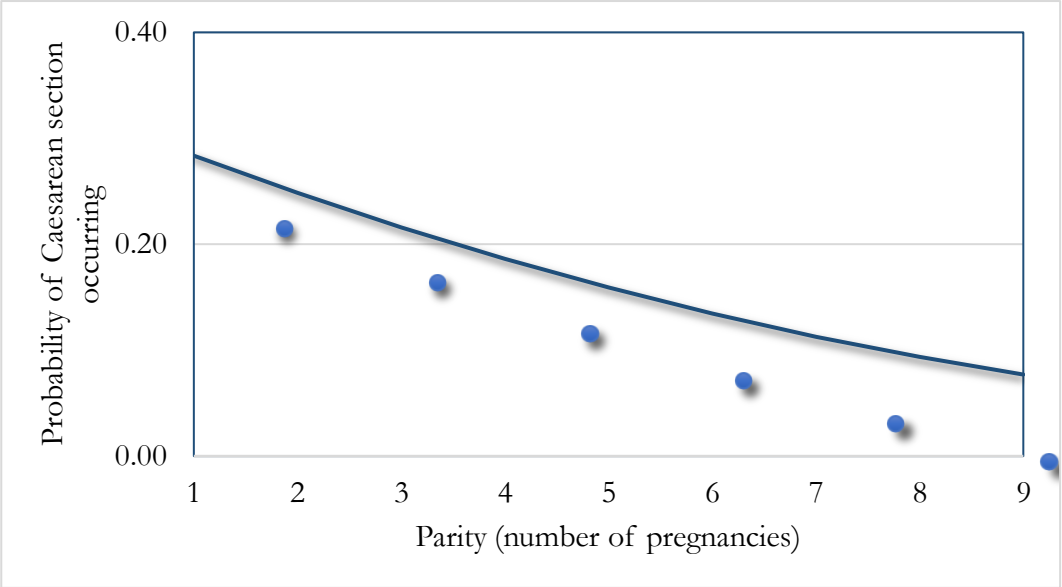


Figure 7: Probability of c-section as a function of parity.

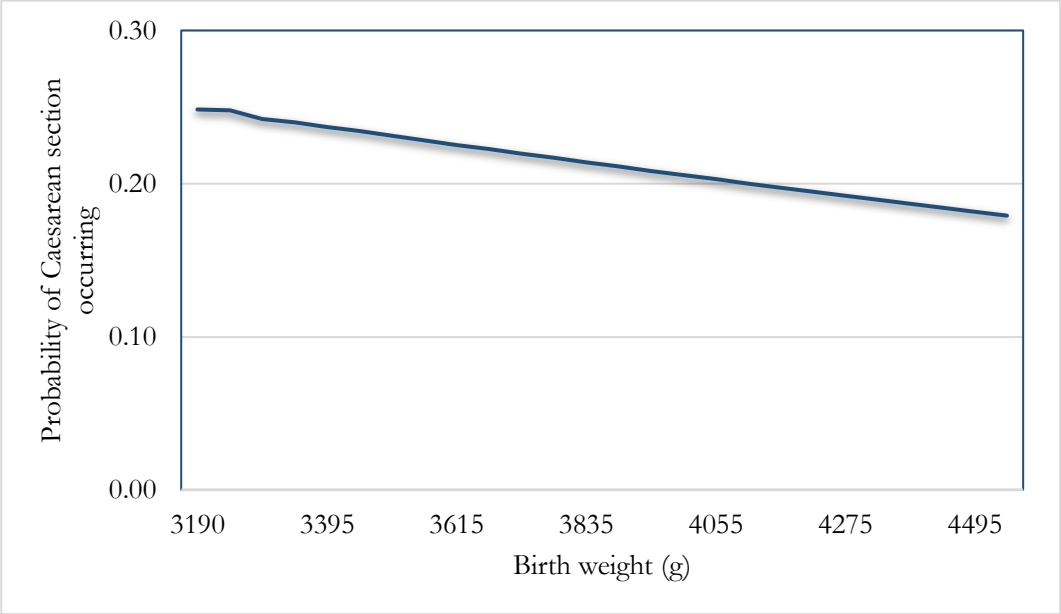


Figure 8: Probability of c-section as a function of birth weight.

When comparing the average head circumference of a newborn (35 cm) with the circumference of a newborn with abnormal head growth (50cm), the percentage of C-section almost triples, from 27.47% to 79.36% (Figure 9). These results make sense

anatomically, as a very large fetal head circumference can hinder the process, with the woman eventually undergoing caesarean section (Vries et al., 2016).

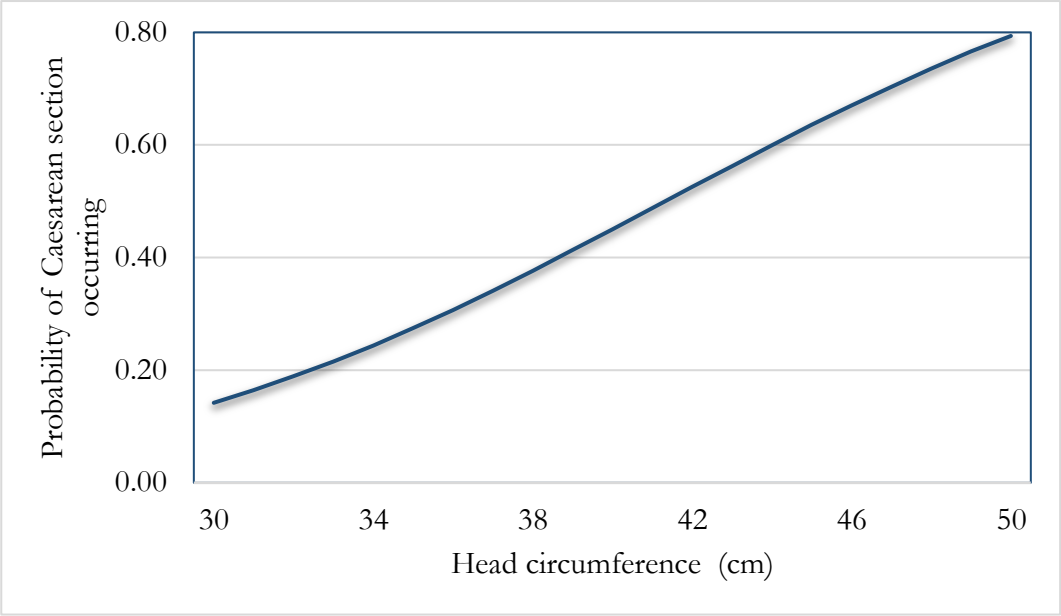


Figure 9: Probability of c-section as a function of head circumference.

The probability of C-section was also evaluated as a function of age for multiple/ singleton pregnancy and smokers/non-smokers (Figure 10 and 11).

Considering Figure 12 it is possible to infer that with increasing age, multiple pregnancies have a higher probability of C-section compared to singleton pregnancies. According to the model presented, an 16-year-old pregnant woman with a single gestation has a 13.48% probability of a C-section, while with a multiple gestation, she has a 34.26% probability. A 45-year-old pregnant woman with a single pregnancy has a C-section probability of 38.28%, while with a multiple gestation, she has a probability of 65.56%. This trend of the probability to proceed to caesarean section, are in agreement with studies indicating that the vast majority of multiple pregnancies are delivered by C-section (Kurdi et al., 2004).

A woman aged 18 who smokes presents a difference of 4.15 percentage points more when compared to a woman who does not smoke. With increasing age, this difference shows a slight tendency to increase. A woman aged 45 who smokes has a difference of 6.80 percentage points compared to a woman who does not smoke (Figure 13). These results corroborate with the study by Lurie et al. which indicates that women with uncomplicated term pregnancies who smoke during pregnancy have an increased risk of operative delivery (caesarean or instrumental) (Lurie et al., 2014).

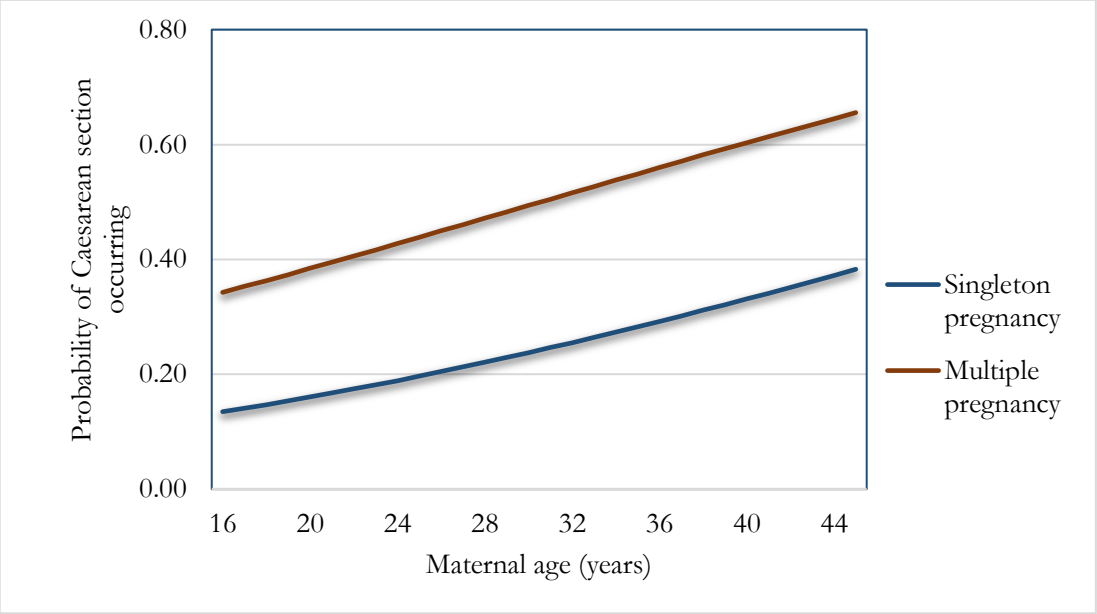


Figure 10: Probability of c-section as a function of maternal age for multiple and singleton pregnancy.

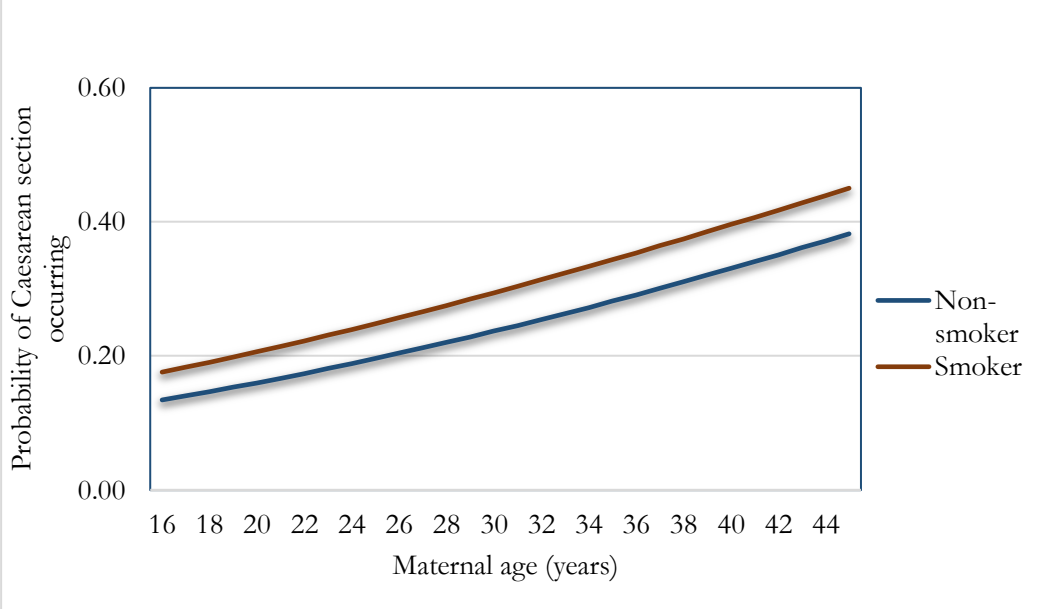


Figure 11: Probability of c-section as a function of maternal age for smoker and non-smoker.

5. Concluding Remarks and Future Perspectives

C-sections can save maternal and neonatal lives, but overuse of C-sections is a risk to short and long-term maternal/perinatal health. Importantly, the financial costs of C-sections are not trivial, with such deliveries costing almost twice as much as vaginal deliveries. Therefore, reducing the annual rate of C-section delivery is important from a public health perspective, as well as a financial standpoint.

Currently, there is a high and growing number of C-sections, and it is important to determine the factors that explain this occurrence, to reduce this high number of C-sections. In Portugal, the determinants that explain the increase in the rate of C-sections are not well-understood, probably due to the difficulty of obtaining data and information. Intending to fill the lack of empirical studies in Portugal on C-sections, the intention arises to perform the present study. Therefore, this is a novel work, since there are not many national works, and the last one published was conducted in 2013. Additionally, this database has never been explored in this context.

In Portugal, some measures have been adopted that aim to decrease the C-section rate, always considering that they do not lead to an increase in health risks for patients. However, in light of the results, the policies that have been adopted may not be the most appropriate. The data revealed that between 2018 and 2020, the rate of c-sections in the Centro Hospitalar Entre o Douro e Vouga has been increasing. Considering the repercussions established by the CNRTC, the Hospital has been suffering financial losses due to high caesarean rates. Since the risk characteristics of the mother/birth child can significantly influence this rate, it is important to analyse.

According to the literature review, the level of education and the prevalence of chronic hypertension and gestational diabetes in women are factors that influence the percentage of C-sections. The results of this cross-sectional study indicated that the determinants that promote the increased rate of this procedure are high maternal age, high BMI, nulliparity, a higher head circumference perimeter, multiple pregnancies and smoking habits.

The factors that have contributed most to the increase in C-section rates are BMI and head circumference. High maternal BMI can increase maternal pelvic soft tissue, which reduces birth canal diameters and increases risks related to dystocia, and large newborn

head circumference can lead to prolonged labour, fetal distress, maternal distress, and extraction vacuum.

Inherent to this study are some limitations that should be taken into consideration when interpreting the results. One of the main limitations is related to the sources of information available for Portugal. The truth is that the Portuguese studies are very scarce and, therefore, it is not possible to compare and predict results. A further limitation is the errors associated with the measurement of clinical data (such as the newborn's weight and head circumference), as these measurements were performed by different clinicians.

Nonetheless, the present dissertation leaves room for further research. Firstly, the analysis was conducted only for the Entre o Douro e Vouga Hospital Centre. Although this sample is considerable, extending the study to the whole country would be interesting to check the robustness of the established model. Second, some determinants such as the occurrence of previous C-sections and family income should be included in the study. Furthermore, the determinants of each group of the Robson classification can be related to C-section rates. Thirdly, the same analysis can be applied to private hospitals. It would be relevant to compare maternal and obstetric factors and how these influence the likelihood of C-section between public and private hospitals. Finally, a model should be established separately for each year of the sample. In this way, the evolution of caesarean rates over the years and the characteristics that significantly influenced this increase would be analysed.

This work can serve as an impetus for a critical and focused analysis on the threshold of penalty-free C-section rates. Furthermore, it has the potential to develop a predictive model of C-sections, with a view to providing interventions to reduce the risk of these surgeries.

6. Bibliographic References

Agrawal, A., & Wenger, N. K. (2020). Hypertension During Pregnancy. *Current Hypertension Reports, 22*(9), 64. doi:10.1007/s11906-020-01070-0

Al Busaidi, I., Al-Farsi, Y., Ganguly, S., & Gowri, V. (2012). Obstetric and non-obstetric risk factors for cesarean section in oman. *Oman medical journal, 27*(6), 478-481. doi:10.5001/omj.2012.114

Al Rifai, R. H. (2017). Trend of caesarean deliveries in Egypt and its associated factors: evidence from national surveys, 2005–2014. *BMC Pregnancy and Childbirth, 17*(1), 417. doi:10.1186/s12884-017-1591-2

Amjad, A., Amjad, U., Zakar, R., Usman, A., Zakar, M. Z., & Fischer, F. (2018). Factors associated with caesarean deliveries among child-bearing women in Pakistan: secondary analysis of data from the demographic and health survey, 2012–13. *BMC Pregnancy and Childbirth, 18*(1), 113.

Bentes, M. (1996). A utilização dos GDH como instrumentos de financiamento hospitalar. In *Gestão Hospitalar* (Vol. 33, pp. 33-40).

Betrán, A. P., Torloni, M. R., Zhang, J. J., & Gülmezoglu, A. M. (2016). WHO Statement on Caesarean Section Rates. *BJOG: An International Journal of Obstetrics & Gynaecology, 123*(5), 667-670. doi:https://doi.org/10.1111/1471-0528.13526

Betran, A. P., Ye, J., Moller, A.-B., Souza, J. P., & Zhang, J. (2021). Trends and projections of caesarean section rates: global and regional estimates. *BMJ Global Health, 6*(6), e005671. doi:10.1136/bmjgh-2021-005671

Betrán, A. P., Ye, J., Moller, A.-B., Zhang, J., Gülmezoglu, A. M., & Torloni, M. R. (2016). The Increasing Trend in Caesarean Section Rates: Global, Regional and National Estimates: 1990-2014. *PLOS ONE, 11*(2), e0148343. doi:10.1371/journal.pone.0148343

Boatin, A. A., Schlotheuber, A., Betran, A. P., Moller, A.-B., Barros, A. J., Boerma, T., . . . Hosseinpoor, A. R. (2018). Within country inequalities in caesarean section rates: observational study of 72 low and middle income countries. *bmj, 360*.

Boley, J. P. (1991). The history of caesarean section. 1935. *CMAJ : Canadian Medical Association journal = journal de l'Association medicale canadienne, 145*(4), 319-322. Retrieved from https://pubmed.ncbi.nlm.nih.gov/1873766

Bramham, K., Parnell, B., Nelson-Piercy, C., Seed, P. T., Poston, L., & Chappell, L. C. (2014). Chronic hypertension and pregnancy outcomes: systematic review and meta-analysis. *bmj, 348*.

Byamugisha, J., & Adroma, M. (2020). Caesarean Section in Low-, Middle-and High-Income Countries. In *Recent Advances in Cesarean Delivery*: IntechOpen.

Campos, I. (2004). *Sistematização das indicações para cesariana*. Retrieved from : https://sigarra.up.pt/fmup/en/conteudos_service.conteudos_cont?pct_id=3487&pv_cod=18jqaMpKadh0

Cesaroni, G., Forastiere, F., & Perucci, C. A. (2008). Are cesarean deliveries more likely for poorly educated parents? A brief report from Italy. *Birth, 35*(3), 241-244.

Chu, S. Y., Kim, S. Y., Schmid, C. H., Dietz, P. M., Callaghan, W. M., Lau, J., & Curtis, K. M. (2007). Maternal obesity and risk of cesarean delivery: a meta-analysis. *Obesity Reviews, 8*(5), 385-394. doi:https://doi.org/10.1111/j.1467-789X.2007.00397.x

Cohen, W. (2014). Does maternal age affect pregnancy outcome? *Bjog, 121*(3), 252-254. doi:10.1111/1471-0528.12563

Comissão para a redução da taxa de cesarianas da ARS NORTE, I. P. (2010). *Medidas para reduzir a taxa de cesarianas na região Norte de Portugal*. Retrieved from http://portal.arsnorte.minsaude.pt/portal/page/portal/ARSNorte/Conte%C3%BAdos/GRP/Ficheiros/Cesarianas/Relatorio_Taxas_Cesarianas.pdf

Crane, S., Wojtowycz, M., Dye, T., Aubry, R., & Artal, R. (1997). Association between pre-pregnancy obesity and the risk of cesarean delivery. *Obstetrics & Gynecology, 89*(2), 213-216.

Doi, S. A. R., Furuya-Kanamori, L., Toft, E., Musa, O. A. H., Mohamed, A. M., Clark, J., & Thalib, L. (2020). Physical activity in pregnancy prevents gestational diabetes: A meta-analysis. *Diabetes Research and Clinical Practice, 168*, 108371. doi:https://doi.org/10.1016/j.diabres.2020.108371

Elvander, C., Hogberg, U. L. F., & Ekeus, C. (2012). The influence of fetal head circumference on labor outcome: a population-based register study. *Acta Obstetricia et Gynecologica Scandinavica, 91*(4), 470-475. doi:https://doi.org/10.1111/j.1600-0412.2012.01358.x

EViews. (2020). Binary Dependent Variable Models. Retrieved from http://www.eviews.com/help/helpintro.html#page/content/limdep-Binary_Dependent_Variable_Models.html

Gabert, H. A., & Bey, M. (1988). History and development of cesarean operation. *Obstetrics and gynecology clinics of North America, 15*(4), 591-605.

Gibbons, L., Belizán, J. M., Lauer, J. A., Betrán, A. P., Merialdi, M., & Althabe, F. (2010). The global numbers and costs of additionally needed and unnecessary caesarean sections performed per year: overuse as a barrier to universal coverage. *World health report, 30*(1), 1-31.

Guihard, P., & Blondel, B. (2001). Trends in risk factors for caesarean sections in France between 1981 and 1995: lessons for reducing the rates in the future. *British Journal of Obstetrics and Gynaecology, 108*(1), 48-55.

Herstad, L., Klungsøyr, K., Skjaerven, R., Tanbo, T., Forsén, L., Åbyholm, T., & Vangen, S. (2015). Maternal age and emergency operative deliveries at term: a population-based registry study among low-risk primiparous women. *Bjog, 122*(12), 1642-1651. doi:10.1111/1471-0528.12962

Isaacs, J. D., Magann, E. F., Martin, R. W., Chauhan, S. P., & Morrison, J. C. (1994). Obstetric challenges of massive obesity complicating pregnancy. *Journal of Perinatology, 14*(1), 10-14.

Kaiser, P. S., & Kirby, R. S. (2001). Obesity as a risk factor for cesarean in a low-risk population. *Obstetrics & Gynecology, 97*(1), 39-43.

Karim, F., Ali, N. B., Khan, A. N. S., Hassan, A., Hasan, M. M., Hoque, D. M. E., . . . Chowdhury, M. A. K. (2020). Prevalence and factors associated with caesarean section in four Hard-to-Reach areas of Bangladesh: Findings from a cross-sectional survey. *PLOS ONE, 15*(6), e0234249. doi:10.1371/journal.pone.0234249

Keag, O. E., Norman, J. E., & Stock, S. J. (2018). Long-term risks and benefits associated with cesarean delivery for mother, baby, and subsequent pregnancies: Systematic review and meta-analysis. *PLoS Med, 15*(1), e1002494. doi:10.1371/journal.pmed.1002494

Klemetti, R., Gissler, M., Sainio, S., & Hemminki, E. (2016). At what age does the risk for adverse maternal and infant outcomes increase? Nationwide register-based study on first births in Finland in 2005-2014. *Acta Obstet Gynecol Scand, 95*(12), 1368-1375. doi:10.1111/aogs.13020

Kurdi, A. M., Mesleh, R. A., Al-Hakeem, M. M., Khashoggi, T. Y., & Khalifa, H. M. (2004). Multiple pregnancy and preterm labor. *Saudi medical journal, 25*(5), 632-637. Retrieved from http://europepmc.org/abstract/MED/15138532

Lee, S. I., Khang, Y. H., Yun, S., & Jo, M. W. (2005). Rising rates, changing relationships: caesarean section and its correlates in South Korea, 1988–2000. *BJOG: An International Journal of Obstetrics & Gynaecology, 112*(6), 810-819.

Li, Y., Ren, X., He, L., Li, J., Zhang, S., & Chen, W. (2020). Maternal age and the risk of gestational diabetes mellitus: A systematic review and meta-analysis of over 120 million participants. *Diabetes Res Clin Pract, 162*, 108044. doi:10.1016/j.diabres.2020.108044

Lin, H.-C., & Xirasagar, S. (2004). Institutional factors in cesarean delivery rates: policy and research implications. *Obstetrics & Gynecology, 103*(1), 128-136.

Linton, A., Peterson, M. R., & Williams, T. V. (2004). Effects of maternal characteristics on cesarean delivery rates among US Department of Defense healthcare beneficiaries, 1996–2002. *Birth, 31*(1), 3-11.

Long, Q., Kempas, T., Madede, T., Klemetti, R., & Hemminki, E. (2015). Caesarean section rates in Mozambique. *BMC Pregnancy and Childbirth, 15*, 253-253. doi:10.1186/s12884-015-0686-x

Lurie, S., Ribenzaft, S., Boaz, M., Golan, A., & Sadan, O. (2014). The effect of cigarette smoking during pregnancy on mode of delivery in uncomplicated term singleton pregnancies. *The Journal of Maternal-Fetal & Neonatal Medicine, 27*(8), 812-815.

Manyeh, A. K., Amu, A., Akpakli, D. E., Williams, J., & Gyapong, M. (2018). Socioeconomic and demographic factors associated with caesarean section delivery in Southern Ghana: evidence from INDEPTH Network member site. *BMC Pregnancy and Childbirth, 18*(1), 405. doi:10.1186/s12884-018-2039-z

Mi, J., & Liu, F. (2014). Rate of caesarean section is alarming in China. *The Lancet, 383*(9927), 1463-1464.

Milcent, C., & Zbiri, S. (2018). Prenatal care and socioeconomic status: effect on cesarean delivery. *Health economics review, 8*(1), 1-21.

Miranda, M. L., Edwards, S. E., & Myers, E. R. (2011). Adverse birth outcomes among nulliparous vs. multiparous women. *Public Health Rep, 126*(6), 797-805. doi:10.1177/003335491112600605

Mpotora, J. C., Yahaya, J. J., Ngw'eshemi, S. K., & Mwampagatwa, I. H. (2021). Rationale of indications for caesarean delivery and associated factors among primigravidae in Tanzania. *J Taibah Univ Med Sci, 16*(3), 350-358. doi:10.1016/j.jtumed.2021.01.009

Mylonas, I., & Friese, K. (2015). Indications for and risks of elective cesarean section. *Deutsches Ärzteblatt International, 112*(29-30), 489.

Nunes, P. (2012). *Financiamento hospitalar em Portugal - Incentivos à seleção e equidade.* (Master). Universidade Nova de Lisboa,

OECD. (2019). Caesarean sections. In *Health at a Glance 2019: OECD Indicators*. Paris: OECD Publishing.

Oliveira, A. R. (2013). Fatores associados e indicações para a prática de cesariana: um estudo caso-controlo. *Revista Portuguesa de Medicina Geral e Familiar, 29*, 151-159. Retrieved from http://www.scielo.mec.pt/scielo.php?script=sci_arttext&pid=S2182517320130003 00003&nrm=iso

Oliveira, M., Santos, L., & Fortuna, N. (2018). *Econometria* (2a ed.): Escolar Editora.

Onwuzuruike, B., & Onah, H. (2004). Caesarean Section in Twin Pregnancies in Enugu, Nigeria. *International Journal of Medicine and Health Development, 9*, 8-11.

Panaitescu, A. M., Syngelaki, A., Prodan, N., Akolekar, R., & Nicolaides, K. H. (2017). Chronic hypertension and adverse pregnancy outcome: a cohort study. *Ultrasound in Obstetrics & Gynecology, 50*(2), 228-235. doi:https://doi.org/10.1002/uog.17493

Patel, R. R., Peters, T. J., Murphy, D. J., & the, A. S. T. (2005). Prenatal risk factors for Caesarean section. Analyses of the ALSPAC cohort of 12 944 women in England. *International Journal of Epidemiology, 34*(2), 353-367. doi:10.1093/ije/dyh401

Pereira, A. M., Maranhão, P. A., Silva-Costa, T., & Correia, R. J. C. (2019). *The Impact of Electronic Obstetric Records Using the ObsCare Software on Scientific Production.* Paper presented at the EFMI-STC.

Phaloprakarn, C., & Tangjitgamol, S. (2020). Risk score for predicting primary cesarean delivery in women with gestational diabetes mellitus. *BMC Pregnancy Childbirth, 20*(1), 607. doi:10.1186/s12884-020-03306-y

Poma, P. A. (1999). Correlation of birth weights with cesarean rates. *Int J Gynaecol Obstet, 65*(2), 117-123. doi:10.1016/s0020-7292(98)00261-6

Poobalan, A. S., Aucott, L. S., Gurung, T., Smith, W. C. S., & Bhattacharya, S. (2009). Obesity as an independent risk factor for elective and emergency caesarean delivery in nulliparous women – systematic review and meta-analysis of cohort studies. *Obesity Reviews, 10*(1), 28-35. doi:https://doi.org/10.1111/j.1467-789X.2008.00537.x

PORDATA. (2019). Cesarianas nos hospitais (%) Qual a percentagem de cesarianas no total dos partos feitos nas unidades hospitalares? Retrieved from https://www.pordata.pt/Portugal/Cesarianas+nos+hospitais+(percentagem)-

1985.
https://www.pordata.pt/Portugal/Cesarianas+nos+hospitais+(percentagem)-1985

Ronsmans, C., Holtz, S., & Stanton, C. (2006). Socioeconomic differentials in caesarean rates in developing countries: a retrospective analysis. *The Lancet, 368*(9546), 1516-1523.

Rydahl, E., Declercq, E., Juhl, M., & Maimburg, R. D. (2019). Cesarean section on a rise-Does advanced maternal age explain the increase? A population register-based study. *PLOS ONE, 14*(1), e0210655-e0210655. doi:10.1371/journal.pone.0210655

Sandall, J., Tribe, R. M., Avery, L., Mola, G., Visser, G. H., Homer, C. S., . . . Kidanto, H. (2018). Short-term and long-term effects of caesarean section on the health of women and children. *The Lancet, 392*(10155), 1349-1357.

Santas, G., & Santas, F. (2018). Trends of caesarean section rates in Turkey. *Journal of Obstetrics and Gynaecology, 38*(5), 658-662.

Saraiva, J., Gouveia, H., & Gonçalves, A. (2017). Factors associated with cesarean sections in a high complexity university hospital in southern Brazil. *Revista gaucha de enfermagem, 38*(3), e69141-e69141.

Schmid, C. H., Stark, P. C., Berlin, J. A., Landais, P., & Lau, J. (2004). Meta-regression detected associations between heterogeneous treatment effects and study-level, but not patient-level, factors. *Journal of clinical epidemiology, 57*(7), 683-697.

Siega-Riz, A. M., Siega-Riz, A. M., & Laraia, B. (2006). The implications of maternal overweight and obesity on the course of pregnancy and birth outcomes. *Matern Child Health J, 10*(5 Suppl), S153-156. doi:10.1007/s10995-006-0115-x

Signorelli, C., Cattaruzza, M. S., & Osborn, J. F. (1995). Risk factors for Caesarean section in Italy: results of amulticentre study. *Public Health, 109*(3), 191-199. doi:https://doi.org/10.1016/S0033-3506(05)80052-6

Suzuki, S., & Nakata, M. (2013). Factors Associated with the Recent Increasing Cesarean Delivery Rate at a Japanese Perinatal Center. *ISRN Obstetrics and Gynecology, 2013*, 863282. doi:10.1155/2013/863282

Tadevosyan, M., Ghazaryan, A., Harutyunyan, A., Petrosyan, V., Atherly, A., & Hekimian, K. (2019). Factors contributing to rapidly increasing rates of cesarean section in Armenia: a partially mixed concurrent quantitative-qualitative equal status study. *BMC Pregnancy and Childbirth, 19*(1), 2. doi:10.1186/s12884-018-2158-6

Temerinac, D., Chen, X. I., Sütterlin, M., & Kehl, S. (2015). Influence of Fetal Birth Weight on Caesarean Section Rate and Fetal Outcome After Induction of Labor. *In Vivo, 29*(5), 519-524.

Tollanes, M. C., Thompson, J. M. D., Daltveit, A. K., & Irgens, L. M. (2007). Cesarean section and maternal education; secular trends in Norway, 1967–2004. *Acta Obstetricia et Gynecologica Scandinavica, 86*(7), 840-848. doi:https://doi.org/10.1080/00016340701417422

Townsend, R., Chmielewska, B., Barratt, I., Kalafat, E., van der Meulen, J., Gurol-Urganci, I., . . . Khalil, A. (2021). Global changes in maternity care provision during the COVID-19 pandemic: A systematic review and meta-analysis. *EClinicalMedicine, 37*, 100947. doi:10.1016/j.eclinm.2021.100947

Urbano, J., & Bentes, M. (1990). Definição da Produção do Hospital: Os Grupos de Diagnósticos Homogéneos. *Revista Portuguesa de Saúde Pública, 8(1).*

Uzunoz, M., & Akcay, Y. (2012). A Case Study of Probit Model Analysis of Factors Affecting Consumption of Packed and Unpacked Milk in Turkey. *Economics Research International, 2012*. doi:10.1155/2012/732583

Vahratian, A., Zhang, J., Troendle, J. F., Savitz, D. A., & Siega-Riz, A. M. (2004). Maternal prepregnancy overweight and obesity and the pattern of labor progression in term nulliparous women. *Obstetrics & Gynecology, 104*(5), 943-951.

Vaughan, D. A., Cleary, B. J., & Murphy, D. J. (2014). Delivery outcomes for nulliparous women at the extremes of maternal age - a cohort study. *Bjog, 121*(3), 261-268. doi:10.1111/1471-0528.12311

Vogel, J. P., Betrán, A. P., Vindevoghel, N., Souza, J. P., Torloni, M. R., Zhang, J., . . . Temmerman, M. (2015). Use of the Robson classification to assess caesarean section trends in 21 countries: a secondary analysis of two WHO multicountry surveys. *The Lancet Global Health, 3*(5), e260-e270. doi:https://doi.org/10.1016/S2214-109X(15)70094-X

Vries, B., Bryce, B., Zandanova, T., Ting, J., Kelly, P., Phipps, H., & Hyett, J. A. (2016). Is neonatal head circumference related to caesarean section for failure to progress? *Australian and New Zealand Journal of Obstetrics and Gynaecology, 56*(6), 571-577.

Waldenström, U., & Ekéus, C. (2017). Risk of labor dystocia increases with maternal age irrespective of parity: a population-based register study. *Acta Obstet Gynecol Scand, 96*(9), 1063-1069. doi:10.1111/aogs.13167

WHO. (2015). Caesarean sections should only be performed when medically necessary. Retrieved from https://www.who.int/mediacentre/news/releases/2015/caesarean-sections/en/

WHO, UNFPA, & UNICEF. (2009). Monitoring emergency obstetric care : a handbook. In. Geneva: World Health Organization.

Witt, W. P., Wisk, L. E., Cheng, E. R., Mandell, K., Chatterjee, D., Wakeel, F., . . . Zarak, D. (2015). Determinants of Cesarean Delivery in the US: A Lifecourse Approach. *Maternal and Child Health Journal, 19*(1), 84-93. doi:10.1007/s10995-014-1498-8

Witter, F. R., Caulfield, L. E., & Stoltzfus, R. J. (1995). Influence of maternal anthropometric status and birth weight on the risk of cesarean delivery. *Obstetrics & Gynecology, 85*(6), 947-951.

World Health, O. (2021). Caesarean section rates continue to rise, amid growing inequalities in access: WHO. Retrieved from https://www.who.int/news/item/16-06-2021-caesarean-section-rates-continue-to-rise-amid-growing-inequalities-in-access-who

Ye, J., Betrán, A. P., Guerrero Vela, M., Souza, J. P., & Zhang, J. (2014). Searching for the optimal rate of medically necessary cesarean delivery. *Birth, 41*(3), 237-244.

Young, T. K., & Woodmansee, B. (2002). Factors that are associated with cesarean delivery in a large private practice: the importance of prepregnancy body mass index and weight gain. *American journal of obstetrics and gynecology, 187*(2), 312-320.

Yu, Y., Lin, F., Dong, W., Li, H., Zhang, X., & Chen, C. (2019). The effectiveness of financial intervention strategies for reducing caesarean section rates: a systematic review. *BMC Public Health, 19*(1), 1080. doi:10.1186/s12889-019-7265-4

Zhang, J., Zhang, Y., Ma, Y., Ke, Y., Huo, S., He, L., . . . Zhao, A. (2020). The associated factors of cesarean section during COVID-19 pandemic: a cross-sectional study in nine cities of China. *Environmental Health and Preventive Medicine, 25*(1), 60. doi:10.1186/s12199-020-00899-w

Zwecker, P., Azoulay, L., & Abenhaim, H. A. (2011). Effect of fear of litigation on obstetric care: a nationwide analysis on obstetric practice. *American journal of perinatology, 28*(04), 277-284.

Other sources of information

Cruz, B. (2020). Mais cesarianas, complicações pós-parto e problemas na placenta. O que a Covid-19 pode fazer às grávidas. Retrieved from https://tvi24.iol.pt/tecnologia/gravidez/mais-cesarianas-complicacoes-pos-parto-e-problemas-na-placenta-o-que-a-covid-19-pode-fazer-as-gravidas

Jan, C. (2020). Mães assintomáticas ou com sintomas leves tiveram que ser levadas à UTI após a cirurgia em 13,5% dos casos, segundo um estudo feito na Espanha. *El Pais*. Retrieved from https://brasil.elpais.com/sociedade/2020-06-10/cesariana-aumenta-risco-de-complicacoes-em-gravidas-com-covid-19.html

Marques, P. (2017). 25% dos hospitais fazem cesarianas acima do limite. *Diário de Notícias*. Retrieved from https://www.dn.pt/portugal/25-dos-hospitais-fazem-cesarianas-acima-do-limite-8955698.html

Taxa de cesarianas aumenta e atinge o maior valor desde 2010. (2021). *Expresso*. Retrieved from https://expresso.pt/sociedade/2021-04-07-Taxa-de-cesarianas-aumenta-e-atinge-o-maior-valor-desde-2010-3d14ce27

REPÚBLICA PORTUGUESA
SAÚDE

40 ANOS | SNS SERVIÇO NACIONAL DE SAÚDE 1979-2019

Centro Hospitalar de Entre o Douro e Vouga, E.P.E.

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SUA REFERÊNCIA	SUA COMUNICAÇÃO DE	NOSSA REFERÊNCIA	DATA:
		Nº: CA-317/2020-0t_MP/AC	29 de outubro de 2020

ASSUNTO: Estudo - "Impacto da COVID-19 nas taxas de cesarianas por classificação de Robson nos hospitais portugueses"

No seguimento do pedido apresentada por V. Exa., para a realização do estudo sob o tema identificado em epígrafe, informamos que o mesmo foi objeto de apreciação em reunião do Conselho de Administração de 27 de outubro de 2020, tendo sido proferido o seguinte despacho:

"Deliberado autorizar."

Com os melhores cumprimentos,

O Presidente do Conselho de Administração

Miguel Paiva, Dr.

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Rua Dr. Cândido Pinho, 4520-211 Santa Maria da Feira, PORTUGAL
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Appendix 2

Nº	Variables
1	ID_gestação
2	Idade_materna
3	Peso_inicial
4	Peso_admissão_internamento
5	IMC
6	Cigarros
7	Álcool
8	Estupefacientes
9	Malformação uterina
10	Cirurgia uterina prévia
11	Conização prévia
12	Incompatibilidade Rh actual
13	De abortamentos de repetição (>=3)
14	De eclâmpsia
15	De pré-eclâmpsia
16	De HTA gestacional
17	De diabetes gestacional
18	De tromboembolismo
19	Parto pré-termo anterior
20	Laceração perineal de 3º grau
21	Laceração perineal de 4º grau
22	Hemorragia pós-parto anterior
23	Doença.renal
24	Doença.cardíaca
25	Doença.pulmonar (asma e outra doença pulmonar)
26	Hematológica (anemia, trombocitopenia, coagulopatia,…)
27	Tromboembolismo
28	Doença.tiroideia

29	Epilepsia
30	Cirurgia(s)
31	Psicológica/psiquiátrica (exemplo depressão e ansiedade)
32	Data de admissão (Hora precisa: hora e minutos)
33	Data de alta (Hora precisa: hora e minutos)
34	Data da última consulta antes do parto
35	Data do nascimento do recém-nascido (Hora precisa: hora e minutos)
36	Duração do período expulsivo
37	A_gesta (numero de gestações que a doente já teve incluindo a actual)
38	Nº de abortamentos espontâneos
39	Nº de abortamentos IMG
40	Nº de abortamentos IVG
41	Nº de gravidez ectópica
42	Eutócito_anterior
43	Ventosas_anterior
44	Fórceps_anterior
45	Tipo_gravidez
46	Vigiada
47	Número_consultas_pré_natal
48	Vigiada_hospital
49	Vigiada_particular
50	Vigiada_centro_saúde
51	Vigiada_neste_hospital
52	Patologia obstétrica do colo uterino
53	Ameaça/trabalho de parto pré-termo
54	RPM (sim/não, data)
55	Corioamnionite
56	Placenta prévia
57	Acretismo placentário
58	Vasa prévia
59	DPPNI
60	Hemorragia feto-materna
61	Apresentação/situação fetal anómala

62	Apresentação_admissão
63	Bishop_score
64	Idade_gestacional_admissão
65	Idade_gestacional_parto
66	Trabalho_parto_espontâneo
67	Trabalho_parto_induzido
68	Trabalho_parto_induzido_método (protoglandinas, oxcitocina, amniotomia ou sonda de Foley)
69	Rotura de membranas em trabalho parto_espontânea
70	Rotura de membranas em trabalho parto_induzida
71	Tipo_parto
72	Tipo_parto_procedimentos/ocorrências/analgesia
73	Parto_instrumentado
74	Cesariana_programada_urgente_emergente
75	Motivo_cesariana
76	Número de recém-nascidos
77	Grupo de Robson
78	Diagnóstico materno de COVID-19
79	Diagnóstico materno de COVID-19_data
80	Fármacos administrados durante o parto (Antibioterapia)
81	Nascimento (no hospital ou fora do hospital)
82	Hiprtensão_crónica
83	Hipertensão_gestacional
84	Hipertensão_pre_eclampsia
85	HTA crónica com pré-eclâmpsia sobreposta
86	Eclâmpsia
87	Diabetes_gestacional
88	Diabetes_gestacional_dieta
89	Diabetes_gestacional_insulina
90	Diabetes_gestacional_antidiabético oral
91	Diabetes_materna
92	Diabetes_tipo1
93	Diabetes_tipo2

94	Depressão pós-parto com data de diagnóstico
95	Febre intraparto
96	Rotura uterina
97	Prolapso do cordão umbilical
98	Retenção da placenta
99	Circular cervical apertada
100	Nó verdadeiro do cordão
101	Laceração cervical
102	Hemorragia pós-parto precoce (<24h)
103	Hemorragia pós-parto precoce (<24h) por atonia uterina
104	Hemorragia pós-parto precoce (<24h) por retenção da placenta
105	Hemorragia pós-parto precoce (<24h) por retenção de fragmentos placentários
106	Hemorragia pós-parto precoce (<24h) por laceração do canal de parto
107	Hemorragia pós-parto precoce (<24h) por outra causa
108	Choque hemorrágico
109	Coagulopatia de consumo
110	Inversão uterina
111	Embolia do líquido amniótico
112	Complicações anestésicas do parto
113	Complicações anestésicas do parto Aspiração do conteúdo gástrico
114	Complicações anestésicas do parto Paragem cárdio-respiratória
115	Necessidade de transfusão durante o parto
116	Resolução de hemorragia pós-parto_Inserção de balão intra-uterino
117	Resolução de hemorragia pós-parto_Embolização das artérias uterinas_direita
118	Resolução de hemorragia pós-parto_Embolização das artérias uterinas_esquerda
119	Resolução de hemorragia pós-parto_Pontos de B-Lynch
120	Resolução de hemorragia pós-parto_Desvascularização uterina progressiva
121	Resolução de hemorragia pós-parto_Laqueação das artérias hipogástricas
122	Resolução de hemorragia pós-parto_Resolução da inversão uterina
123	Resolução de hemorragia pós-parto_Resolução da inversão uterina_Reposição uterina manual
124	Resolução de hemorragia pós-parto_Resolução da inversão uterina_Reposição uterina cirúrgica

125	Resolução de hemorragia pós-parto_Histerectomia subtotal periparto com anexectomia bilateral - via aberta
126	Resolução de hemorragia pós-parto_Histerectomia subtotal periparto com anexectomia bilateral - via laparoscópica
127	Resolução de hemorragia pós-parto_Histerectomia subtotal periparto - via aberta
128	Resolução de hemorragia pós-parto_Histerectomia subtotal periparto - via laparoscópica
129	Resolução de hemorragia pós-parto_Histerectomia total periparto com anexectomia bilateral - via aberta
130	Resolução de hemorragia pós-parto_Histerectomia total periparto com anexectomia bilateral - via laparoscópica
131	Resolução de hemorragia pós-parto_Histerectomia total periparto - via aberta
132	Resolução de hemorragia pós-parto_Histerectomia total periparto - via laparoscópica
133	Morte materna (anteparto, intraparto ou no puerpério)
134	Índice de Apgar (1 minuto)
135	Índice de Apgar (5 minutos)
136	Peso ao nascer
137	Perímetro cefálico_percentil
138	Destino do recém-nascido (internamento em UCIN)
139	Suporte de oxigénio
140	Intubação
141	Acidose metabólica do RN
142	Malformações visíveis do RN
143	Nado-morto
144	Contacto pele com pele
145	Amamentação na 1ª hora de vida
146	Aleitamento durante o internamento
147	Hemorróides
148	Febre puerperal de origem inexplicada
149	Hemorragia pós-parto tardia (> 24h)
150	Retenção de fragmentos placentários
151	Anemia puerperal
152	Endometrite puerperal

153	Hematoma/abcesso pélvico
154	Sepsis puerperal
155	Cefaleias pós punção da dura mater
156	Cardiomiopatia periparto
157	Complicações da cicatriz da parede abdominal__
158	Complicações da cicatriz da parede abdominal__Infecção da cicatriz da parede abdominal
159	Complicações da cicatriz da parede abdominal__Hematoma da cicatriz da parede abdominal
160	Complicações da cicatriz da parede abdominal__Deiscência da cicatriz da parede abdominal
161	Complicações perineais_Infecção da cicatriz perineal_
162	Complicações perineais_Infecção da cicatriz perineal_Infecção da cicatriz perineal
163	Complicações perineais_Infecção da cicatriz perineal_Hematoma perineal
164	Complicações perineais_Infecção da cicatriz perineal_Deiscência da cicatriz perineal
165	Complicações mamárias
166	Complicações mamárias_Gretas mamilares
167	Complicações mamárias_Hipogalactia
168	Complicações mamárias_Mamilos invertidos
169	Complicações mamárias_Engurgitamento mamário
170	Complicações mamárias_Supressão do leite materno
171	Complicações mamárias_Mastite puerperal
172	Complicações mamárias_Abcesso mamário
173	Depressão pós-parto_Data de diagnóstico
174	Ressutura de deiscência de cicatriz perineal
175	Drenagem de hematoma perineal_via percutânea
176	Drenagem de hematoma perineal_via aberta
177	Drenagem de hematoma vaginal
178	Ressutura de deiscência de cicatriz abdominal
179	Drenagem de hematoma da parede abdominal
180	Drenagem de abcesso da parede abdominal
181	Drenagem de hematoma pélvico
182	Drenagem de abcesso pélvico

183	Drenagem de abcesso mamário
184	Nº de consultas de enfermagem de seguimento pós-parto
185	Nº de consultas médicas de seguimento pós-parto
186	Nº de urgências no puerpério (até 7 semanas)

Appendix 3

Maternal age (years)	Probability of C-section
16	0.1396
17	0.1458
18	0.1523
19	0.1589
20	0.1657
21	0.1727
22	0.1799
23	0.1873
24	0.1949
25	0.2026
26	0.2106
27	0.2187
28	0.2270
29	0.2354
30	0.2441
31	0.2529
32	0.2618
33	0.2709
34	0.2802
35	0.2897
36	0.2992
37	0.3090
38	0.3188
39	0.3288
40	0.3389
41	0.3491
42	0.3595
43	0.3699
44	0.3804
45	0.3911

Figure 12: Probability of c-section and maternal age.

BMI	Probability of C-section
16	0.1732
17	0.1808
18	0.1887
19	0.1968
20	0.2051
21	0.2136
22	0.2223
23	0.2312
24	0.2403
25	0.2495
26	0.2590
27	0.2687
28	0.2785
29	0.2885
30	0.2987
31	0.3090
32	0.3195
33	0.3301
34	0.3409
35	0.3518
36	0.3628
37	0.3739
38	0.3852
39	0.3965
40	0.4079
41	0.4194
42	0.4310
43	0.4427
44	0.4543
45	0.4661

Figure 13: Probability of c-section and BMI.

Parity (number of pregnances)	Probability of C-section
1	0.2836
2	0.2486
3	0.2161
4	0.1861
5	0.1589
6	0.1344
7	0.1127
8	0.0936
9	0.0770

Figure 14: Probability of c-section and parity.

Head Circumference	Probability of C-section
30	0.1421
31	0.1644
32	0.1889
33	0.2155
34	0.2441
35	0.2747
36	0.3071
37	0.3411
38	0.3764
39	0.4127
40	0.4499
41	0.4874
42	0.5251
43	0.5626
44	0.5995
45	0.6355
46	0.6704
47	0.7039
48	0.7357
49	0.7656
50	0.7936

Figure 15: Probability of c-section and head circumference.

Birth weight (g)	Probability of C-section
3190	0.2484
3200	0.2479
3300	0.2423
3340	0.2401
3395	0.2371
3450	0.2342
3505	0.2312
3560	0.2283
3615	0.2253
3670	0.2225
3725	0.2196
3780	0.2167
3835	0.2139
3890	0.2111
3945	0.2083
4000	0.2055
4055	0.2028
4110	0.2001
4165	0.1974
4220	0.1947
4275	0.1920
4330	0.1894
4385	0.1868
4440	0.1842
4495	0.1816
4550	0.1791

Figure 16: Probability of c-section and birth weight.

Maternal age (years)	Singleton pregnancy	Multiple pregnancy	Δ
16	0.1348	0.3426	0.2078
17	0.1409	0.3529	0.2119
18	0.1472	0.3632	0.2160
19	0.1537	0.3737	0.2200
20	0.1604	0.3843	0.2239
21	0.1673	0.3949	0.2277
22	0.1743	0.4057	0.2313
23	0.1816	0.4165	0.2349
24	0.1890	0.4273	0.2384
25	0.1966	0.4383	0.2417
26	0.2044	0.4492	0.2449
27	0.2124	0.4603	0.2479
28	0.2205	0.4713	0.2508
29	0.2288	0.4824	0.2535
30	0.2373	0.4935	0.2561
31	0.2460	0.5045	0.2585
32	0.2548	0.5156	0.2608
33	0.2638	0.5267	0.2629
34	0.2730	0.5377	0.2647
35	0.2823	0.5488	0.2664
36	0.2918	0.5597	0.2680
37	0.3014	0.5707	0.2693
38	0.3111	0.5816	0.2704
39	0.3210	0.5924	0.2714
40	0.3310	0.6031	0.2721
41	0.3412	0.6138	0.2726
42	0.3514	0.6244	0.2730
43	0.3618	0.6349	0.2731
44	0.3722	0.6453	0.2730
45	0.3828	0.6556	0.2728

Figure 17: Probability of c-section for multiple and singleton pregnancy (and difference between the two probabilities) as a function of maternal age.

Maternal age (years)	Non-smoker	Smoker	Δ
16	0.1345	0.1760	0.0415
17	0.1406	0.1833	0.0427
18	0.1469	0.1908	0.0439
19	0.1534	0.1984	0.0450
20	0.1601	0.2063	0.0462
21	0.1669	0.2143	0.0474
22	0.1740	0.2225	0.0485
23	0.1812	0.2308	0.0496
24	0.1886	0.2394	0.0508
25	0.1962	0.2481	0.0519
26	0.2040	0.2570	0.0530
27	0.2119	0.2660	0.0541
28	0.2201	0.2752	0.0551
29	0.2284	0.2846	0.0562
30	0.2369	0.2941	0.0572
31	0.2456	0.3037	0.0581
32	0.2544	0.3135	0.0591
33	0.2634	0.3234	0.0600
34	0.2725	0.3334	0.0609
35	0.2818	0.3436	0.0618
36	0.2913	0.3539	0.0626
37	0.3009	0.3643	0.0634
38	0.3106	0.3748	0.0641
39	0.3205	0.3853	0.0648
40	0.3305	0.3960	0.0655
41	0.3406	0.4067	0.0661
42	0.3509	0.4176	0.0667
43	0.3612	0.4284	0.0672
44	0.3717	0.4394	0.0677
45	0.3823	0.4503	0.0680

Figure 18: Probability of c-section for smokers and non-smokers (and difference between the two probabilities) as a function of maternal age.