

MODE OF DELIVERY BY MATERNAL CHARACTERISTICS: THE CASE OF C-SECTIONS IN SLOVAKIA

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Abstract

This study focuses on mode of delivery by maternal characteristics such as age, education, marital status, region, and mode of previous delivery. We use microdata provided by the Ministry of Health and find that the likelihood of a C-section increases with the age of the mother, but a previous natural delivery weakens this association. Women who are married more often give birth by planned C-section. Emergency C-sections occur more often among unmarried women. Women in the Trenčín region more often deliver spontaneously, and women in the Bratislava and Nitra regions more often deliver by C-section. Due to the early onset of fertility, women with primary education more often deliver spontaneously. Women with secondary education under the age of 35 more often deliver by planned C-section than university-educated women. Our results are policy-relevant for further decision-making and planning in obstetrics and gynaecology in Slovakia, especially by pinpointing the different risk categories in terms of maternal education or marital status by mother's age.

Keywords: mode of delivery, Caesarean section, marital status, age, education, parity

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1. INTRODUCTION

The aim of this study is to analyse the mode of delivery in childbirth by selected maternal characteristics. We focus on the biological (age, mode of previous delivery), socio-economic (marital status and education), and geographic (region of residence) characteristics of the mothers. We work with microdata that include all the deliveries that took place in health centres in Slovakia in 2009–2010 and 2019–2020.

In this article, we focus on caesarean sections (C-sections) and their (over)use in Slovakia. Research on C-sections is particularly important, as C-sections

are surgeries (that carry corresponding risks) and they tend to be overused not only in Europe but also other developed regions (*Gibbons et al.*, 2010; *Montilla et al.*, 2020). Some authors have even compared the increase in the number of C-sections to an epidemic (*Fait et al.*, 2022). According to *EUROSTAT* data (2023a, 2023b), the rate of C-sections (the proportion of children born by C-section) in EU countries (and candidate countries) was 34% in 2020, which is almost 20 percentage points (p.p.) more than the 15% limit recommended by *WHO* (2015). Compared to other European countries (see Figure 1), Slovakia ranks 'only' in the 2nd quartile of countries with a relatively

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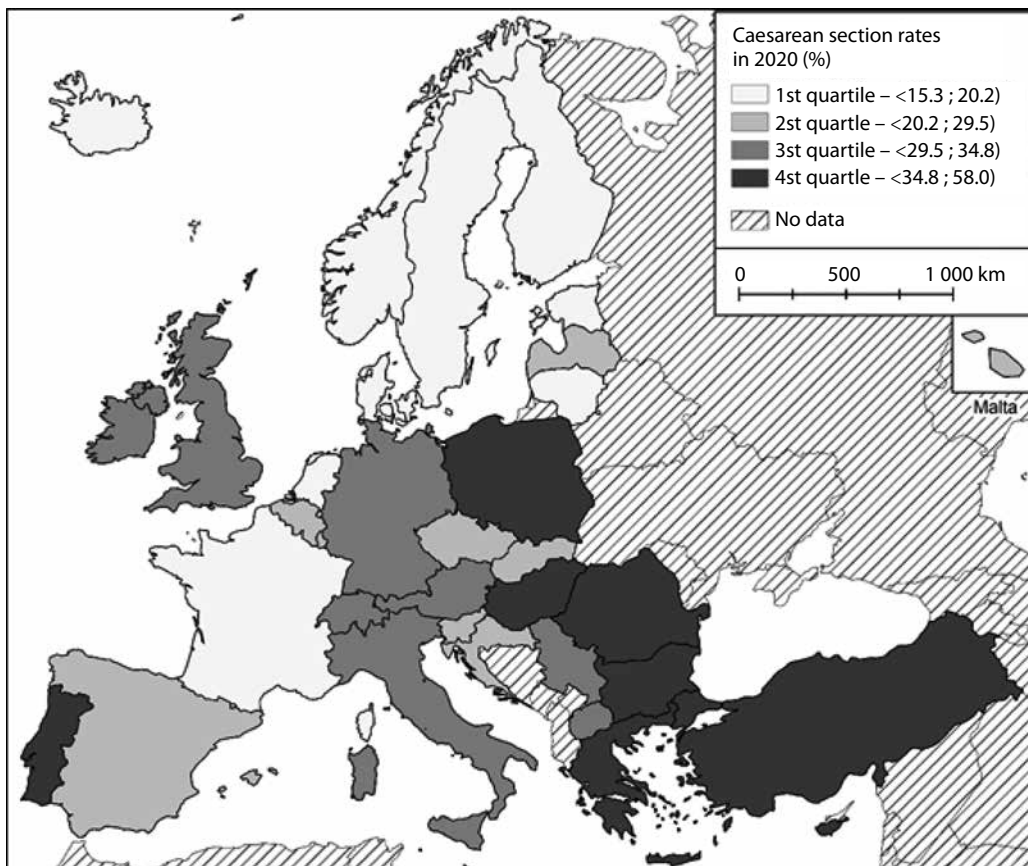
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lower C-section rate, but the actual share is very close to the median. Figure 2 shows the trends in Slovakia for all births and births by C-section over time, with an unprecedented increase in the number of C-sections during a substantial decline in the birth rate. However, after the highest rate of C-sections was reached in 2013, a slight, gradual decrease is observed in 2015–2021. This decrease may be the result of efforts by the Slovak Society of Gynaecology and Obstetrics (Kaščák et al., 2011; Dosedla, et al., 2011; Cupaník et al., 2016) and the government to reduce the rate of C-sections, which are both more expensive than natural births (SUB, 2021) and pose a health risk to the mother and her child (Kilsztajn et al., 2007; Wallenborn et al., 2017; Londero, et al., 2019). In particular, elective caesarean sections leave newborns with a serious lifelong

risk of certain diseases, since natural childbirth is an important condition for healthy human development (Hederlingova et al., 2017).

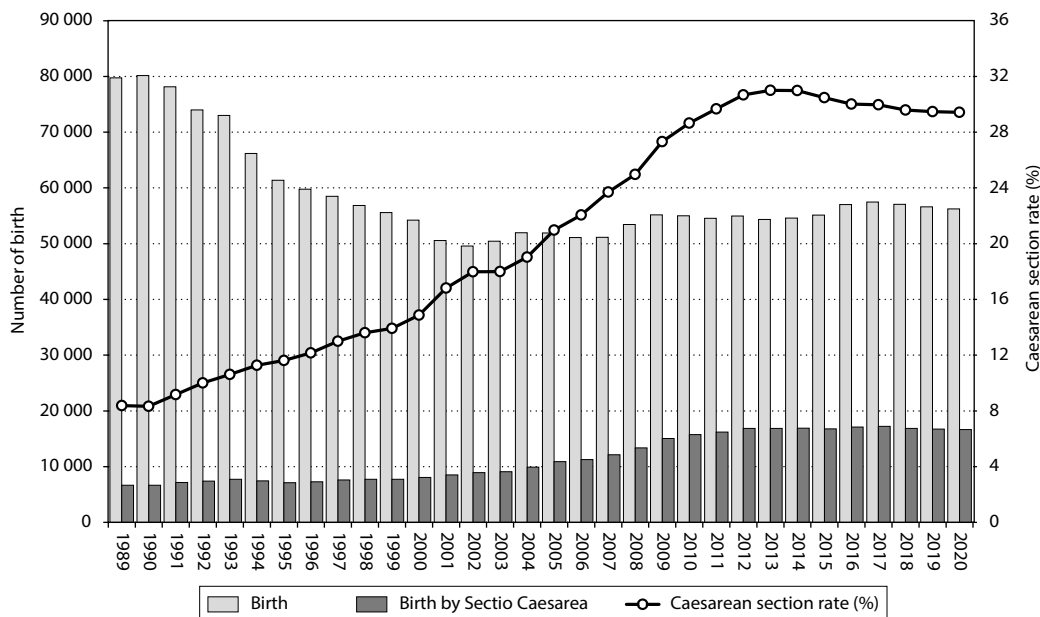
Analysing modes of delivery may also be important for understanding their impact on the birth rate and the total fertility rate in the entire population. Surgical delivery may discourage couples from planning to have another child (O'Neill et al., 2013; Zahumensky et al. 2021), or they might need to postpone the next pregnancy to an older age for medical reasons (Hall et al., 1989; Gurol-Urganci et al., 2013), when the probability of a successful delivery of the foetus decreases (Londero et al., 2019). Nam et al. (2017) found a higher incidence of postpartum depression and lactation problems in women who gave birth by C-section. All these factors related to C-sections

Figure 1 Caesarean section rates in selected European countries in 2020



Source: EUROSTAT, 2023a, 2023b.

Figure 2 Caesarean sections in Slovakia between 1989 and 2020



Source: NCZI, 2001; NCZI, 2021.

may discourage women from planning to have another child. Having a caesarean section affects the number of subsequent children in the family, not only through voluntary decisions by the couples, but also because it increases the risk of involuntary infertility and subsequent foetal death in utero (Murphy et al., 2002; Chen – Hancock, 2012; Hinterleitner et al., 2021).

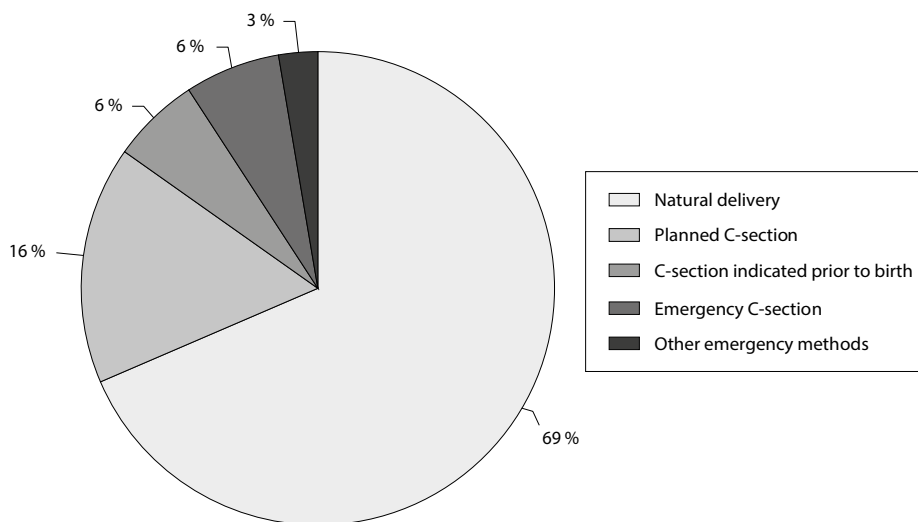
2. DATA AND METHODS

The data stem from individual records of the ‘Report on Maternity Z (Ministry of Health) 4–12’ covering all deliveries in Slovakia in the years 2009, 2010, 2019, and 2020³⁾ provided by NCZI (2022). Among the deliveries analysed here, 49.3% were in the 2009–2010 period and 50.7% were in the 2019–2020 period. We have microdata on individual mothers regarding their age, region of residence, marital status, educa-

tion, and mode of previous delivery. The entire data set consists of 222,849 deliveries, with missing values for some variables: 15% of the data on education, 9% of the data on marital status, and 0.2% of the data on region of residence are missing, while there is no missing data for year, age, and mode of delivery. We did not impute the missing data; for individual differentiation criteria, missing data were not included in the analysis. Table 1 shows the number of deliveries by different maternal characteristics. Figure 3 presents the distribution of the mode of delivery in our data. More than 69% of deliveries in Slovakia took place naturally, while a planned C-section was used in approximately 16% of deliveries. Approximately 6% of deliveries were performed as an acute C-section right before labour and another 6% during labour. Other (emergency) delivery methods account for up to 3% of the total number of deliveries.

3) Originally, we intended to analyse changes in delivery mode over a longer time period, but due to a change in the reporting methodology by the NCZI, the earliest available year was 2009. We use two consecutive years in order to increase the sample size, and we consider two decades (2009–2010 and 2019–2020). Since the largest changes in delivery mode took place prior to 2009 (see Figure 2), the importance of evaluating individual years separately has been partially lost.

Figure 3 The distribution of modes of delivery in Slovakia (average for the years 2009, 2010, 2019, and 2020)



Note: Other emergency methods' includes delivery using forceps, vacuum extraction, expression, and extraction.

Source: Authors' computation

Since some modes of delivery occur with low frequency, we grouped them into three categories:

- 1) spontaneous (natural) deliveries;
- 2) planned C-sections (decided before delivery): a C-section planned well before the due date and an acute C-section decided right before delivery – both of these C-sections are decided before labour starts;
- 3) emergency C-sections (decided during delivery) and other complicated deliveries (forceps, vacuum extraction, expression, and extraction) – these emergency methods are decided during labour.

We analyse these three types of delivery by different maternal characteristics. Our main focus is on age as a major risk factor for complications during pregnancy and delivery (Londero *et al.*, 2019; Bouzaglou *et al.*, 2020). Other variables of interest, such as place of residence, marital status, education, and number of previous deliveries, are evaluated in combination with age. We also analyse temporal changes between the years 2009–2010 and 2019–

2020. Our descriptive analysis consists of combined graphs, where we show the relative frequency of the different modes of delivery by maternal characteristics (age + another characteristic).⁴⁾ In addition to these graphs, we also calculate the odds ratios (OR) for the different modes of delivery by maternal age and other characteristics in Table 2 (the reference category is always marked 'ref.'). The following formula is used to calculate the ORs (Mareš *et al.*, 2019):

$$OR = \frac{\frac{P_1}{1 - P_1}}{\frac{P_0}{1 - P_0}}$$

where P_1 is the probability of the observed phenomenon in the group of interest and P_0 is the probability of the observed phenomenon in the reference group. The OR expresses how many times more likely it is that the observed phenomenon will occur in the group of interest compared to the reference group.

4) In all graphs, we consider the sample size. Samples smaller than 30 observations are depicted as bars with a dashed margin. In consider the results in these smaller samples to be less reliable and interpret them with caution.

Figure 4 Example of an odds ratio (OR) calculation

Data:

Planned C-section	Mother's age at delivery	
	Under the age of 20 (reference group)	Age 40 and over
Yes	1,849 (a)	2,090 (b)
No	12,884 (c)	3,457 (d)
Total	14,733	5,547

$$\text{Calculation: } OR = \frac{\frac{P_1}{1 - P_1}}{\frac{P_0}{1 - P_0}} = \frac{\frac{2,090/5,547}{3,457/5,547}}{\frac{1,849/14,733}{12,884/14,733}} = \frac{2,090/5,547}{3,457/5,547} \cdot \frac{12,884/14,733}{1,849/14,733} = \frac{2,090}{3,457} \cdot \frac{12,884}{1,849} = \frac{b}{d} \cdot \frac{c}{a} = 4.2$$

Interpretation: The likelihood of a planned C-section among mothers over the age of 40 is four times higher than among women who delivered when under the age of 20.

Source: NCZI, 2022; authors' calculation.

When looking at the OR of giving birth in a particular way (e.g. natural birth) by age only, the reference group are mothers under the age of 20 and the groups of interest are mothers aged 20–24, 25–29, etc. (see Panel A in Table 2). Figure 4 presents an example of an OR calculation and interpretation from Panel A in Table 2.

In all other cases, where we focus on the ORs of giving birth in a particular way by age *and* another characteristic, the OR always expresses the likelihood of one group of women (e.g. married women) of a certain age of giving birth naturally or via a planned C-section or via an emergency method, in comparison to the reference group (e.g. single women) of the same age. This means that in Panels B–F of Table 2, the ORs are defined within each column (Panel A, mentioned above, is an exception, where the ORs are defined within each row).

All graphs and ORs take into account the number of women in the population of a specific age. For regions and years, we calculated the so-called age-specific delivery rates (analogous to the age-specific fertility rate) according to the following formula:

$${}_t d_x = \frac{{}_t D_x}{{}_{1.7..t} S_x}$$

where:

${}_t d_x$ is the age-specific delivery rate of women at age (x) in year (t),

${}_t D_x$ is the number of deliveries to women at age (x) in year (t),

${}_{1.7..t} S_x$ is the number of women at age (x) in year (t) on July 1.

For regions, the age-specific rates were calculated as a weighted harmonic mean of years 2009, 2010, 2019, and 2020.

We then calculated the reduced age-specific delivery rates for the differentiating criteria of marital status, education, and mode of previous deliveries according to the following formula:

$${}_s r d_x = \frac{{}_s D_x}{{}_{1.7..t} S_x}$$

where:

${}_s r d_x$ is the reduced age-specific delivery rate of women in category (s) at age (x) in year (t),

${}_s D_x$ is the number of deliveries to women in category (s) at age (x) in year (t),

${}_{1.7..t} S_x$ is the number of women at age (x) in year (t) on July 1,

(s) are individual categories of marital status (single, married, divorced+widowed), education (primary school – ISCED 2, high school without the school-leaving exam – ISCED 3C, high school with the school-leaving exam – ISCED 3, university – ISCED 5A + ISCED 6) and mode of previous deliveries (only spontaneous deliveries, only caesarean sections, a combination of both modes).

For individual categories, the age-specific rates were calculated as a weighted harmonic mean of years 2009, 2010, 2019, and 2020.

When calculating the OR, the largest group is normally used as the reference category. However, in our analysis we wanted to use an approach related to the arrival of primary life events during the mother's life. This means that our reference categories capture those events which happen first in a woman's life. Therefore, the youngest mothers, unmarried women, women with primary education, and first-time mothers were selected as the reference category. The exception is the Bratislava region, which we chose to mark the differences between the capital (which constitutes the majority of this region) and the rest of Slovakia.

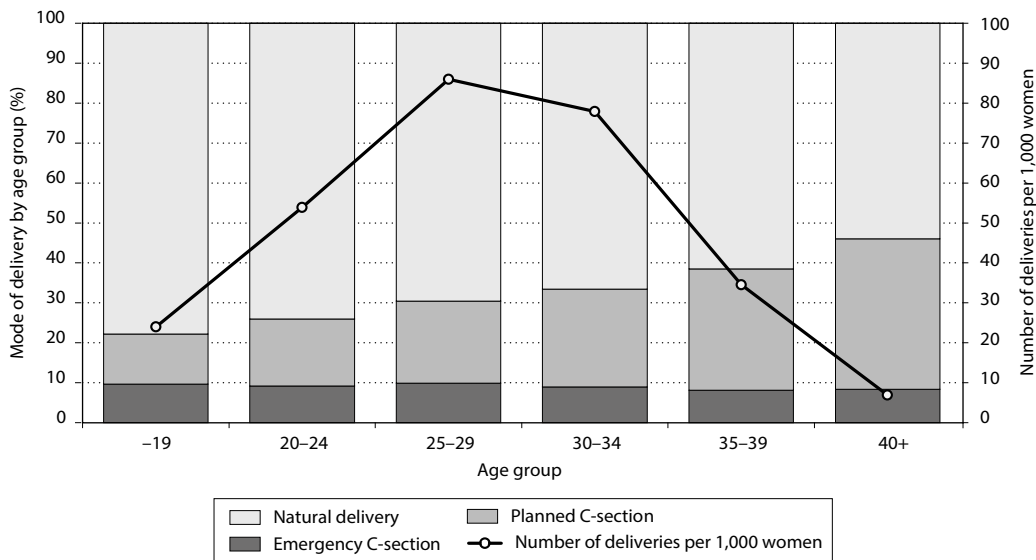
3. ANALYSIS

3.1 Mode of delivery by age

Figure 5 shows the timing of fertility with respect to maternal age in Slovakia. It also represents a benchmark for further comparisons by age and other maternal characteristics. We identify four main findings.

First, prime fertility age in Slovakia is 25–34 years.⁵⁾ Second, the share of natural deliveries decreases with age: under the age of 20, natural deliveries account for 78% of all deliveries, while for women aged 30–34 it is 67% and for women over the age of 40 it is only 54%. Women aged 30–34 are 0.6 times less likely to give birth spontaneously than women under 20, while women over 40 are 0.3 times less likely than women in the youngest cohort (Panel A, Table 2). Third, in each age category, 8–10% of deliveries occur via an emergency C-section or using another emergency method. Emergency deliveries decrease slightly with age. For example, the chances of a woman aged 30–34 or 40+ of having an emergency C-section are 0.9 times lower than those of a woman under 20, while for women aged 35–39 the odds ratio is the lowest (0.8). This is because older women are more likely to have health problems during pregnancy (Clarke – Hammarberg, 2005), and, if necessary, C-sections are planned. Fourth, the proportion

Figure 5 Mode of delivery by age in Slovakia (aggregation of the years 2009, 2010, 2019, and 2020)



Source: NCZI, 2022.

5) Ideally, an analysis focusing on the timing of births would relate the absolute number of births to the size of the exposed population (all women in the respective age categories) and analyse individual years separately. Since other demographic studies have already mapped the timing of fertility in Slovakia in detail (for example Bleha et al., 2020), our approach is simpler. We focus on the absolute number of births, on the modal maternal age, and on its shifts by individual maternal characteristics.

of planned C-sections increases with age. Among women under 20, only 13% of cases have a planned C-section, while for women aged 30–34 the share is approximately 25% of deliveries, and for women over 40 it increases to 37%. This means that women aged 30–34 are 2.3 times more likely to have a planned C-section than women under 20, and for women over 40 the likelihood is even 4.2 times greater.

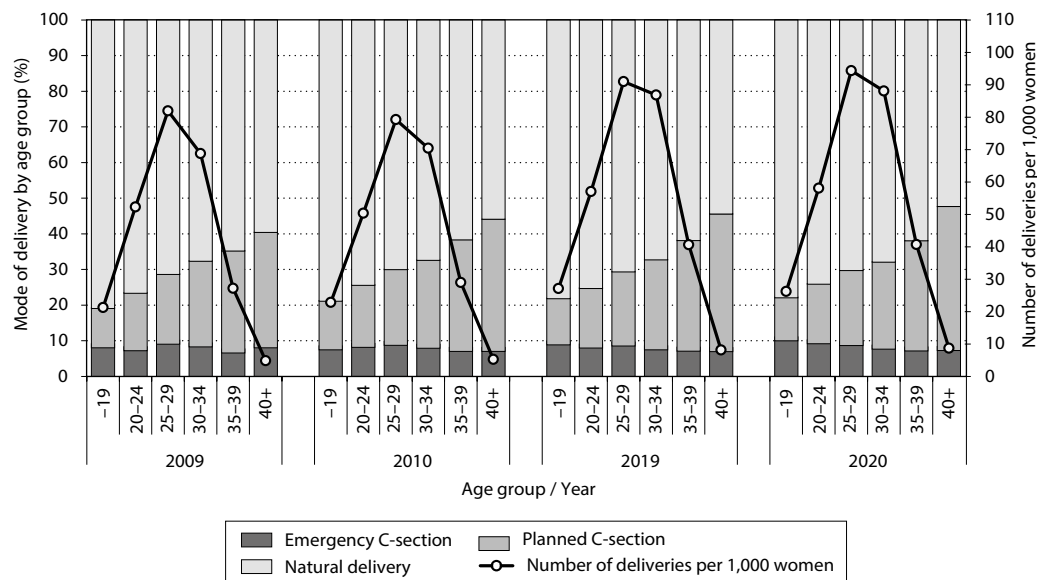
3.2 Mode of delivery over time

Figure 6 decomposes the information in Figure 5 by year of birth. The first finding is that the peak of fertility is relatively stable in the wider age category of 25–34. At the same time, the number of deliveries among women 35+ slightly increased between 2010s and 2020s. This is a consequence of the postponement of fertility and its realisation at an older age (Bleha et al., 2020).

Second, in 2019–2020 we can see a slight decrease in the proportion of spontaneous deliveries compared to the period 10 years earlier (2009–2010). This decrease is most prevalent in the youngest and oldest age groups, i.e. among women under 20 and women over 40. In 2020, women aged 40+ had a 30% lower chance (OR=0.7) of a spontaneous delivery than women of the

same age in 2009; among women under the age of 20, the odds ratio was 0.8 (Panel B, Table 2). The decrease in the likelihood of a natural delivery in these two groups is caused by different factors. Among women under the age of 25, we observe an increase in the proportion of emergency C-sections or in the use of other emergency delivery methods. More specifically, women under the age of 20 were 1.2 times more likely to have an emergency delivery in 2020 than in 2009. On the other hand, for women aged 40+, the chance of a planned section increased 1.4 times between 2009 and 2020. This trend is likely related to an increase in the proportion of primiparous mothers among older women. Obstetricians are aware of the higher risk of complications among primiparous ‘older’ women and they may thus propose a planned C-section as a precautionary measure. In fact, the fraction of primiparous women in the age bracket 40+ increased from 13% in 2009 to 23% in 2020. If we exclude women who had given birth via a C-section in the past, then the share of primiparous mothers aged 40–44 increased from 15% to 30% over the 12-year period. Nevertheless, the overall differences in the mode of delivery between the time periods 2009–2010 and 2019–2020 are relatively small. This can be explained by the fact that

Figure 6 Mode of delivery by age and year



Source: NCZI, 2022.

the use of C-sections in Slovakia has already passed its initial phase, and by 2009 it had become a fully (over) used delivery method, as shown in Figure 2.

3.3 Mode of delivery by region

Figure 7 shows the eight different regions of Slovakia. In the Bratislava region, which consists mainly of the capital city, a low share of spontaneous deliveries is observed for all ages compared to the national average (Figure 5). Correspondingly, the share of planned C-sections is rather high, as is the share of emergency C-sections or other complications during delivery. Emergency C-sections are the highest in the Bratislava region out of all eight regions in Slovakia, and they are so across all age groups, with odds ratios in the other regions reaching from 0.4 to 0.9, depending on the region and age group (Panel C, Table 2). Peak of fertility is clearly at ages 30–34.

In the neighbouring region of Trnava, the proportion of spontaneous deliveries is similar to that in Bratislava (the ORs oscillate at every age around the value 1), but the share of planned C-sections is larger, while the share of emergency deliveries is lower. The peak of fertility is during a broader age range than in Bratislava, at 25 to 34 years. The timing of fertility is similar in the neighbouring region of Trenčín. However, this region has the highest proportion of spontaneous deliveries in the entire country and in all age groups. For instance, women from Trenčín region have a 1.5 to 1.9 times greater chance of a spontaneous delivery than women from Bratislava. At the same time, the share of planned C-sections is among the lowest in Slovakia. These findings are not surprising as obstetricians in this region are famous for their stricter adherence to medical procedures that lead to spontaneous deliveries (Cupaník et al., 2016; Šomodí, 2019; Kováčiková, 2022). In general, regional differences in delivery modes are to some extent driven by workplace philosophy and by local obstetricians' willingness to adhere to evidence-based medicine (Korbel' et al., 2021).

Similarly to Trnava and Trenčín, in the south-western region of Nitra fertility also peaks between age 25 and 34. However, Nitra has the lowest rate of natural deliveries in Slovakia. Between 45% and two thirds of deliveries are spontaneous, depending on maternal age. At the same time, the share

of planned C-sections is the highest in Slovakia, across all maternal ages. For instance, a mother from Nitra region has a 1.2 to 1.6 times greater likelihood of giving birth via a planned C-section than a woman from Bratislava. One possible explanation may be that inhabitants of this region are generally in poorer health (Šprocha, 2022; Mészáros, 2008), which may be reflected in a higher proportion of high-risk pregnancies and thus more planned or emergency C-sections.

Until now, we have discussed the (south)western regions of Slovakia, where peak fertility was in the 30–34 age group in the capital and in the 25–34 age group in the other three regions. Women in Northern, Central, and Eastern Slovakia have a lower fertility age: the peak in fertility is at 25–29 years (Figure 7). Note that Eastern and Northern regions are marked with fewer economic opportunities (Korec, 2014) and higher religiosity (Majo, 2015).

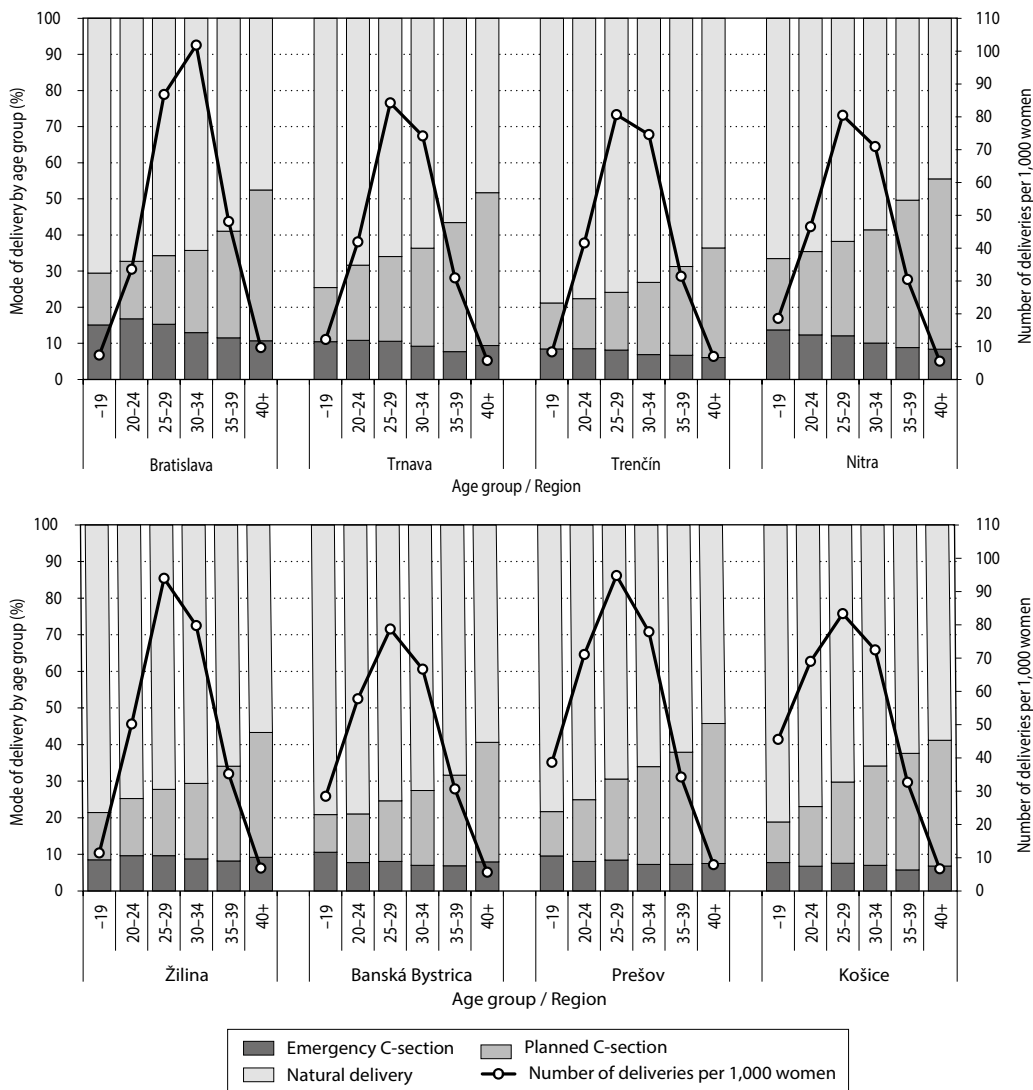
In the Northern region of Žilina, the share of natural deliveries is slightly higher than the national average (the OR with respect to Bratislava oscillates around 1.3 to 1.5). This higher share of natural deliveries is mirrored in a lower share of planned C-sections (20%). The share of emergency C-sections and other complications at delivery in Žilina region correspond to the national average. The Central region of Banská Bystrica has the highest share of natural deliveries overall (74%), with the ORs in individual age categories ranging from 1.5 to 1.8 compared to in Bratislava. At the same time, women in this region have one of the lowest probabilities of giving birth via a planned C-section or an emergency C-section.

The Prešov region has the youngest mothers: the peak of fertility is clearly located at the age of 25–29 years, and there are substantially more deliveries in the under 20 and 20–24 age groups than there are in the rest of the country. This is likely because Roma minority communities live predominantly in the Prešov and Košice regions (see below for details) and they are characterised by a very early onset of reproductive behaviour (Šprocha, 2017). In terms of type of delivery, the distribution resembles the national average, with fewer emergency C-sections or other complications at delivery (the OR at each age is only 0.4–0.7 compared to Bratislava). In the last region, Košice, the timing of fertility is similar

to that in the Prešov region, with a less pronounced mode category in the 25–29 age group. A somewhat larger proportion of natural deliveries is observed in this region, mainly in the age group up to age 25. And while planned C-sections correspond to the national average, emergency C-sections (and other complications) are least frequent at 7% overall (OR at each age are 0.4–0.6 compared to Bratislava).

Overall, it is not only the peak of fertility that is different between Western and the rest of Slovakia. The four regions of Northern, Central, and Eastern Slovakia show little correlation between age and emergency C-sections (or other complications). Spontaneous deliveries are also somewhat more represented in these regions. Despite the differences in the general health status of regional populations (Mészáros, 2008), the main explanation for the higher share of natural

Figure 7 Mode of delivery by age and region (aggregation of the years 2009, 2010, 2019, and 2020)



Source: NCZI, 2022.

deliveries in these regions seems to be the different timing of fertility compared to Western Slovakia. In the 'non-Western' regions, a significant number of women realise their fertility at the relatively young age of up to 25 years (Šprocha *et al.*, 2019), when the incidence of health complications at delivery is low. Subsequently, if more births take place at an older age, the incidence of a C-section is to a large extent pre-determined by the mode of delivery of the previous delivery, which we will focus on later.

3.4 Mode of delivery and marital status

In Figure 8, we see that both the timing of fertility and the mode of delivery in Slovakia differ substantially by marital status. While single women's fertility peaks between 20 and 24 years, the peak among married women is 25–34 years, and among divorcees and widows it is 30–39 years. This distribution is consistent with the general life cycle in terms of marital life. As for magnitude, 61% of children are born to married women, 28% to single women, and only 11% to divorcees and widows.

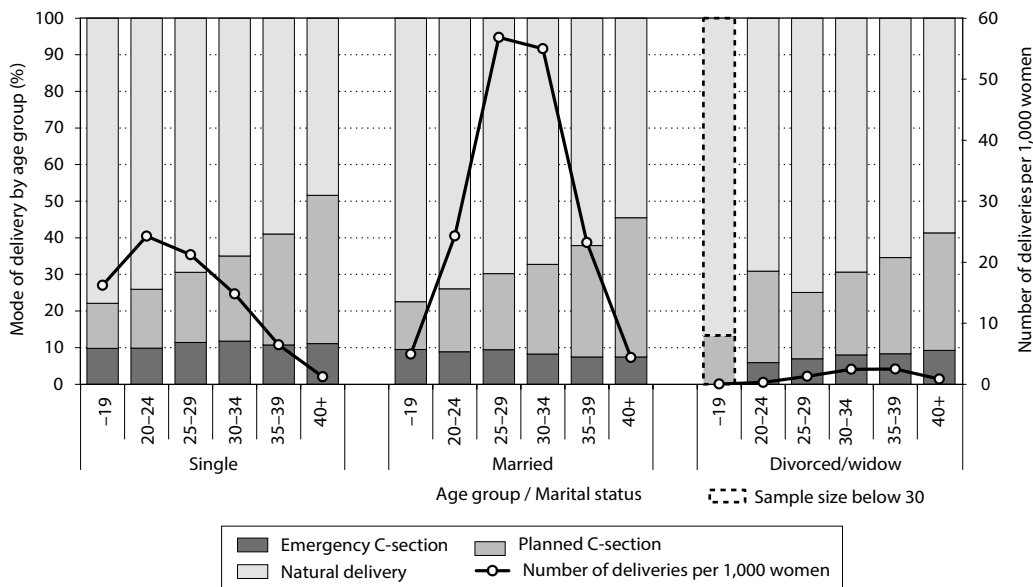
In terms of mode of delivery by age, the distribution among married women copies that of the entire population. This is not surprising, as the deliveries of married women account for almost two thirds of all deliveries. Among single and widowed/divorced women, the distribution of the mode of delivery diverges from the average, especially at ages 30+.

Single women under the age of 30 have a similar likelihood of a spontaneous delivery as the average. However, single women aged 30+ have the lowest likelihood of a natural delivery – the odds ratio is 1.1–1.3 in favour of married women and 1.2–1.5 in favour of divorced/widowed women (Panel D, Table 2). In both cases, the gradient increases with age, i.e. the older the mother, the greater the difference between single and other women in terms of having a spontaneous delivery. This lower likelihood of a natural delivery among single women is mirrored in an increased likelihood of an emergency C-section and other delivery complications (the OR for an emergency C-section among married, divorced, and widowed women aged 30+ is 0.6–0.8 compared to single women). This systematically higher proportion of emergency C-sections among single women aged 30+ may be partly explained by single motherhood, which affects a certain share

of these women (we have no data on this). In general, single mothers face difficult social, economic, and health conditions, which may result in these women receiving insufficient medical care during pregnancy and in obstetricians deciding to perform a C-section at the last moment, during delivery (Castiglioni – Schmiedeborg, 2018). This hypothesis is supported by the observation that married women have approximately a 1.1 times higher likelihood of a planned C-section than single women. Additionally, single motherhood may have a negative psychological impact on the mother during delivery, since she does not have a partner for mental support and to take care of any children she already has (Hallgreen *et al.*, 1999), which could lead to a slower progression of labour and ultimately to an emergency C-section.

Divorced and widowed women are a special group of mothers, as they have few births, especially at a young age. Conducting an analysis of this group of women under the age of 25 is not possible because of the small number of events. Divorced and widowed women over the age of 25 have the highest likelihood of a natural delivery, i.e. higher than that of single women (OR 1.2–1.5) and married women. This may be because divorced and widowed women are more likely to already have children from a previous marriage. According to our data, 63% of divorced/widowed women already have children, while among married women the figure is 60% and among single women it is 41%. Several studies have shown that women who are giving birth to a second or higher-order child are more likely to give birth spontaneously (Waldaufová – Štátná, 2022; Fait *et al.*, 2022). The likelihood of an emergency C-section among divorced/widowed women is like that of married women and lower than that of single women (OR 0.7–0.8), as noted above. The reasons may be similar to those in the case of single mothers, such as limited monitoring of health status during pregnancy and the increased nervousness of the mother during delivery due to concerns about caring for the family. Finally, divorced/widowed women aged 35+ are least likely to be scheduled for a planned C-section out of all the groups (the ORs compared to single women are 0.7–0.8). A possible explanation for this observation could be the lower likelihood of them being first-time mothers.

Figure 8 Mode of delivery by age and marital status (aggregation of the years 2009, 2010, 2019, and 2020)



Source: NCZI, 2022.

3.5 Mode of delivery by maternal education

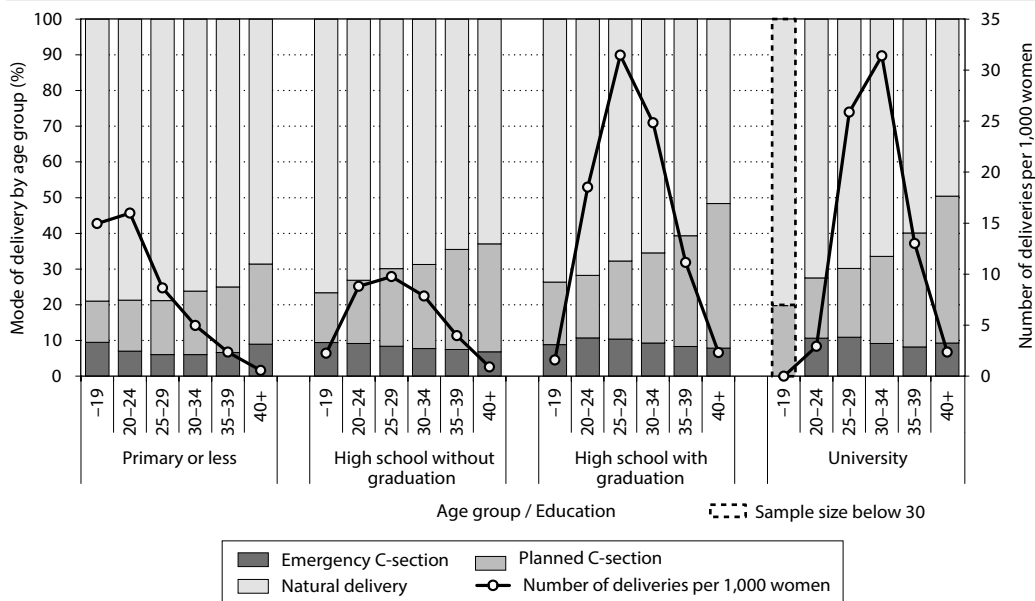
When we divide mothers into subgroups by their education, we see that women with basic education (17%) are characterised by an early timing of fertility (see Figure 9). Their modal age is between 20 and 24 years, but deliveries under the age of 19 are also very common. Women with high school education (without or with the school-leaving exam – 13% and 37%, respectively) reach peak fertility at 20–29 and 25–29 years, respectively. In general, university graduates (32% of the sample) postpone their fertility aspirations until an older age, which is also reflected in our data: their fertility peaks at 30–34 years.

In Slovakia, women with primary education have the highest likelihood of giving birth naturally, with the odds ratios in higher educational groups being 0.5–0.9 (Panel E, Table 2). Correspondingly, the least educated women are least likely to give birth via a planned C-section (the ORs in higher educational groups are 1.2–2.4). As regards emergency C-sections or other emergency methods, women with primary education are again least likely to experience these methods, but only in the 20–39 age categories (the ORs in higher educational groups are 1.1–1.9). In the oldest age group of 40+ women, a non-linear effect emerg-

es: women with primary education are more likely to have an emergency C-section than women with high school (the ORs among them are 0.7–0.9) and equally as likely as women with a university degree. These patterns can be explained by the higher prevalence of spontaneous deliveries among less-educated women in their older age because of the early onset of motherhood in this group. Women with primary education in Slovakia often give birth to their first-born child before the age of 22 (Šprocha et al., 2022), which is the age with the lowest incidence of health complications that could lead to a C-section. Natural deliveries at low parity then lead to giving birth naturally at an older age as well.

In our data, we can distinguish between women with secondary education without and with the school-leaving exam. In the past, this was a meaningful distinction. However, over time secondary schools that do not offer the school-leaving exam have been disappearing and in general, the school-leaving exam has become a new standard. This can also be seen in Figure 9, where the number of deliveries among secondary-educated women without the school-leaving exam is relatively low. In general, women without the school-leaving exam do not resemble those who

Figure 9 Mode of delivery by age and education (aggregation of the years 2009, 2010, 2019, and 2020)



Source: NCZI, 2022.

do have the school-leaving exam in terms of their delivery mode. As we shall see, women with the school-leaving exam are more like university graduates, and women without the school-leaving exam are more like women with a primary education.

As for the educational gradient in relation to natural deliveries, we see that it almost does not exist beyond primary education: women without the school-leaving exam, with the school-leaving exam, and with a university degree are roughly similarly less likely to give birth naturally compared to the least-educated women: the odds ratios are 0.5–0.7 among women aged 20+. These odds ratios are relatively stable across the age spectrum among women without the school-leaving exam and steadily decrease in magnitude with age among the most-educated women. This means that the older the woman, the bigger the difference between primary- and tertiary-educated women in terms of giving birth naturally.

For planned C-sections, we see the opposite pattern: women with higher than primary education are more likely to be scheduled for them, and this is even more

true at an older age. While the odds-ratios for women with at least the school-leaving exam are in the order of 1.2–1.6 for women aged 20–34, they increase to 2.0–2.4 for women aged 35+.⁶⁾ Especially university-educated women over the age of 35 are more than twice as likely to have a planned C-section than their peers with primary education. The reason is that among older mothers with a university degree, there is a relatively high share of first-time mothers (*Šprocha et al.*, 2016). Older first-time mothers are more likely to have health complications associated with advanced age, leading to a (planned) C-section. Among secondary-educated women without the school-leaving exam, the odds ratios are similar but somewhat lower (1.3–1.7 across the age spectrum).

Finally, in terms of emergency C-sections, the age pattern is different from natural deliveries and planned C-sections: the biggest difference seems to be among young women and the smallest among older mothers. More specifically, younger women aged 25–34 are more likely to end up with an emergency C-section if they are more educated than

6) For women with university education, the age category under 20 is not relevant because the number of events is very small.

if they have only primary education (the OR is 1.3–1.4 in the case of no school-leaving exam and 1.6–1.9 in the case of at least secondary education with a school-leaving exam). Among older women (35–39 years), these odds ratios decrease to 1.1 for secondary education without the school-leaving exam and 1.2–1.3 for at least the school-leaving exam. In the oldest age group of women 40+, there is a reversal in the educational gradient – women with secondary education have ORs for emergency C-sections of 0.7–0.9 compared to least educated women.

3.6 Current mode of delivery by previous mode of delivery

The last differentiating criterion that we consider in our analysis is the previous mode of delivery. In Figure 10, we see the expected result that the fertility timing of first-time mothers is earlier (modal age is 25–29 years) than that of mothers at a higher birth order (the peak of their fertility is at 30–34 years).

In terms of mode of delivery, the probability of a spontaneous delivery is lower among first time mothers than the national average. What is more, at ages 35+, the probability of a spontaneous delivery becomes so low that it is even lower than the probability of having a planned C-section. In general, age is a significant risk factor for a C-section in primiparous women (*Waldaufová – Štastná, 2022*). In Slovakia, we see that the lower probability of a natural delivery at ages 35+ comes in exchange for an increased risk of emergency C-sections. Clearly, as the age of first-time mothers rises, the proportion of emergency C-sections and other complications during delivery increases, too. What is more, primiparous women have the highest probability of an emergency C-section out of all women. For example, among women aged 30 to 34, the proportion of emergency C-sections is relatively high at 16%, while the national average in this age group is 9%. Even women who previously had only C-sections have a 10%–50% lower chance (OR=0.9 to 0.5) of experiencing an emergency C-section than primiparous women (Panel F, Table 2). Lastly, the share of planned C-sections among first-time mothers increases with age, but this is generally true also among other types of mothers.

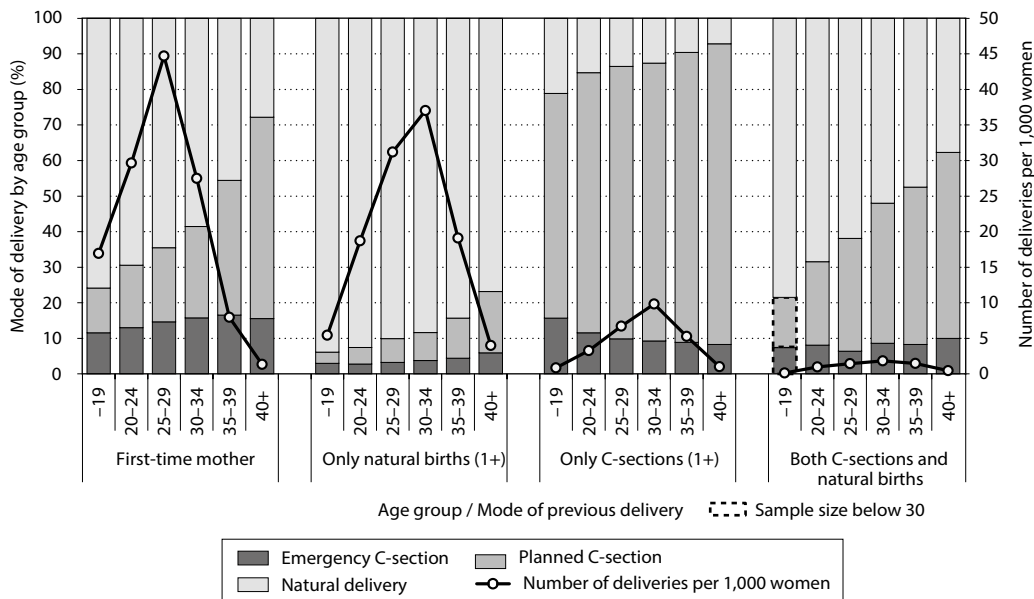
As for women who already had children, we distinguish between those who had previously given birth

only naturally, only via a C-section, and those who experienced both types of delivery. Among women who previously gave birth to all their children naturally, the proportion of spontaneous deliveries is the highest. For example, these women have a 4.9 to 6.4 times higher chance of a spontaneous delivery than primiparous women up to the age of 39, and a 9.6-times higher chance in women aged 40+. This clearly shows that the first birth greatly influences how subsequent pregnancies are delivered. Note that even if women who previously delivered naturally are most likely to deliver naturally again, they exhibit an age pattern similar to first-time mothers in terms of C-sections: the older the woman, the higher the likelihood of a planned C-section or an emergency C-section. Thus, age seems to remain a relevant risk factor even for women who have successfully undergone a natural delivery in the past. Nevertheless, the extent of the age-related risk of a C-section is substantially lower in this group than among first-time mothers.

At the other end of the spectrum, women who previously gave birth only by C-section have the lowest likelihood of a spontaneous delivery in their current pregnancy (13%). The most common mode of delivery in this group is a planned C-section, and the proportion of such deliveries further increases with age. These mothers are 10–13 times more likely to have a planned C-section than primiparous women under the age of 35. This is additional proof of how the previous mode of delivery affects the current one. Interestingly, the likelihood of an emergency C-section decreases with age among women who previously had a C-section. This means that obstetricians are cautious, and that they prefer to avoid delivery complications by planning a C-section in advance as a precautionary measure.

Finally, there are women who previously gave birth both by C-section and naturally (they have at least two children). Among them, the proportion of spontaneous deliveries is on average lower (55%) than among first-time mothers (64%) or among women who have only had natural deliveries (89%), but not as low as among women who have only given birth by C-section (13%). There is a clear age gradient – the older the mother, the lower the chance of a natural delivery. However, while at ages up to 35 years, these women are slightly less likely to give

Figure 10 Current mode of delivery by age and previous mode of delivery (aggregation of years 2009, 2010, 2019, and 2020)



Source: NCZI, 2022.

birth naturally than first-time mothers (likely due to their previous C-section), after that this relationship reverses and at ages 35+ they have a higher chance of a spontaneous delivery than first-time mothers (OR 1.1–1.6). Finally, among women who in the past gave birth both by C-section and naturally, the relationship between age and the likelihood of an emergency C-section or other complications is not clearly visible. Conversely, a positive relationship is visible between age and the likelihood of a planned C-section.

4. CONCLUSION

The aim of this study was to document the associations between selected demographic characteristics of mothers and the mode of delivery of their child (natural delivery, planned C-section, emergency C-section or other emergency method).

We confirmed the results of previous studies that found that, in general, the share of natural deliveries decreases with age, while the probability of a planned C-section increases. The reason is that the risks associated with pregnancy are more common in older

women, which incentivises obstetricians to plan a C-section. As the modal age of mothers continues to increase in most European countries, it is very likely that it will lead to an increase in C-sections.

In terms of regional differences, we found that the Bratislava region, which consists mainly of the capital city, differs from the rest of Slovakia in that it has a smaller share of spontaneous deliveries and planned C-sections. Conversely, women from this region have a greater chance of an emergency C-section. The Nitra region diverges from the national average in that it has a lower share of natural deliveries and a higher share of planned and emergency C-sections. These differences may be driven by the generally poorer health status in Nitra and by different preferences regarding the mode of delivery either by the medical staff or by mothers. Conversely, the Trenčín region differs significantly from the Bratislava and Nitra regions in that it has the (second) highest share of spontaneous deliveries in Slovakia. The reason may be the stricter adherence to the medical procedures that support natural delivery that this region is famous for. Women in other regions in Slovakia have a lower age at first childbirth, which is reflected in a lower incidence of C-sections.

In terms of marital status, single women have a lower likelihood of a natural delivery and a greater likelihood of an emergency C-section than women with any other marital status (married, divorced, widowed). One possible reason for this phenomenon could be that the 'single' marital status category includes also single mothers. Single mothers face economic hardships and have less psychological support, which could lead to problems during delivery. The fact that divorced and widowed women have a higher chance of a natural delivery than unmarried women is likely due to previous motherhood, which has a substantial impact on the subsequent mode of delivery.

As for education, it seems that the earlier start of reproductive life among women with primary education leads to a higher likelihood of spontaneous deliveries even at an older age. In general, the share of natural deliveries is larger among primary education women than among secondary- or tertiary-educated women, regardless of their age. Interestingly, there is

a non-linear association between education and planned C-sections: while the share of C-sections is the lowest among least educated women, this share is slightly higher among women with secondary education than among university graduates (especially at age 25–34 years).

Importantly, we find evidence that the mode of delivery at first birth largely determines the way in which a woman gives birth in future. Our findings may be useful for obstetricians and help them identify women who might be more likely to give birth via a C-section. C-sections are more expensive than natural deliveries and are thus a greater financial burden on the health-care system. C-sections may also lead to health complications for both the woman and the child, depending on the circumstances. At the same time, our findings can be helpful for developing helpful population policies. In a time of intensive population ageing in Slovakia, every single additional child is a positive contribution to the reversal of this negative trend.

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PŘÍLOHA / APPENDIX

Table 1 Absolute number of deliveries according to mode of delivery and selected maternal characteristics

Panel A																		
Mode of delivery →	Emergency C-sections + other emergency methods						Planned C-sections						Natural births					
Age →	-19	20-24	25-29	30-34	35-39	40+	-19	20-24	25-29	30-34	35-39	40+	-19	20-24	25-29	30-34	35-39	40+
	1,417	3,448	6,799	6,007	2,327	464	1,849	6,299	14,201	16,524	8,715	2,090	11,467	27,810	47,979	44,836	17,624	2,993
Panel B																		
Mode of delivery →	Emergency C-sections + other emergency methods						Planned C-sections						Natural births					
Age → Year ↓	-19	20-24	25-29	30-34	35-39	40+	-19	20-24	25-29	30-34	35-39	40+	-19	20-24	25-29	30-34	35-39	40+
2009	355	907	1,848	1,486	415	80	437	1,757	3,577	3,787	1,537	281	3,104	8,206	12,837	10,553	3,450	513
2010	344	946	1,721	1,471	490	77	551	1,787	3,699	4,009	1,865	347	3,114	7,496	12,064	10,820	3,649	520
2019	346	752	1,609	1,514	709	146	454	1,385	3,450	4,449	2,673	692	2,679	6,134	11,596	11,711	5,281	969
2020	372	843	1,621	1,536	713	161	407	1,370	3,475	4,279	2,640	770	2,570	5,974	11,482	11,752	5,244	991
Panel C																		
Mode of delivery →	Emergency C-sections + other emergency methods						Planned C-sections						Natural births					
Age → Region ↓	-19	20-24	25-29	30-34	35-39	40+	-19	20-24	25-29	30-34	35-39	40+	-19	20-24	25-29	30-34	35-39	40+
Bratislava region	63	371	1,247	1,590	634	109	60	353	1,557	2,793	1,630	424	295	1,488	5,369	7,878	3,251	483
Tŕnava region	75	312	737	621	211	47	107	602	1,630	1,839	976	211	534	1,972	4,594	4,306	1,546	241
Trenčín region	45	261	564	466	184	37	68	426	1,110	1,361	676	185	421	2,382	5,262	4,963	1,892	388
Nitra region	184	486	956	762	281	48	264	908	2,073	2,362	1,293	269	891	2,545	4,897	4,420	1,598	254
Žilina region	82	458	949	759	299	63	124	737	1,789	1,788	947	233	755	3,543	7,123	6,111	2,406	387
Banská Bystrica region	219	373	589	465	203	43	214	636	1,214	1,356	730	176	1,641	3,786	5,517	4,810	2,014	320
Prešov region	407	680	1,010	700	291	66	513	1,422	2,643	2,565	1,229	335	3,328	6,331	8,299	6,354	2,491	475
Košice region	340	502	738	629	222	51	488	1,204	2,153	2,435	1,224	256	3,566	5,696	6,830	5,901	2,399	439
Panel D																		
Mode of delivery →	Emergency C-sections + other emergency methods						Planned C-sections						Natural births					
Age → Marital status ↓	-19	20-24	25-29	30-34	35-39	40+	-19	20-24	25-29	30-34	35-39	40+	-19	20-24	25-29	30-34	35-39	40+
Single	979	1,669	1,947	1,509	575	110	1,226	2,715	3,257	2,978	1,629	402	7,763	12,525	11,826	8,308	3,167	480
Married	287	1,501	4,301	3,917	1,441	263	396	2,922	9,489	11,659	5,864	1,339	2,343	12,522	31,814	31,953	11,986	1,920
Divorced or widowed	0	12	73	171	171	64	2	51	191	480	539	223	13	141	789	1,475	1,342	407
Panel E																		
Mode of delivery →	Emergency C-sections + other emergency methods						Planned C-sections						Natural births					
Age → Education ↓	-19	20-24	25-29	30-34	35-39	40+	-19	20-24	25-29	30-34	35-39	40+	-19	20-24	25-29	30-34	35-39	40+
Primary or less	874	784	420	259	131	41	1,061	1,592	1,050	763	360	103	7,254	8,765	5,472	3,266	1,475	314
High school without grad.	131	561	658	524	248	49	193	1,088	1,702	1,598	925	217	1,061	4,484	5,475	4,666	2,130	452
High school with grad.	86	1,386	2,625	1,993	767	146	171	2,259	5,511	5,423	2,867	751	717	9,268	17,107	14,057	5,610	959
University	0	217	2,267	2,489	884	176	1	344	3,993	6,623	3,447	777	4	1,479	14,495	18,025	6,466	937
Panel F																		
Mode of delivery →	Emergency C-sections + other emergency methods						Planned C-sections						Natural births					
Age → Previous mode of delivery ↓	-19	20-24	25-29	30-34	35-39	40+	-19	20-24	25-29	30-34	35-39	40+	-19	20-24	25-29	30-34	35-39	40+
First-time mother	1,201	2,688	5,243	3,744	1,095	166	1,314	3,625	7,477	6,108	2,503	605	7,900	14,361	23,130	13,916	3,012	297
Only natural deliveries (1+)	99	359	811	1,206	699	189	105	607	1,679	2,523	1,782	551	3,132	12,078	22,544	28,275	13,364	2,455
Only C-sections (1+)	83	262	530	785	390	66	335	1,661	4,134	6,637	3,575	675	112	347	728	1,071	420	57
Both C-sections and nat.del.	6	55	74	136	102	37	11	160	367	621	543	194	62	466	717	820	583	140

Source: NCZI, 2022; authors' calculations.

Table 2 Odds ratios for mode of delivery by age and other maternal characteristics

Panel A																		
Mode of delivery →	Emergency C-sections + other emergency methods						Planned C-sections						Natural deliveries					
Age →	-19 (ref.)	20-24	25-29	30-34	35-39	40+	-19 (ref.)	20-24	25-29	30-34	35-39	40+	-19 (ref.)	20-24	25-29	30-34	35-39	40+
	1	0.9	1.0	0.9	0.8	0.9	1	1.4	1.8	2.3	3.0	4.2	1	0.8	0.7	0.6	0.5	0.3
Panel B																		
Mode of delivery →	Emergency C-sections + other emergency methods						Planned C-sections						Natural deliveries					
Age → Year ↓	-19	20-24	25-29	30-34	35-39	40+	-19	20-24	25-29	30-34	35-39	40+	-19	20-24	25-29	30-34	35-39	40+
2009 (ref.)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2010	0.9	1.1	1.0	1.0	1.1	0.9	1.3	1.1	1.1	1.0	1.1	1.2	0.9	0.9	0.9	1.0	0.9	0.9
2019	1.1	1.1	0.9	0.9	1.1	0.9	1.2	1.0	1.1	1.1	1.1	1.3	0.9	0.9	1.0	1.0	0.9	0.8
2020	1.2	1.3	1.0	0.9	1.1	0.9	1.1	1.0	1.1	1.0	1.1	1.4	0.8	0.9	1.0	1.0	0.9	0.7
Panel C																		
Mode of delivery →	Emergency C-sections + other emergency methods						Planned C-sections						Natural deliveries					
Age → Region ↓	-19	20-24	25-29	30-34	35-39	40+	-19	20-24	25-29	30-34	35-39	40+	-19	20-24	25-29	30-34	35-39	40+
Bratislava region (ref.)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Trnava region	0.7	0.6	0.7	0.7	0.6	0.9	1.0	1.4	1.3	1.3	1.3	1.0	1.2	1.0	1.0	1.0	0.9	1.0
Trenčín region	0.5	0.5	0.5	0.5	0.6	0.5	0.9	0.8	0.8	0.8	0.8	0.6	1.6	1.7	1.6	1.5	1.5	1.9
Nitra region	0.9	0.7	0.8	0.8	0.7	0.8	1.5	1.6	1.5	1.5	1.6	1.2	0.8	0.9	0.8	0.8	0.7	0.9
Žilina region	0.5	0.5	0.6	0.6	0.7	0.8	0.9	1.0	0.9	0.9	0.8	0.7	1.5	1.4	1.4	1.3	1.3	1.4
Banská Bystrica region	0.7	0.4	0.5	0.5	0.6	0.7	0.7	0.8	0.8	0.9	0.8	0.7	1.6	1.8	1.6	1.5	1.5	1.6
Prešov region	0.6	0.4	0.5	0.5	0.6	0.7	0.8	1.1	1.2	1.2	1.1	0.9	1.5	1.5	1.2	1.1	1.1	1.3
Košice region	0.5	0.4	0.5	0.5	0.5	0.6	0.7	1.0	1.2	1.3	1.1	0.7	1.8	1.6	1.2	1.1	1.2	1.6
Panel D																		
Mode of delivery →	Emergency C-sections + other emergency methods						Planned C-sections						Natural births					
Age → Marital status ↓	-19	20-24	25-29	30-34	35-39	40+	-19	20-24	25-29	30-34	35-39	40+	-19	20-24	25-29	30-34	35-39	40+
Single (ref.)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Married	1.0	0.9	0.8	0.7	0.7	0.6	1.1	1.1	1.1	1.1	1.0	0.9	1.0	1.0	1.0	1.1	1.1	1.3
Divorced or widowed	0.0	0.6	0.6	0.7	0.8	0.8	1.1	1.7	0.9	1.0	0.8	0.7	1.8	0.8	1.3	1.2	1.3	1.5
Panel E																		
Mode of delivery →	Emergency C-sections + other emergency methods						Planned C-sections						Natural deliveries					
Age → Education ↓	-19	20-24	25-29	30-34	35-39	40+	-19	20-24	25-29	30-34	35-39	40+	-19	20-24	25-29	30-34	35-39	40+
Primary or less (ref.)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
High school without grad.	1.0	1.3	1.4	1.3	1.1	0.7	1.2	1.3	1.6	1.4	1.7	1.5	0.9	0.7	0.6	0.7	0.6	0.8
High school with grad.	0.9	1.6	1.8	1.6	1.3	0.9	1.6	1.3	1.6	1.6	2.0	2.3	0.7	0.7	0.6	0.6	0.5	0.5
University	0.0	1.6	1.9	1.6	1.2	1.0	1.9	1.2	1.3	1.5	2.1	2.4	1.1	0.7	0.6	0.6	0.5	0.5
Panel F																		
Mode of delivery →	Emergency C-sections + other emergency methods						Planned C-sections						Natural deliveries					
Age → Previous mode of delivery ↓	-19	20-24	25-29	30-34	35-39	40+	-19	20-24	25-29	30-34	35-39	40+	-19	20-24	25-29	30-34	35-39	40+
First-time mother (ref.)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Only natural deliveries (1+)	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.3	0.2	0.2	0.2	4.9	5.5	5.0	5.4	6.4	8.6
Only C-sections (1+)	1.4	0.9	0.6	0.5	0.5	0.5	11.9	12.8	12.5	10.3	7.2	4.2	0.1	0.1	0.1	0.1	0.1	0.2
Both C-sections and nat.del.	0.6	0.6	0.4	0.5	0.5	0.6	1.1	1.4	1.8	1.9	1.3	0.8	1.2	1.0	0.9	0.8	1.1	1.6

Notes: In Panel A, the ORs are defined within each row. In Panels B-F, the ORs are defined within each column.

Source: NCZI, 2022; authors' calculations.