INFLUENCE OF MATERNAL SMOKING DURING PREGNANCY ON BIRTH OUTCOMES

Jana Diabelková[1], Kvetoslava Rimárová[1], Peter Urdzík[2], Erik Dorko[1], Andrea Houžvičková[1], Štefánia Andraščíková[3], Lívia Kaňuková[1], Dana Kluková[4], Erik Drabiščák[1], Nika Konrádyová[1], Gabriela Škrečková[5]

[1]Department of Public Health and Hygiene, Faculty of Medicine, Pavol Jozef Šafárik University in Košice, Košice, Slovak Republic
[2]Department of Gynaecology and Obstetrics, Faculty of Medicine, Pavol Jozef Šafárik University and Louis Pasteur University Hospital in Košice, Košice, Slovak Republic
[3]Department of Midwifery, Faculty of Health Care, University of Prešov, Prešov, Slovak Republic
[4]Polyclinic ProCare, Košice, Slovak Republic
[5]Department of Physiotherapy, Faculty of Health Care, University of Prešov, Prešov, Slovak Republic

SUMMARY

Objectives: Smoking during pregnancy is causally associated with reduced birth weight and is strongly related to preterm birth. This study analyses the differences in birth outcomes between non-smokers and women who continued to smoke during pregnancy.

Methods: We conducted a study of 1,359 mothers who gave birth in 2017–2019 at the Department of Gynaecology and Obstetrics of Louis Pasteur University Hospital in Košice. Data on mothers and newborn infants have been reported from the birth book and from the reports on mothers at childbirth. For low birth weight we considered the weight of a newborn being less than 2,500 g and as for premature birth we referred to childbirth before pregnancy week 37. Two groups of mothers were classified according to the smoking habit during pregnancy and statistically processed in IBM SPSS Statistics 23.0.

Results: Infants born by women who smoked during pregnancy had the lower birth weight (2,769.0 grams on average) compared to non-smokers (3,224.1 grams) ($p < 0.001$). The differences in prevalence of premature birth have not been confirmed as statistically significant. Women who continued smoking during pregnancy were significantly more likely to be very young (OR = 5.9; 95% CI: 3.9–8.9; $p < 0.001$), unmarried (OR = 9.3; 95% CI: 6.1–14.0; $p < 0.001$), of lower level of education (OR = 39.6; 95% CI: 22.6–69.5; $p < 0.001$), and more likely to consume alcohol (OR = 6.6; 95% CI: 5.8–7.5; $p < 0.01$), and drugs (OR = 6.6; 95% CI: 5.8–7.5; $p < 0.01$) during pregnancy. When pregnant, they were most likely to see a doctor for the first time after the first trimester (OR = 0.1; 95% CI: 0.1–0.2; $p < 0.001$) and were more likely to see a doctor less than 8 times (OR = 6.1; 95% CI: 4.2–8.8; $p < 0.001$) during pregnancy.

Conclusion: Tobacco prevention and cessation campaigns should focus on improving pregnancy outcomes in the future.

Key words: birth outcomes, birth weight, preterm birth, risk factors, smoking

Address for correspondence: K. Rimárová, Department of Public Health and Hygiene, Faculty of Medicine, P. J. Šafárik University in Košice, Šrobárova 2, 041 80, Košice, Slovak Republic. E-mail: kvetoslava.rimarova@upjs.sk

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INTRODUCTION

More than 6 million people per year die from tobacco use across the globe. Globally, 942 million men and 175 million women aged 15 or older are current smokers. Nearly three quarters of male daily smokers live in countries with a medium or high human development index, whereas half of female daily smokers live in very high human development index countries (1).

In Central and Eastern Europe, especially in the former communist countries, smoking prevalence increased in the 1990s, particularly among women (2). Even though fewer women smoke in Slovakia on average than in very high human development index countries, there are still more than 295,400 women who smoke cigarettes each day, making it an ongoing and dire public health threat. Even though fewer women die from tobacco in Slovakia on average than in very high human development index countries, tobacco still kills 39 women every week, necessitating action from policymakers (1).

Smoking tobacco causes exposure to a lethal mixture of more than 7,000 toxic chemicals, including at least 70 known carcinogens that can damage nearly every organ system in the human body (1). Tobacco use is one of the most important preventable causes of premature death in the world. Concentrations of nicotine and cotinine, the major nicotine metabolite, in the foetal blood are highly correlated with those of their smoking mothers, some have even reported higher levels in the foetal blood compared to their mothers (3, 4). Smoking cigarettes has a tremendous negative impact on the genetic and cellular level of not only the mother but of the foetus as well (5). Consequently, cigarette smoke may well interfere with both the intrauterine environment as well as the foetal endocrine system; thus, affecting foetal growth and development. Smoking during pregnancy is causally associated with reduced birth weight, and existing evidence suggests that

smoking is strongly related to preterm birth, placental abruption, stillbirth, ectopic pregnancies, and placenta previa (6, 7). Some studies suggest a link between maternal smoking and cleft lip. Studies also suggest a relationship between tobacco and miscarriage. Carbon monoxide in tobacco smoke can keep the developing baby from getting enough oxygen. Tobacco smoke also contains other chemicals that can harm unborn babies (8, 9). Maternal smoking during pregnancy has been linked to decrease in the size of the foetal brain as well as to diminishing general reasoning, visual-motor integration, verbal competence, and language comprehension in the offspring (5).

Maternal smoking during pregnancy is also linked to increased child mortality and offspring health problems including delayed growth, asthma, behavioural, cardiovascular, and neurodevelopmental problems (10, 11). Efforts to reduce smoking during pregnancy are therefore critically important.

The aim of this study was to investigate the prevalence and possible predictors for smoking during pregnancy and to compare neonatal outcomes between a group of smokers and non-smokers.

MATERIALS AND METHODS

Setting and Subjects

The research of gynaecological and neonatal indicators was carried out in the years 2017–2019 in Eastern Slovakia. Databases included 1,359 randomly selected majority non-Roma mothers and their newborn's parameters. The collection of data took place in the context of the daily work and the academic and research activity of the Faculty of Medicine of Pavol Jozef Šafárik University and the Department of Gynaecology and Obstetrics of the Louis Pasteur University Hospital in Košice. This hospital is the East Slovakian centre for low birth weight and premature birth and this is the reason why there is also a higher concentration of mothers at risk.

Measurements

Basic medical records on mothers (socioeconomic anamnesis, behavioural factors, health condition, and course of pregnancy) and basic data on newborns (birth weight, term of birth) were collected from the medical record documentation. The data have been reported from the birth book and from the reports on mothers at childbirth. From the records regarding mothers, we were primarily interested in the age, education, marital status, visits to antenatal care, but also risk behaviour such as smoking, alcohol and drug use. The age of mothers at the time of delivery was calculated on the basis of the date of birth indicated in the reports on mothers at childbirth and delivery date. When observing the use of tobacco, in our file we considered for a smoker a woman smoking at least one cigarette a day during the pregnancy. For alcohol consumer we considered every woman who consumed 15 g of alcohol a day. This corresponds to 0.5 litres of 12 degree beer or 0.3 l of wine or 0.5 dl of spirits. We obtained all this information, including information on illicit drug use, from the reports on mothers at childbirth, which were completed in a personal interview. Women with multiple pregnancy who are at higher risk of preterm birth and whose newborn babies are also more likely to be born with a lower birth weight were excluded from the study. Mothers of newborn babies with birth weight not reaching 1,500 g (very low birth weight) were also excluded from the study. Low birth weight has been defined as a birth weight of less than 2,500 grams.

Statistical Analysis

Data on newborns were included in the database created in IBM SPSS Statistics 23.0. Primary characteristics (obtained directly from the reports on mothers at childbirth) and transformed characteristics (recategorized) were used to process the data. The analysis contains significant findings linked to the obtained empirical data when the vast majority of the findings have been statistically significant. Two groups of mothers were classified according to the smoking habit during pregnancy (smokers and non-smokers) and statistically processed in IBM SPSS Statistics 23.0. In order to compare the frequency of individual variations of properties in the examined groups and subgroups, the χ^2 independence test was used. Continuous variables were processed by comparing the arithmetic mean by Student's t-test. To compare the frequency of social and anamnestic factors, the odds ratio (OR) was used as the ratio of a certain factor present in the smokers and non-smokers populations.

RESULTS

Table 1 presents descriptive statistics on the sample of pregnant women, overall and also by smoking status: smokers and non-smokers. The final data set consisted of 1,359 singleton births and their mothers. Of all mothers included in the analyses, 210 (15.5%) reported that they had smoked during pregnancy. Average age was 28.3 years. Smokers were more often 18 years old or younger (24.3%, $p<0.001$). More than 27% of our subjects attained less than high school level of education. Our survey confirmed the lower education level of women who smoked during pregnancy ($p<0.001$), having only primary education (89.6%). Alcohol consumption during pregnancy was relatively low (0.4%). Only 5 mothers (0.4%) admitted the use of drugs during pregnancy, but all of them were smokers. Among 54.7% of smokers, the pregnancy was diagnosed by gynaecologist only after the first trimester. Regarding non-smoker women group, it was 13.3% of women ($p<0.001$) who visited the doctor with their pregnancy for the first time only after the first trimester. Most of the mothers visited the antenatal care eight times, so we divided the set into two groups – the mothers who visited the doctor less than 8 times and the group of mothers who visited the doctor 8 times and more. Then we compared the groups of smokers and non-smokers. Up to 79.7% of smokers visited the doctor during pregnancy less than 8 times, while 39.2% of non-smokers visited the antenatal care less than 8 times ($p<0.001$) (Table 1).

Women who continued smoking during pregnancy were significantly more likely to be very young (OR = 5.9; 95% CI: 3.9–8.9; $p<0.001$), unmarried (OR = 9.3; 95% CI: 6.1–14.0; $p<0.001$), of lower level of education (OR = 39.6; 95% CI: 22.6–69.5; $p<0.001$), and more likely to consume alcohol (OR = 6.6; 95% CI: 5.8–7.5; $p<0.01$), and drugs (OR = 6.6; 95% CI: 5.8–7.5; $p<0.01$), during pregnancy. When pregnant, they were most likely to see a doctor for the first time after the first trimester (OR = 0.1; 95% CI: 0.1–0.2; $p<0.001$) and were more likely to see a doctor

Table 1. *Characteristics of women by pregnancy smoking status (N = 1,359)*

Variables		All n (%)	Non-smokers n (%)	Smokers n (%)	p-value
Maternal age group	≤ 18	110 (8.1)	59 (5.1)	51 (24.3)	**< 0.001**
	19–34	1,028 (75.6)	889 (77.4)	139 (66.2)	
	> 34	221 (16.3)	201 (17.5)	20 (9.5)	
Marital status	Single	412 (37.4)	287 (30.3)	125 (80.1)	**< 0.001**
	Married	678 (61.5)	648 (68.5)	30 (19.2)	
	Divorced/widowed	12 (1.1)	11 (1.2)	1 (0.6)	
Education	Primary	293 (27.5)	164 (17.8)	129 (89.6)	**< 0.001**
	High school	385 (36.2)	372 (40.4)	13 (9.0)	
	University	386 (36.3)	384 (41.7)	2 (1.4)	
Alcohol consumption during pregnancy	Yes	6 (0.4)	0 (0.0)	6 (2.9)	**< 0.001**
	No	1,353 (99.6)	1,149 (100.0)	204 (97.1)	
Drug consumption during pregnancy	Yes	5 (0.4)	0 (0.0)	5 (2.4)	**< 0.001**
	No	1,354 (99.6)	1,149 (100.0)	205 (97.6)	
First visit of gynaecologist	1st trimester	1,077 (80.7)	990 (86.7)	87 (45.3)	**< 0.001**
	Later	257 (19.3)	152 (13.3)	105 (54.7)	
Visits to prenatal counselling	< 8	601 (45.1)	448 (39.2)	153 (79.7)	**< 0.001**
	≥ 8	733 (54.9)	694 (60.8)	39 (20.3)	

Numbers in bold indicate statistically significant values.

Table 2. *Factors associated with smoking among pregnant women*

Variables	OR	95% CI	p-value
Age < 18 years/other	5.9	3.9–8.9	**< 0.001**
Non-married/married	9.3	6.1–14.0	**< 0.001**
Education basic/more	39.6	22.6–69.5	**< 0.001**
Alcohol consumption during pregnancy Y/N	6.6	5.8–7.5	**< 0.001**
Drug consumption during pregnancy Y/N	6.6	5.8–7.5	**< 0.001**
First visit of gynaecologist 1st trimester/later	0.1	0.1–0.2	**< 0.001**
Visits to prenatal counselling < 8/more	6.1	4.2–8.8	**< 0.001**

Numbers in bold indicate statistically significant values.

less than 8 times (OR = 6.1; 95% CI: 4.2–8.8; p < 0.001) during pregnancy (Table 2).

The average birth weight in our sample was 3,153.7 grams. Infants born by women who smoked during pregnancy had the lower birth weight (2,769.0 grams on average) compared to non-smokers (3,224.1 grams) (Table 3).

Of all children, 11.3% were defined as low birth weight (< 2,500 g) and 8.5% were born preterm. Smoking during pregnancy is one of the most modifiable risk factor for poor birth outcomes. There were significant differences in birth outcomes of the newborns by mother's smoking status. The newborns of women who smoke during pregnancy were significantly more likely to have a low birth weight compared to non-smokers. The risk of preterm birth was not confirmed in boys or girls born to smoking mothers (Table 3).

The sex differences in birth weight were statistically significant, so we decided to compare selected neonatal indicators in the group of boys and girls. Also boys and girls born by women who smoked during pregnancy had the lower birth weight compared to non-smokers and were more likely to have low birth weight. The risk of preterm birth was not confirmed in boys or girls born to smoking mothers (Table 3).

DISCUSSION

Smoking is one of the major modifiable risk factors, responsible for the premature death and considerable economic costs to health systems. Smoking is of special concern to pregnant women, as this behaviour affects not only the mother's health, but also the health of the foetus. Pregnancy represents a major life event that requires a mother to assume a healthy lifestyle to increase the probability of healthy development of the foetus and long-term well-being of her child. Despite the importance of good health

Table 3. *Birth outcomes in smokers' and non-smokers' infants*

Variables		All n (%)	Non-smokers n (%)	Smokers n (%)	p-value
All newborns	Birth weight (g), mean (SD)	3,153.7 (546.3)	3,224.1 (525.1)	2,769.0 (498.1)	**<0.001**
	Low birth weight (<2,500 g)	154 (11.3)	93 (8.1)	61 (29.0)	**<0.001**
	Preterm birth (<37 weeks)	116 (8.5)	91 (7.9)	25 (11.9)	0.057
Girls	Birth weight (g), mean (SD)	3,103.1 (531.5)	3,162.8 (520.0)	2,749.1 (455.4)	**<0.001**
	Low birth weight (<2,500 g)	83 (12.5)	55 (9.7)	28 (29.2)	**<0.001**
	Preterm birth (<37 weeks)	52 (7.8)	43 (7.6)	9 (9.4)	0.543
Boys	Birth weight (g), mean (SD)	3,202.3 (556.4)	3,284.1 (523.7)	2,785.8 (532.8)	**<0.001**
	Low birth weight (<2,500 g)	71 (10.2)	38 (6.6)	33 (28.9)	**<0.001**
	Preterm birth (<37 weeks)	64 (9.2)	48 (8.3)	16 (14.0)	0.052

Numbers in bold indicate statistically significant values.

for herself and her children, smoking during pregnancy remains a global problem, especially in Europe (12).

The five countries with the highest estimated prevalence of smoking during pregnancy are Ireland (38.4%), Uruguay (29.7%), Bulgaria (29.4%), Spain (26.0%), and Denmark (25.2%). The five countries with the lowest prevalence of smoking during pregnancy are Tanzania (0.2%), Burundi (0.3%), St. Lucia (0.3%), Sri Lanka (0.3%), and Malawi (0. 3%). The global prevalence of smoking during pregnancy is estimated at 1.7%. The highest prevalence of smoking during pregnancy is in the European Region (8.1%), and the lowest prevalence of smoking during pregnancy is in the African Region (0.8%) (13).

Borland et al. (14) has estimated that 10% to 27% of pregnant women in the European Union continue smoking during pregnancy. Our data reveal a high prevalence of pregnant women who smoked that endanger not only themselves but also their children's health. Of all mothers included in our analyses, 210 (15.5%) reported that they had smoked during pregnancy.

The prevalence of preterm birth in the groups of smokers and non-smokers was not significantly different and surprising for the authors.

The association between continuing smoking in pregnancy and low birth weight was highlighted by our study. The average birth weight in our sample was 3,153.7 grams. Infants born by women who smoked during pregnancy had the lower birth weight (2,769.0 grams on average) compared to non-smokers (3,224.1 grams). In the European Longitudinal Study of the Pregnancy and Childhood (ELSPAC), which included 4,530 women from the Czech Republic, children of mothers who were moderately heavy/heavy smokers during pregnancy had on average 245 g lower birth weight than non-smokers (15). In our study, the weight of smokers' children was on average 455 g lower.

Intrauterine hypoxia (i.e., lack of oxygen that enters the body tissues in the uterus) is the most important mechanism for slowing foetal growth in smokers. The hypoxia could occur as a result of factors associated with smoking such as increased levels of carbon monoxide in the blood, reduction of blood flow, and inhibition of respiratory enzymes (16–18).

These results also correspond to the results of Smedberg et al. (12), women who live in Eastern Europe (OR = 2.07; 95% CI: 1.12–3.83) and have less than high school as highest education level (OR = 2.76; 95% CI: 1.32–5.78) were more likely to smoke during pregnancy. Women who are 20 years of age or younger (OR = 0.12; 95% CI: 0.02–0.90) are less likely to smoke more than 10 cigarettes per day.

In our study, women who continued smoking during pregnancy were significantly more likely to be very young (OR = 5.9; 95% CI: 3.9–8.9; $p < 0.001$). There were only 20 smokers (9.5%) in the group of women older than 34, compared to 51 (24.3%) in the group of women under 18 years of age. In this group of smokers, the most numerous group consisted of 17-year-old girls, who made up 10% of all smokers.

Slovakia has made progress on tobacco control in recent years. However, people continue to die and become sick needlessly, and the costs to society from tobacco use continue to mount. Slovakia can still do more to make the proven tobacco control tools work for its citizens' wellbeing.

Women of childbearing age need to be educated about the potential detrimental effects of tobacco use on the developing foetus and infant. It is important that the messages about tobacco use during pregnancy be provided to women clearly and consistently. Prenatal care provides an opportune time for healthcare professionals to ask about tobacco use and provide appropriate referrals to smoking cessation programmes whenever necessary. Evidence-based smoking cessation interventions should be integrated into routine prenatal care. Universal screening protocols need to be established for all pregnant women and women of childbearing age. Finally, prevention efforts and intervention programmes need to be expanded to reach the broader population of women of childbearing age (19, 20).

The most impactful campaigns have been shown to be those using mass media to target large segments of the population, with hard-hitting messages on the harms of tobacco for most months of the year. Australia's long-running efforts using mass media have helped drive down tobacco use to record lows among adults and youth. The country's sustained effort uses television, radio and digital platforms to achieve greater population reach and has produced graphic advertising that has been adapted around the world. Turkey's comprehensive tobacco control legislation requires TV and radio stations to air 90 minutes of the Ministry of Health ads each month, including 30 minutes in peak hours. Using this innovative strategy, Turkey has mounted numerous

antitobacco campaigns each year, reaching most citizens and driving millions to quit smoking (1).

A high percentage of women of reproductive age smoke and continue to smoke despite their knowledge about risk of smoking during pregnancy. The mechanisms behind tobacco taxation are simple. A sufficiently large tax increase will raise tobacco product prices. By observing smokers' behaviour, researchers have determined that on average a 10% increase in cigarette prices makes the consumption of cigarettes fall by between 2% and 8%. Higher tobacco prices are especially effective in reducing tobacco use in more vulnerable populations, such as youth and lower-income groups, because those groups are particularly sensitive to price increases. Frequently, significant tax increases are especially needed in countries where consumer purchasing power is growing. When incomes rise faster than cigarette prices, smoking becomes more affordable, encouraging consumption. Excise tax increases are a proven and effective way to make cigarettes and other tobacco products less affordable. Unfortunately, many governments are still reluctant to increase taxes, because they often rely on tobacco industry reports that typically suggest that any additional tax increase will cause declines in tax revenue or a massive increase in cigarette smuggling. Independent studies have shown that these claims are usually greatly exaggerated; new tax increases bring in additional revenue for the governments, whereas illicit trade in tobacco products can be controlled while keeping prices high (1).

Limitations of the Study

Our study did not include all possible negative factors influencing pregnancy outcome. We did not follow the nutritional habits of pregnant women or possible effect of passive smoking. The limitations of the survey are incomplete registered items as well as their possible dissimulation by patients.

CONCLUSIONS

Nicotine from maternal smoking is still the most prevalent substance of abuse during pregnancy in industrialized countries. Smoking cigarettes throughout pregnancy is one of the single most important avoidable causes of adverse pregnancy outcomes and it represents the first major environmental risk of the unborn. Despite so many related hazards, smoking is still frequent among pregnant women. Therefore, anti-nicotine education should include young women and should be continued by outpatient clinics for pregnant women. Tobacco prevention and cessation campaigns should focus on improving pregnancy outcomes in lower middle income countries in the future.

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Conflict of Interests

None declared

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