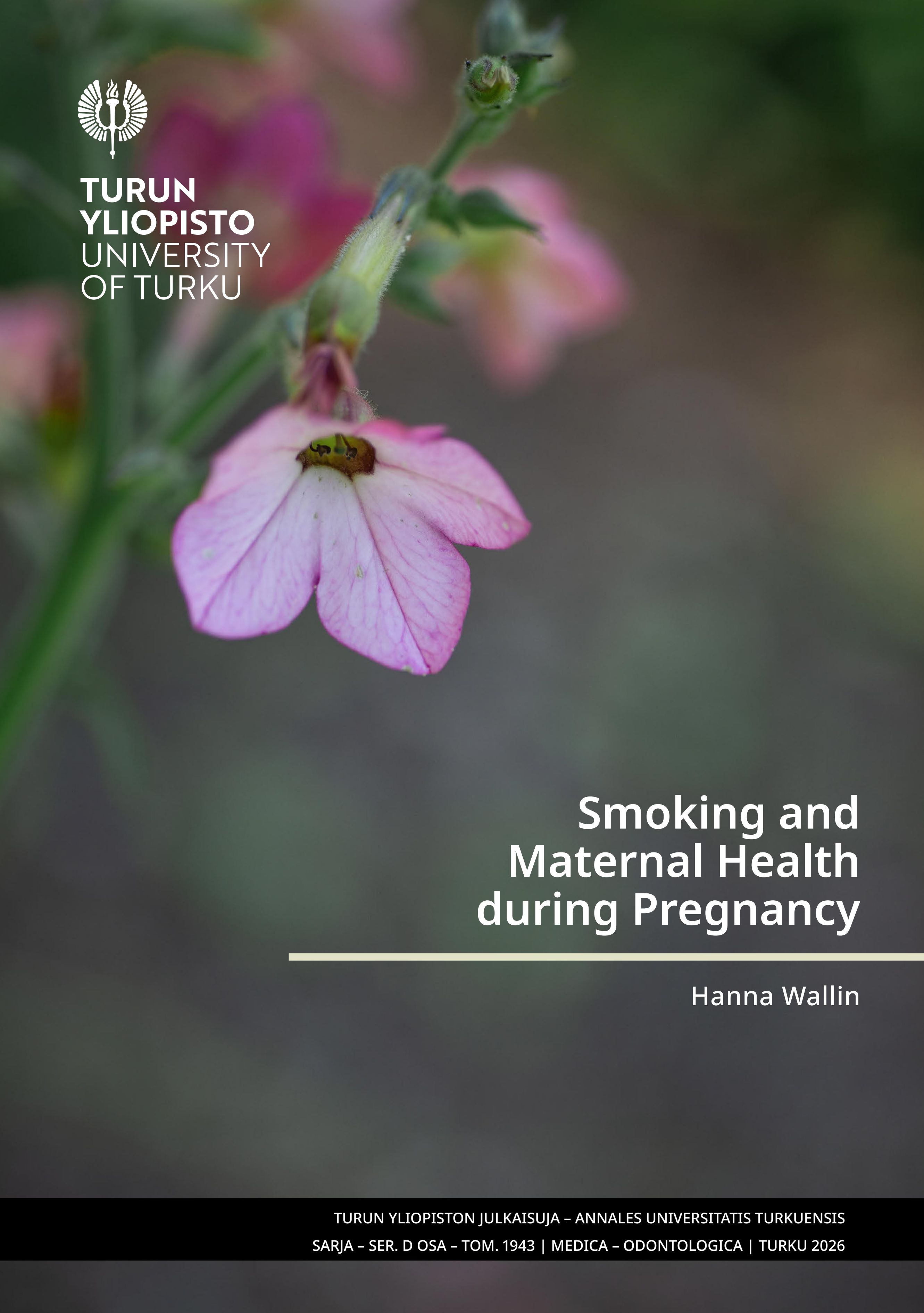

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Smoking and Maternal Health during Pregnancy

Hanna Wallin

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To all those who wish to become mothers

UNIVERSITY OF TURKU
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ABSTRACT

In Europe, about 6%–8% of women smoke during pregnancy. Smoking has numerous harmful effects on fetal growth and pregnancy outcomes and is the most preventable cause of pregnancy complications. This dissertation studies the association between smoking and maternal health during pregnancy and smoking in consecutive pregnancies.

This dissertation utilized data from two Finnish registers. The smoking data were retrieved from the Medical Birth Register and was connected to data concerning specialized care during pregnancy from the Finnish Care Register for Health Care. The first study examined the association between smoking and specialized care due to different ICD-10 diagnoses (in chapters) among pregnant women in Finland from 1999 to 2015 (n = 936,113). The second study investigated the relationship between smoking and urinary tract infections among pregnant women from 2006 to 2018 in Finland (n = 723,433). In the third study, the connection between prior psychiatric specialized care and smoking during the second pregnancy was studied among women who had smoked during their first pregnancy and had two deliveries from 2006 to 2019 (n = 29,683). These associations were studied using logistic regression analysis and adjusted for several confounding factors, e.g., year of delivery, maternal age, parity, and marital status.

The smoking prevalence in these studies was 14.5%–16.0%. According to our findings, women who smoke during pregnancy are more likely to receive specialized care during pregnancy than women who do not smoke. This association is even more pronounced in women who continue smoking after the first trimester. Smoking appears to be linked to an increased likelihood of urinary tract infections. Lifetime psychiatric morbidity was associated with smoking during the second pregnancy, compared to women without a previous psychiatric diagnosis, among women who smoked during their first pregnancy.

These results strengthen the knowledge that, in addition to harmful effects on the fetus and pregnancy, smoking also impairs maternal health during pregnancy. Smoking cessation support is still needed before, during, and after pregnancy. Smoking cessation support should be more precisely tailored, with particular consideration given to the mother's prior mental health history.

KEYWORDS: smoking, pregnancy, cigarette, nicotine, specialized care, urinary tract infection, mental health, psychiatric morbidity, consecutive pregnancies

TURUN YLIOPISTO
Lääketieteellinen Tiedekunta
Kliininen laitos
Yleislääketiede
HANNA WALLIN: Tupakoinnin yhteys raskaudenaikaiseen terveyteen
Väitöskirja, 166 s.
Turun kliininen tohtoriohjelma
Tammikuu 2026

TIIVISTELMÄ

Euroopassa noin 6–8 % raskaana olevista naisista tupakoi. Raskaudenaikaisella tupakoinnilla on lukemattomia haittavaikutuksia sikiön kehitykseen sekä raskauteen. Tupakointi onkin yksi merkittävimmistä estettävissä olevista tekijöistä, jotka vaikuttavat raskauden ennusteeseen. Tämän väitöskirjan tavoitteena on tutkia tupakoinnin yhteyttä raskaana olevan naisen omaan terveyteen raskausaikana sekä tupakointia kahdessa peräkkäisessä raskaudessa.

Tutkimusaineisto ja raskaudenaikainen tupakointitieto saatiin Suomen syntymärekisteristä ja näihin yhdistettiin tieto raskausajan sairaalahoidosta Suomen hoitoilmoitusrekisteristä. Ensimmäisessä osatyössä selvitettiin tupakoinnin ja sairaalahoidon yhteyttä ICD-10-diagnoosiryhmittäin raskaana olevilla naisilla Suomessa vuosina 1999–2015 (n = 936 113). Toisessa osatyössä tutkittiin tupakoinnin ja virtsatieinfektioiden yhteyttä raskaana olevilla naisilla Suomessa vuosina 2006–2018 (n = 723 433). Kolmannessa osatyössä selvitettiin aiemman psykiatrisen erikoissairaanhoidon yhteyttä tupakointiin toisessa raskaudessa naisilla, jotka tupakoivat ensimmäisen raskauden aikana ja joilla oli kaksi synnytystä Suomessa vuosina 2006–2019 (n = 29 683). Tilastollista yhteyttä tutkittiin logistisella regressioanalyysillä, ja sekoittavina tekijöinä huomioitiin mm. synnytysvuosi, äidin ikä, pariteetti, ja siviilisääty.

Tutkimusaineistossa tupakoinnin esiintyvyys oli 14,5–16,0 %. Tupakointi oli yhteydessä äidin sairaalahoitoon raskausaikana, ja yhteys oli selkeämpi tupakointia ensimmäisen kolmanneksen jälkeen jatkaneilla naisilla. Tupakoinnilla vaikuttaa myös olevan yhteys virtsatieinfektoiden todennäköisyyteen raskausaikana. Äidin aiempi psykiatrinen sairastavuus oli yhteydessä tupakoinnin todennäköisyyteen toisessa raskaudessa ensimmäisen raskauden aikana tupakoineilla naisilla, verrattuna naisiin, joilla ei ollut aiempaa psykiatrista diagnoosia.

Tulostemme mukaan raskaudenaikainen tupakointi on haitallista myös odottavan äidin omalle terveydelle. Tupakoinnin lopetus alkuraskauden aikana voi pienentää tupakoinnin haitallisia vaikutuksia. Neuvoloissa tarvitaan toimenpiteitä tupakoinnin lopettamiseksi raskausaikana sekä sen jälkeen. Tupakoinnin lopettamiseen kohdistuva psykososiaalinen tuki tulisi räätälöidä aiempaa tarkemmin huomioimalla esimerkiksi äidin aiempi mielenterveys.

AVAINSANAT: raskaus, tupakointi, nikotiini, savuke, sairaalahoito, virtsatieinfektio, mielenterveys, psykiatrinen sairastavuus, peräkkäiset raskaudet

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Abbreviations

ADHD	attention-deficit hyperactivity disorder
BMI	body mass index
CI	confidence interval
CO	carbon monoxide
DNA	deoxyribonucleic acid
DSM-IV	Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition
GP	general practitioner
HSI	heaviness of smoking index
IVF	in vitro fertilization
ICD-10	International Statistical Classification of Diseases and Related Health Problems, Tenth Revision
MRI	magnetic resonance imaging
NCDS	National Child Development Study
NRT	nicotine replacement therapy
OR	odds ratio
RCT	randomized controlled trial
SDP	smoking during pregnancy
SES	socioeconomic status
SIDS	sudden infant death syndrome
THL	Finnish Institute for Health and Welfare
UK	United Kingdom
US	United States
UTI	urinary tract infection
WHO	World Health Organization

List of Original Publications

This dissertation is based on the following original publications, which are referred to in the text by their Roman numerals:

I Wallin HP, Gissler M, Korhonen PE, Ekblad MO. Maternal Smoking and Hospital Treatment During Pregnancy. *Nicotine & Tobacco Research*. 2020; 22(7): 1162–1169.

II Wallin HP, Gissler M, Korhonen PE, Ekblad MO. New insights into smoking and urinary tract infections during pregnancy by using pregnancy-pair design: A population-based register study. *Acta Obstetricia et Gynecologica Scandinavica*. 2023; 102(1): 25–32.

III Wallin HP, Gissler M, Korhonen PE, Ekblad MO. Lifetime psychiatric morbidity and maternal smoking in consecutive pregnancies: A Finnish register study. *Acta Obstetricia et Gynecologica Scandinavica*. 2025; 104: 1092–1100.

1 Introduction

Smoking among fertile-aged women has decreased steadily over the last decades, according to the World Health Organization (WHO, 2021). However, the decline rate has been substantially lower among less educated women in Europe (Giskes et al., 2005). In contrast, the use of new nicotine products, such as nicotine pouches and electronic nicotine delivery systems, is rising in the general population, especially among teenagers in Europe and North America (Jackson et al., 2024; Park-Lee et al., 2021). The prevalence of smoking during pregnancy (SDP) did not decline in Finland until the late 2010s, but especially young pregnant women continue to smoke while pregnant, according to statistics from the Finnish Institute for Health and Welfare. (THL, 2024).

The various harmful effects of prenatal smoking on the developing fetus are widely reported; many of these are accepted to be causal. SDP impairs fetal growth and causes lower birth weight; infants exposed to maternal smoking in utero are more often small for gestational age than those not exposed (Ko et al., 2014; Pereira et al., 2017). These effects include adverse effects on body proportions and structures, such as the brain (Abraham et al., 2017; Ekblad et al., 2015). SDP has also been associated with various pregnancy complications, such as pre-term birth, stillbirth, and neonatal complications, such as sudden infant death syndrome (SIDS). Tobacco-induced health challenges have been proposed to extend to later childhood and adolescence. (Avşar et al., 2021)

The numerous detrimental effects of smoking are well-documented in the general population (National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health, 2014). Current knowledge is lacking on the effect of SDP on prenatal maternal health, as extensive research has focused primarily on pregnancy and newborn outcomes. Pregnant women who smoke seem to have many similar health risks as smoking individuals in general, e.g., susceptibility to respiratory infections and deep vein thrombosis (Roelands et al., 2009). Some pregnancy-related maternal health concerns also seem to reach beyond the pregnancy and puerperium.

Prenatal smoking cessation support seems inadequate, as about 3,000 children per year in Finland are exposed to the hazards of maternal smoking in utero (THL, 2024). In Finland, the primary care prenatal clinics are mainly responsible for executing smoking cessation interventions during pregnancy. Studies have reported that maternity clinic personnel perceive implementing the interventions as challenging due to a lack of knowledge and tools, as well as a fear of consequences to the patient-relationship during routine appointments (Longman et al., 2018; McLeod et al., 2003). According to a systematic review, the implementation of the standard guidelines is also insufficient during pregnancy (Gould et al., 2019).

This dissertation aims to increase the knowledge about prenatal smoking and its effects on maternal health during pregnancy. Additionally, it attempts to deepen the understanding of factors contributing to continued SDP. This information is essential for enhancing smoking cessation interventions and support in prenatal clinics in Finland and worldwide.

2 Review of the Literature

2.1 Smoking Among Women

2.1.1 Prevalence and Trends

Smoking prevalence among women has decreased globally, but the highest prevalence worldwide among women over age 15 was estimated in the European region (18.5%) in 2022 (WHO, 2024). Despite globally declining tobacco consumption among women, drastic regional differences still exist, including within Europe. The overall estimates of the prevalence of smoking among women in European countries in 2022 range from 7% in Iceland up to 32% in Serbia. The prevalence of smoking among women in high-income countries has decreased across all age groups. (WHO, 2024) Figure 1 illustrates the global estimated and projected smoking prevalences among fertile-aged women according to age groups.

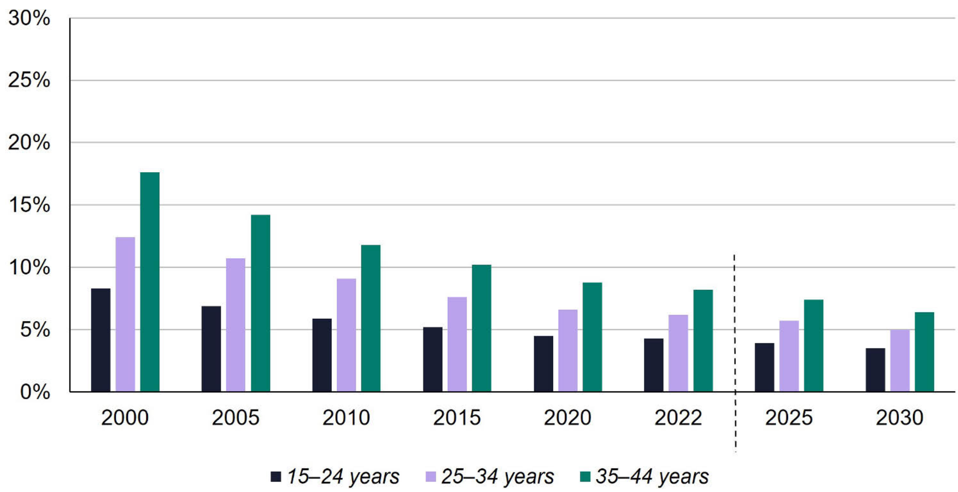

Figure 1. The global estimated (2000–2022) and projected (2025–2030) smoking prevalences (%) for tobacco smoking among women according to age groups from 2000 to 2030. Data source: WHO Global Report on Trends in Prevalence of Tobacco Use 2000–2030.

In Finland, 9% of women between age 20 and 34 and 12% of women aged 35 to 44 smoked daily, according to the most recent national report from 2023 THL, 2024*)*. The prevalence of daily smoking among women has been constant from 2017 to 2023. In contrast, smoking among men has decreased according to the Terve Suomi 2023 survey by THL (THL, 2023). However, Finland still has robust regional differences, and the prevalence of daily smoking among 20–64-year-old women varied from 6% to 15% between regions. Daily smoking rates have even increased in certain areas from time to time, such as in Satakunta and Pirkanmaa, where the prevalence rose again from 2022 to 2024. (THL, n.d.-a) In addition, the impact of educational level on smoking is already visible from a young age. After nine years of basic education, drastic differences exist between the smoking rates of female vocational and upper secondary school students (Figure 2). In 2024, in higher education, female students in polytechnics smoked (7%) more than male students (4%). However, only 2% of female university students reported smoking daily. (THL, 2024)

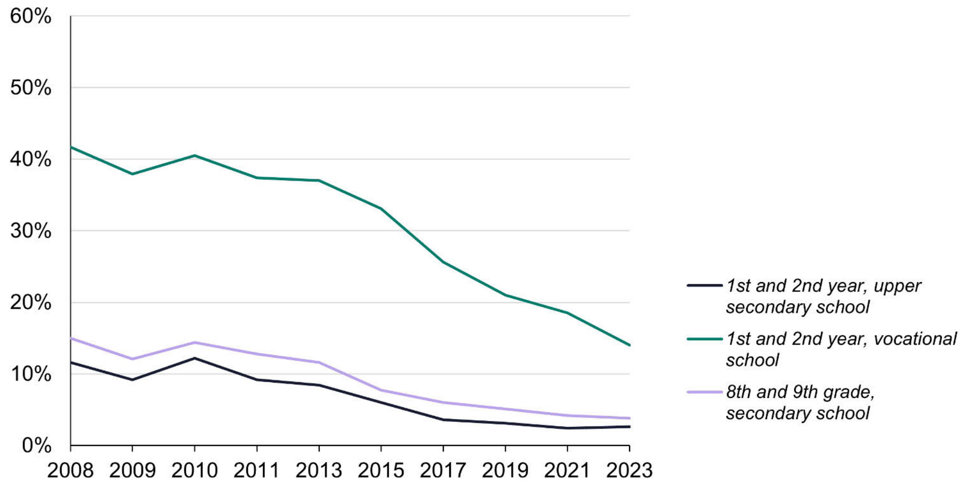

Figure 2. The prevalence of daily smoking (%) among female students, categorized by educational level, in Finland from 2008 to 2023. Data source: Sotkanet Statistics and Indicator Bank (Finnish Institute for Health and Welfare).

2.1.2 The Use of Other Nicotine-containing Products

Unlike the decline of traditional cigarette smoking among fertile-aged women, a recent study showed that the prevalence of vaping and dual-use of tobacco and electronic cigarettes is rising; in England, the increase in electronic cigarette usage has been more pronounced among fertile-aged women from 2013 to 2023 (Jackson et al., 2024). According to the most recent national surveys in Finland, only 2% of 20-to-34-year-old women, reported using electronic cigarettes (THL, 2023a).

However, when examining vaping among teenagers (aged 14–20) in Finland, the Finnish School Health Promotion Study reported a rise in all educational institutions, with the number doubling from 2021 to 2023. Among teenage girls, 5% were already daily users of electronic cigarettes. (THL, 2024) However, drastic differences exist among students at different educational levels (Figure 3). Similar trends have also been reported in the United States (US), where, according to the 2021 National Youth Tobacco Survey, 11% of high school students reported using electronic cigarettes in the past 30 days. In contrast, 3% of middle school students reported current use of electronic cigarettes (Park-Lee et al., 2021).

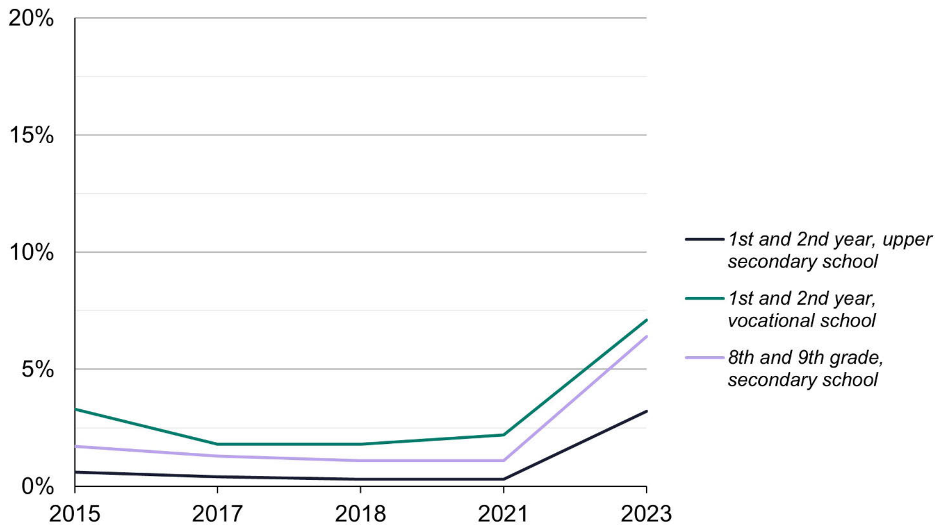

Figure 3. The prevalence of daily use of electronic cigarettes among teenage girls in Finland, according to different educational levels, from 2015 to 2023. Data source: Sotkanet Statistics and Indicator Bank (Finnish Institute for Health and Welfare).

Swedish snus is another tobacco product that is commonly used in Finland. However, according to Terve Suomi 2023 survey, only 5% of women aged 20–34 and 2% of women aged 35–49 used snus (THL, 2023a). According to the Finnish School Health Promotion Study, in 2023 snus use was rare among female students, but daily use was more prevalent among female vocational school students (7%) compared to lower secondary school students (8–9th grade) (2%) and upper secondary school students (1%) (THL, 2023c). Only 1% of female students in higher education reported daily snus use in 2024 (THL, n.d.-e). Also, simultaneous use of different products seems substantially high among young (15 to 16-year-old) adolescents in Nordic countries, where up to 30% were dual users of cigarettes, electronic cigarettes, or snus (Raitasalo et al., 2022).

A new nicotine product—oral non-tobacco nicotine pouches—was introduced to the market in 2016, with the original intention as a smoking-cessation aid. However, the marketing and availability of these oral nicotine pouches resemble those of non-combustible tobacco (Kostygina et al., 2016). Their promotion on social media is often overly positive and seemingly understates the dangers and risks associated with nicotine use (O'Hagan, 2024; Zenone et al., 2025). The data on the efficacy as a cessation aid are scarce (Hartmann-Boyce et al., 2025). The use of oral nicotine pouches has rapidly increased over the past few years, especially among young people, including in Finland. In 2023, the Finnish Medicines Agency (Fimea) no longer classified most nicotine pouches as medical products. This allowed them to be sold without special regulation, thus enabling the rapid growth in use.

According to the Terve Suomi 2023 surveys, 1% of 20–39-year-old women used oral nicotine pouches daily in 2023. (THL, 2023a) The alarming differences among young people at different educational levels are also visible in the use of oral nicotine pouches. In 2023, daily or occasional use was reported by 3% of girls in eighth and ninth grades of lower secondary schools, 2% in upper secondary schools, and 8% in vocational schools (THL, n.d.-e). The surveys included questions about the use of oral nicotine pouches in 2024 among higher education students. Female students in polytechnics reported daily use more often (7%) compared to 3% of female university students who reported daily use in 2024 (THL, 2024). The prevalence of oral nicotine use has risen, especially among young women aged 15–29, in other Nordic countries as well (Arp & Bast, 2025, 2025). In the US, 1% of female high school students reported current use; in the UK, about 2% of the female youth population reported daily use of oral nicotine pouches. About 2%–3% of female youth reported that they had used nicotine pouches at some point. (Brose et al., 2025; Jamal et al., 2024)

2.2 Smoking During Pregnancy

2.2.1 Prevalence and Trends of the Use of Cigarettes and Other Nicotine Products

The prevalence of SDP has been high for decades, until a decrease was observed in the 21st century globally (Zaganjor et al., 2024). Approximately half of the women who smoke continue to smoke while pregnant. In Europe and America, 5.9–8.1% of pregnant women are estimated to smoke. (Lange et al., 2018) In Finland, 7.1% of pregnant women smoked during pregnancy according to the latest statistics from

2023, and 57% quit smoking during the first trimester (THL, 2024). From 2018 onwards, more women have quit smoking than continued after the first trimester in Finland (Figure 4).

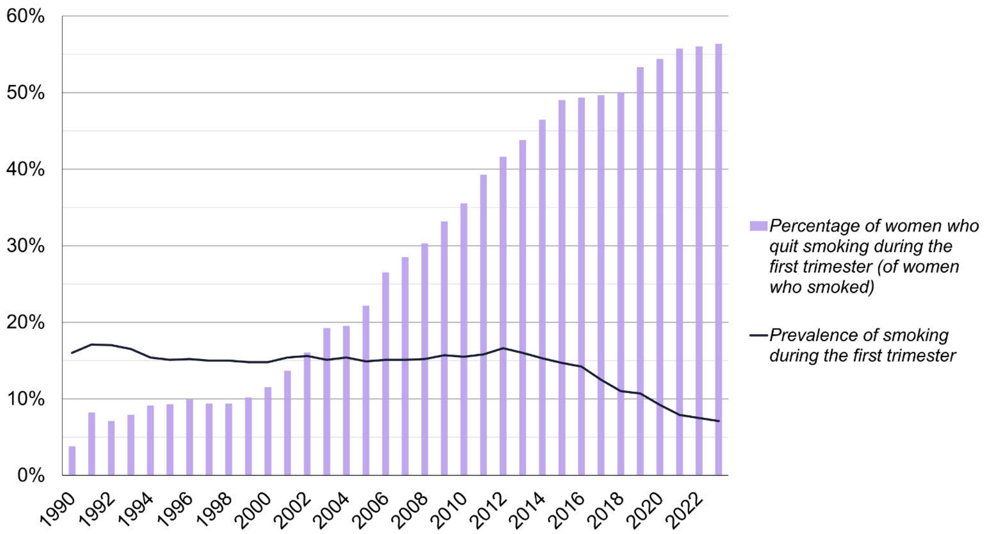

Figure 4. The prevalence of smoking during the first trimester and the percentage of women who quit smoking (of women who smoked during the first trimester) in Finland between January 1990 and December 2023. Data source: Sotkanet Statistics and Indicator Bank (Finnish Institute for Health and Welfare).

Despite the declining national prevalence, Finland still exhibits robust regional differences. The highest prevalence of smoking during the first trimester in 2023 was in North Savo (14.5%), and the lowest was in Ostrobothnia and Uusimaa (4.7%) (THL, n.d.-a). Figure 5 depicts the changing prevalence of continued smoking after the first trimester in different regions in Finland. Regional differences have existed since 2002 and appear to persist to some extent (Räisänen et al., 2014a; Rumrich et al., 2019).

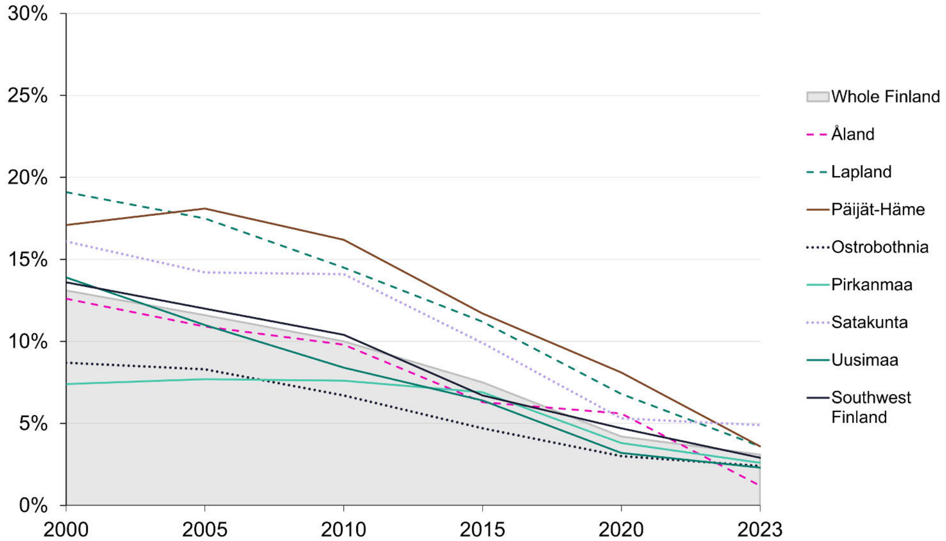

Figure 5. The prevalence of smoking (%) after the first trimester in eight regions compared to the national rate (grey area) in Finland between 2000 and 2023. Data source: Sotkanet Statistics and Indicator Bank (Finnish Institute for Health and Welfare).

The prevalence of SDP remains high in Finland compared to neighboring countries. According to the latest statistics from 2023 (THL, n.d.-b), smoking in early pregnancy in Nordic countries was most prevalent in Finland. In Norway, 1.5% of pregnant women smoked during the first trimester; only 0.7% smoked during the last trimester (Norwegian Institute of Public Health, n.d.). Whereas in Sweden, 2.8% of pregnant women smoked at the time of their first prenatal clinic visit (The National Board of Health and Welfare, n.d.).

Currently, no data from Finland is available concerning the use of other nicotine-containing products during pregnancy. Elsewhere, according to previous studies, 0.5%–1.5% of pregnant women have reported vaping (either sole use or dual use with traditional cigarettes) (Head et al., 2022; Nanninga et al., 2023; Nian et al., 2024; Rice et al., 2024). Over two-thirds of women who initiated electronic cigarette use during pregnancy also smoked traditional cigarettes during the end of pregnancy. However, in a US surveillance study, women were more likely to report a reduction in daily cigarette number when compared to smoking cigarettes alone (Nian et al., 2024). The use of snus is more prevalent in Sweden than in its neighboring countries. In 2023, 1.7% of pregnant women reported snus use during early pregnancy in Sweden. (The National Board of Health and Welfare, n.d.). Current data is lacking on the use of oral nicotine pouches during pregnancy.

2.2.2 Smoking Cessation During Pregnancy

2.2.2.1 Spontaneous Smoking Cessation

A significant number of women can spontaneously quit smoking while wishing to conceive, but these prevalences vary between studies (Table 1). Most women quit either before pregnancy or during the first trimester (Ekblad et al., 2021; Voutilainen et al., 2024). Also, women who smoked during pregnancy have often tried to quit. According to a British cohort study, half the pregnant women who smoked had tried quitting before conceiving (Cooper et al., 2017).

Table 1. Studies on smoking cessation before pregnancy.

STUDY	COUNTRY	*N*	SMOKING PRIOR TO PREGNANCY	SMOKING CESSATION	
				Before pregnancy	During pregnancy
Voutilainen et al. 2024	Finland	21,472	approx. 25%	17%	49%
Ekblad et al. 2021	Finland	248	31% one year prior	57%	-
Liu et al. 2020	USA	25,623,479	10% three months prior	25%	-
De Wolff et al. 2019	Denmark	566	16% at the time of conception	61%	
Scheffers-van Schayck et al. 2019	Netherlands	1,858	17% four weeks prior	-	69%

Several socioeconomic factors have been identified as associated with SDP. According to a Finnish register study, young, single pregnant women who belong to lower social classes are more likely to continue smoking beyond the first trimester (Ekblad et al., 2014). Higher education is associated with better smoking cessation rates during pregnancy (Scheffers-Van Schayck et al., 2019; Härkönen et al., 2018). Unemployed women and women with a shorter education are more likely to smoke during pregnancy (De Wolff et al., 2019; Dejin-Karlsson et al., 1996). In a Finnish study, lower education was the strongest socioeconomic factor associated with continued SDP (Härkönen et al., 2018). There are also considerable differences in SDP across different regions in Finland, which individual socioeconomic factors may not entirely explain (Rumrich et al., 2019).

Several studies have explored further background factors contributing to smoking cessation during pregnancy:

- Smoking history: Spontaneous quitting is more likely among women with fewer years of smoking (Míguez et al., 2017; Woodby et al. 1999).
- Daily cigarette count: Research suggests that women who smoked one to nine cigarettes daily were more likely to quit than those who smoked ten or more cigarettes daily (De Wolff et al., 2019; Hoff et al., 2007; Miguez et al., 2017; Woodby et al., 1999).
- Nicotine dependence: Lower heaviness of smoking index (HSI) is associated with higher cessation rates (Riaz et al., 2018).
- Pregnancy planning: An unplanned pregnancy is more common among women who continue smoking during pregnancy (Dejin-Karlsson et al., 1996; Villalbí et al., 2007; Yu et al., 2022).
- Partner's smoking status: Women who smoke during pregnancy are more likely to have a smoking partner (Míguez et al., 2017; Román-Gálvez et al., 2018; Scheffers-Van Schayck et al., 2019; Voutilainen et al., 2024).

2.2.2.2 Mental Health

Studies have explored mental health in association with SDP, with a pronounced interest in anxiety, perceived stress, and depression. Low stress, and absence of depression support quitting according to a meta-analysis (Riaz et al., 2018). Although the rates of SDP have been decreasing, a similar decreasing trend was not apparent among pregnant women who screened positive for major psychological distress in a study conducted in the US between 2008 and 2014 (Goodwin et al., 2017). Pregnant women with mental health conditions were less likely to quit than women without mental health conditions, but the receipt of treatment was not associated with smoking cessation (Salameh et al., 2022).

In a sample of pregnant women in the US, maternal mood was not associated with the likelihood of smoking cessation, but the cluster of stressful life events was (Gyllstrom et al., 2012). Women suffering from anxiety or depression are also less likely to be able to quit (Tong et al., 2016). In a Finnish birth cohort, self-reported stress during pregnancy was associated with SDP, with a dose-effect relationship (Brannigan et al., 2022). In a Norwegian cohort, women who experienced high levels of anxiety or depressive symptoms were less likely to quit smoking and more likely to relapse postpartum (Hauge et al., 2012). Also, dysthymia was associated with an increase instead of a decrease in the number of cigarettes consumed following cessation intervention (Blalock et al., 2006).

In addition, concordant substance use increased the likelihood of SDP and lowered the likelihood of quitting (Burns et al., 2008). Women who smoke may also use alcohol more often compared to women who do not smoke (Alvik et al., 2006a). Not consuming alcohol before or during pregnancy was associated with higher cessation rates in a systematic review (Riaz et al., 2018). Interestingly, contrasting results have been published: In a Danish study, higher alcohol consumption before pregnancy was associated with a higher likelihood of quitting in a multivariate model (Scheffers-Van Schayck et al., 2019). However, the timing of reporting may be significant: The reporting of alcohol use during pregnancy may underestimate the amount of actual alcohol consumption. Women retrospectively reported higher amounts of alcohol compared to their reports during pregnancy, but smoking did not predict such a difference in reporting (Alvik et al., 2006b).

2.2.2.3 Interventions

Psychosocial interventions seem to increase the likelihood of smoking cessation during pregnancy according to a Cochrane Review (Chamberlain et al., 2017). A review of 12 studies conducted in the primary care setting concluded that higher cessation rates were observed in the psychosocial intervention groups; however, these differences were not statistically significant in all of the studies, and cessation rates also improved in the control groups receiving usual care (Connolly et al., 2024). According to a meta-analysis of cessation trials, only a few pregnant women who smoked succeeded in quitting, as the end-of-pregnancy smoking rate was as high as 87%, and slightly higher, 89%, in studies with a biochemically validated smoking status (Jones et al., 2016). An RCT by Higgins et al. (2022) demonstrated improved cessation rates compared to best practice smoking cessation support during pregnancy and until 12 weeks postpartum. Another trial reported that almost twice the number of women who smoked and received an incentive in addition to standard support were biochemically validated as not smoking at the end of the pregnancy compared to women who received standard cessation support only (Tappin et al., 2022). In a French study, an incentive of up to 520 euros yielded better cessation rates compared to the control group, which received standard care and an 80-euro reward for participating in the smoking cessation program (Berlin et al., 2021).

2.2.2.4 Nicotine Replacement Therapy

Although nicotine has known adverse effects on fetal health and newborns, many countries have ultimately recommended nicotine replacement therapy (NRT) during pregnancy to decrease the exposure to nicotine and various other harmful substances found in cigarettes, based on the principle of least harm (The National

Health Service, n.d.). According to a Cochrane review concerning NRT, it is also a valid option to be used during pregnancy. However, the evidence suggests that NRT may not result in better cessation rates compared to placebo. (Claire et al., 2020). NRT was unsuccessful compared to placebo in long-term abstinence in a large trial (Coleman et al., 2012). However, in this trial, the abstinence rates at one month were better for NRT, but only a few continued using NRT or placebo after that. According to a systematic review and meta-analysis of 12 studies, most studies reported lower cotinine levels in women who were abstinent but used NRT compared to women who smoked (Hickson et al., 2019). A study on nicotine patches found that saliva cotinine levels were lower in pregnant women using 15mg nicotine patches compared to smoking (Bowker et al., 2014).

2.2.3 Smoking Relapse After Birth

Less longitudinal data exists concerning smoking and smoking relapse after birth. Studies have reported relatively high rates of relapse. According to a review, women who spontaneously quit smoking had higher abstinence rates during pregnancy and in postpartum compared to women who quit nonspontaneously (Su & Buttenheim, 2014). Almost one-fourth of early-pregnancy quitters were smoking at one year postpartum in a Japanese study (Murakami et al., 2023). The interest in smoking cessation support drops slightly three months postpartum compared to the time of pregnancy among women who smoke (Naughton et al., 2020). According to a meta-analysis, only a small proportion of women who participated in clinical cessation trials were able to quit, and 43% of women who succeeded in quitting were smoking at six months post-partum (Jones et al., 2016). In a cessation trial with psychosocial intervention, 38% of women were abstinent at 12 weeks, and 24% were abstinent at one year postpartum (Levine et al., 2016). Interventions that include financial incentives have shown better success rates, both postpartum and in the long term, although they also lead to relapse rates comparable to those of other interventions (Su & Buttenheim, 2014). In a RCT in England on women who quit smoking before birth, a 12-month financial incentive was superior to incentives for three months, but no difference for either compared with usual care was significant when considering abstinence rates (Ussher et al., 2024a).

In the English population, women from more deprived areas were more likely to smoke, but living with a person who smoked was the strongest factor contributing to early smoking relapse (Harmer & Memon, 2013). Breastfeeding and smoking relapse after pregnancy has been studied. Evidence suggests that women who quit SDP and breastfeed for at least six months postpartum are more likely to remain abstinent than women who do not breastfeed (Zhang et al., 2022). Some women report that breastfeeding was a reason for delaying smoking initiation (Joseph et al., 2017). Also, electronic cigarette use during pregnancy reduced postpartum smoking relapse (Orton et al., 2022). Women who quit SDP were more likely to relapse into smoking postpartum if they experienced depressive symptoms than women without depressive symptoms (Allen et al., 2009).

Currently, no register or other information is available about smoking after birth in Finland. However, promoting parental smoking cessation should be part of the child health clinic's health education program, according to recommendations (THL, n.d.-c; Current care guidelines: Prevention and treatment of tobacco and nicotine dependence [Tupakka- ja nikotiiniriippuvuuden ehkäisy ja hoito], 2024b). According to the FinTerveys 2017 study, no difference in smoking prevalence was observed between parents of small children and other adults in the same age range; reportedly, 11% of mothers of small children smoked daily (Haapala, 2020).

2.2.4 Smoking During Consecutive Pregnancies

Studies have also examined smoking during more than one pregnancy. About 30%–40% of women who smoked during their first pregnancy did not smoke in their subsequent one. In contrast, only a few percent of women who did not smoke during their first pregnancy initiate smoking in the subsequent one. (Hauge et al., 2013; Kvalvik et al., 2017; Rumrich et al., 2019) The characteristics of women who smoke during their consecutive pregnancies seem similar compared to SDP in general: Women who persist in smoking in two pregnancies are more often young (Cnattingius et al., 2006; Hauge et al., 2013; Tran et al., 2014), single (Tran et al., 2014), and belong to a lower socioeconomic stratum (Tran et al., 2014). Smoking in consecutive pregnancies is also more common among women with a partner who smokes (Hauge et al., 2013), shorter education, or unemployment status (Cnattingius et al., 2006; Reynolds et al., 2020). Women who have partners who smoke are also more likely to relapse into smoking after birth (Orton et al., 2018). Women who reported smoking during the first pregnancy but not during the second were more likely to smoke fewer daily cigarettes (Cnattingius et al., 2006; Hoff et al., 2007; Reynolds et al., 2020).

Although smoking initiation after a smoke-free first pregnancy is rare, some risk factors have been observed. Women who initiated smoking after the first pregnancy were more likely to be young, consume alcohol, and have shorter education (Hoff et al., 2007). Also, persistent smoking during two pregnancies was associated with higher rates of drug and alcohol consumption and lower rates of planned pregnancy and folic acid supplementation compared to women who did not smoke in either pregnancy (Reynolds et al., 2020). Even previous poor birth outcomes, low birth weight, or preterm birth were associated with higher smoking prevalence in the subsequent pregnancy (Varner et al., 2016). However, this may indicate a longer and more intensive smoking history. Women who continued smoking also reported higher rates of psychological problems, such as anxiety and current depression (Reynolds et al., 2020). Women who ceased smoking after their first pregnancy reported less psychological distress than those who continued smoking (Hauge et al., 2013).

2.3 Nicotine Dependence

Nicotine is absorbed fast from the lung alveoli, and it has a short half-life (Hukkanen et al., 2005). Substances with short half-lives can produce more intense and rapid effects, thereby increasing the potential for dependence. Some people who smoke never develop nicotine dependence, but genetic factors seem to contribute in the development of nicotine dependence (MacKillop et al., 2010). Women tend to smoke less compared to men, and other factors might reinforce the nature of addiction in women (e.g., secondary social reinforcement) rather than physical nicotine withdrawal symptoms (Perkins et al., 1999).

Nicotine dependence is considered the main factor contributing to continued smoking behavior. According to the fourth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) published by the American Psychiatric Association (APA, 1994), the main diagnostic criteria for nicotine dependence include tolerance of nicotine without side effects and the presence of withdrawal symptoms (Table 2). These include irritability, anxiety, and concentration difficulties, in addition to increased appetite, dysphoria, and insomnia. Fagerström test for nicotine dependence is designed to measure physical dependence and is often used in clinical and study settings. Greater nicotine dependence scores are associated with lower abstinence rates (Fagerström et al., 2012). Higher dependence scores have also been associated with higher cessation intention, along with lower years smoked in cessation outpatients (Chen et al., 2025).

The metabolism of nicotine appears to be faster during pregnancy, especially during the last trimester (Arger et al., 2019; Bowker et al., 2015). The half-life of cotinine, a nicotine metabolite, is shorter during pregnancy (Dempsey et al., 2002). These changes may also be reflected in smoking patterns during pregnancy, and possibly cause increased cravings. Studies have reported varying prevalences of nicotine dependence among pregnant women who smoke. In a retrospective study, 59% of women who reported smoking and pregnancy during the previous year met the criteria for nicotine dependence (Goodwin et al., 2007). However, in another US study, only 19% of pregnant women who smoked screened positive for nicotine dependence (Flick et al., 2006). In their study, most women who screened positive for nicotine dependence had already quit smoking after a positive pregnancy test.

Table 2. The diagnostic criteria for nicotine dependence, adapted from the fourth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV). Modified from Baker et al. 2012.

THE OCCURRENCE OF AT LEAST THREE OF THE FOLLOWING SYMPTOMS (1–7) AT THE SAME TIME DURING THE PAST 12 MONTHS
1. Tolerance
The absence of physical symptoms of consuming large quantities of nicotine or Diminished effect of consuming the same amount in continued use
2. Withdrawal symptoms
The characteristic nicotine withdrawal symptoms or The use of nicotine as an aid to relieve or avoid withdrawal symptoms
3. Impaired control of use
The use of larger amounts and longer time than the original intention
4. Unsuccessful quit attempts or a persistent wish to quit or reduce
5. The activities necessary to obtain or use nicotine are time-consuming
6. Neglect of social, occupational, or recreational activities
7. Nicotine use is continued despite adverse effects
Persistent or recurrent physical and/or psychological problems

2.4 The Adverse Effects of Smoking During Pregnancy on Offspring

2.4.1 Placental Transfer of Major Harmful Compounds in Tobacco Smoke

Smoked tobacco contains thousands of chemicals, of which over 200 are known to be toxic or carcinogenic (WHO, n.d.). Of these harmful substances, nicotine is considered responsible for many significant adverse effects on pregnancy outcomes and fetal effects, along with carbon monoxide (CO). Other such substances include cotinine (the end product of nicotine metabolism), tar, and other combustion products, such as nitric oxide (NO). Many of the substances are known carcinogens (e.g., arsenic, cadmium, benzene, formaldehyde, hydrazine, and nickel) (Food and Drug Administration, 2012).

The placenta serves as a barrier and a pathway for the exchange of substances between the mother and the fetus. Smoking increases blood pressure on the maternal side and causes endothelial dysfunction, further impacting the placenta by reducing its blood flow (Bakker et al., 2010). Women who smoke reportedly have differences in uterine, umbilical, and fetal middle cerebral artery flow and resistance compared to women who do not smoke (Albuquerque et al., 2004).

Many harmful substances, such as CO, can cross the placenta without difficulty and due to fetal hemoglobin's different properties, the fetal concentrations may be even higher than those of the mother, according to mathematical models (Hill et al., 1977). The binding of CO to hemoglobin results in carboxyhemoglobin formation, leading to transient hypoxia in the fetus (Stone et al., 2014). The amount of carboxyhemoglobin depends on how deep and frequent the inhalations are; thus, those who smoke more cigarettes are more affected. Expiratory CO measurement correlates well with the amount of carboxyhemoglobin (Jarvis et al., 1986).

Also, nicotine crosses the placenta, resulting in fetal concentrations that are estimated to be 15% higher than those concentrations found in maternal circulation (Banerjee et al., 2022). Nicotine acts as a vasoconstrictor, and research suggests that numerous changes in placental morphology, vasculature, and vascular resistance occur, some of which are mediated through oxidative stress (Pintican et al., 2019). These might further lead to reduced blood flow and placental insufficiency (Banerjee et al., 2022). In addition, deoxyribonucleic acid (DNA) methylations are a potential mechanism for the harmful effects of smoking, and methylations are more prevalent among the offspring of mothers who sustained SDP compared to those who did not smoke during pregnancy (Joubert et al., 2016).

2.4.2 Fetus and Newborn

The harmful effects of SDP were first published in the late 1950s when the National Child Development Study (NCDS) was one of the first to report that the newborns of women who smoked had a lower birth weight than those born to women who did not smoke (National Child Development Study, n.d.). The impairment of fetal growth and higher likelihood for low birth weight due to the fetal exposure to maternal smoking has been widely studied since (England et al., 2001; Fox et al., 1994; Jaddoe et al., 2008). The causal effect of SDP on lower birth weight is accepted. Notably, exposure during the last trimester appears to be detrimental (Jaddoe et al., 2008). SDP affects body size, body proportions, and the parameters of head and brain growth (Abraham et al., 2017; Ekblad et al., 2015; Roza et al., 2007).

Studies have also examined the intensity of SDP on various outcomes. Heavy SDP (over 20 cigarettes) showed a more pronounced association with pre-term birth, intrauterine growth retardation, and low birth weight compared to smoking fewer cigarettes (Ko et al., 2014; Tarasi et al., 2022). A dose-dependent association with preterm birth has also been established with fewer daily cigarettes (Fantuzzi et al., 2007). The prevalence of preterm birth among women who did not smoke daily was comparable to that of women who did not smoke at all, and no dose relationship could be found. However, infants of women who smoked daily or non-daily were more likely to be small for gestational age, with a dose-response relationship. (Tong et al., 2017)

Various congenital conditions, such as orofacial clefts and gastrointestinal defects, among others, have been reported in association with SDP (Hackshaw et al., 2011; Leite et al., 2014). The likelihood of birth defects increased with smoking intensity (Nicoletti et al., 2014). Most information about smoking and fetal lung development is drawn from animal studies. Microscopic changes were observed in a study on the lungs of autopsy patients (Chen et al., 1987). However, the lung volumes did not differ in magnetic resonance imaging (MRI) investigations of 32-week-old fetuses between women who smoked and women who did not (Schmid et al., 2011).

SDP has been associated with a higher risk for sudden unexpected infant death, with a dose-dependent relationship; smoking even one cigarette per day increased this risk (Anderson et al., 2019). In all-cause mortality and sudden infant death syndrome (SIDS), a stronger association existed with increasing daily cigarette count if the mother smoked one to five cigarettes per day or more, compared to women who did not smoke, but confidence intervals overlapped so that no definite conclusions can be made for the daily cigarette count (Sun et al., 2023).

Prenatal smoking exposure was also associated with a higher likelihood of transfers to the neonatal intensive care unit at birth, and the length of those admissions was more often longer than seven days among newborns of women who smoked (Tarasi et al., 2022). In addition, the neurobehavior of newborns exposed to smoking in utero has been studied. According to a meta-analysis, exposed newborns exhibit heightened irritability, excitability, and negative affect, as well as lower levels of attention and orientation to visual and auditory stimuli. These infants also showed more muscle tone weakness. (Froggatt et al., 2020) In a prospective study, infants born to women who smoke showed more excitability and hypertonia, required more handling, and showed more stress and withdrawal symptoms during the first ten days of life (Law et al., 2003).

2.4.3 Long-term Effects in Childhood

Studies have indicated that long-term effects of in-utero exposure to cigarette smoke also exist. However, the sole prenatal effect is often challenging to study, as those exposed in utero usually have exposure to tobacco smoke also after birth (Hollams et al., 2014). Avşar et al.'s (2021) umbrella review identified several neonatal and childhood outcomes associated with SDP, with the effect increasing with the intensity of smoking. The most pronounced effect was found for asthma and obesity during infancy and childhood in addition to SIDS. (Avşar et al., 2021)

In an English study on otherwise healthy preterm infants, those born to mothers who smoked had diminished lung function. At the time of testing, none had been exposed to secondhand tobacco smoke after birth. (Hoo et al., 1998) In-utero exposure to smoking is associated with lower respiratory tract illness in childhood, and the offspring of mothers who smoke are more likely to be diagnosed with asthma and wheezing during childhood (Lannerö et al., 2006; McEvoy & Spindel, 2017).

A meta-analysis concluded that a positive association exists between SDP and childhood overweight (Ino, 2010). A more recent meta-analysis concurred that quitting SDP was also associated with increased childhood BMI compared with the offspring of women who did not smoke. However, this effect might not be as pronounced. (Perkins et al., 2023) Moreover, unmeasured genetic and familial factors may confound the association between SDP and childhood obesity, as sibling comparisons have concluded (Hawkins et al., 2019). Data from an Australian cohort study suggested an association between in utero smoking exposure, but not with maternal smoking outside the time of pregnancy, in thoroughly adjusted models (Al Mamun et al., 2006). SDP was also associated with lower aerobic fitness in young adult offspring in a Finnish cohort study (Hagnäs et al., 2016). This association remained statistically significant even after adjusting for body mass index (BMI), and smoking.

Much attention has been paid to examining the association between SDP and offspring's psychiatric disorders. Prenatal smoking has been associated with later psychiatric morbidity in youth (Corrêa et al., 2022; Ekblad et al., 2010), and an independent association was also evident in sibling pair analysis (Ekblad et al., 2017). In a large Swedish birth cohort, adjusting for siblings with discordant maternal smoking exposure attenuated the risk for offspring having schizophrenia or bipolar disorder. However, in the standard model, this association was apparent. (Quinn et al., 2017) In a Finnish longitudinal birth cohort study, the offspring of mothers who smoked more than five cigarettes daily during pregnancy had a higher likelihood of any lifetime personality disorder diagnosis (from inpatient care) but not for any diagnosis at age 30 (Brannigan et al., 2022).

SDP also appears to have an association with offspring behavioral problems, such as disruptive behavior in childhood (Ekblad et al., 2020). In attention deficit disorders and their prevailing contributing factors, SDP has been proposed as one of them. According to two meta-analyses of clinical and retrospective studies, an ADHD diagnosis was more likely among children prenatally exposed to maternal smoking (Godleski et al., 2024; Maher et al., 2024). Prenatal smoking has also been associated with later offspring smoking and nicotine dependence (De Genna et al., 2016; O'Callaghan et al., 2009; Rissanen et al., 2021). Table 3 summarizes the adverse effects and associated outcomes of SDP on offspring.

Table 3. Summary of the adverse effects and associated outcomes of smoking during pregnancy on offspring.

ADVERSE HEALTH OUTCOME		REFERENCES
Impaired fetal growth and development	Lower birth weight, growth retardation, smaller head and brain volumes	Jaddoe et al. 2008, England et al. 2001, Abraham et al. 2017, Ekblad et al. 2015, Roza et al. 2007
Preterm birth		Ko et al. 2014, Tarasi et al. 2022, Fantuzzi et al. 2007
Congenital defects	Orofacial clefts and gastrointestinal defects	Hackshaw et al. 2011, Leite et al. 2014, Nicoletti et al. 2014
Respiratory morbidity	Asthma and respiratory infections during infancy and childhood	Chen et al. 1987, Schmid et al. 2011, McEvoy & Spindel 2017, Hoo et al. 1998, Avşar et al. 2021, Lannerö et al 2006
Sudden infant death syndrome (SIDS)		Anderson et al. 2019, Sun et al. 2023
Newborn neurobehaviour	Heightened irritability, negative affect, and lower levels of orientation to visual and auditory stimuli, hypertonia	Froggatt et al. 2020, Law et al. 2003
Cardiovascular health	Childhood obesity, poor aerobic performance in adolescence	Ino 2010, Perkins et al. 2023, Hagnäs et al. 2016
Mental health	Mental and behavioral disorders in childhood and adolescence Higher likelihood of smoking and nicotine dependence in adolescence	Godleski et al., 2024; Maher et al., 2024, De Genna et al., 2016; Corrêa et al., 2022; Ekblad et al., 2010, Ekblad et al. 2020; O'Callaghan et al., 2009; Rissanen et al., 2021, Brannigan et al., 2022

2.4.4 Benefits of Smoking Cessation and Reduced Smoking

The effects of smoking cessation timing are best reported regarding fetal growth, yet the results are inconsistent. First-trimester cessation appears to be the most beneficial in many respects. According to a register study on cessation timing and low birth weight, only cessation pre-conception yielded a risk comparable to that of non-smokers (Xaverius et al., 2019). Studies have demonstrated the hazardous effects of smoking on fetal growth in ultrasound examinations during the second and third trimesters, as well as a reduction in birth weight and head circumference; however, these were attenuated along with smoking cessation in the first trimester (Abraham et al., 2017; Roza et al., 2007; Vardavas et al., 2010). The risk for premature birth seems to be reversible upon smoking cessation (Liu et al., 2020; Wallace et al., 2017). Also, smoking during the first trimester only seems to be associated with a lower risk for preterm birth, but smoking during the first and second or all trimesters was associated with a higher likelihood for preterm birth (Kondracki & Hofferth, 2019). Smoking cessation after the first pregnancy was associated with higher birthweight in the next pregnancy compared to smoking in subsequent pregnancies (Chertok et al., 2011).

A retrospective study denoted a decreased association of unexpected infant death and all-cause mortality in women who quit smoking during the first trimester compared to those who continued to smoke throughout the pregnancy (Sun et al., 2023). However, there was no reduced risk of all-cause mortality if the woman quit during the second trimester. A Finnish register study reported that quitting smoking during the first trimester was associated with increased likelihood for intensive neonatal care and congenital abnormalities compared to non-smoking women (Räisänen et al., 2014b). Still, smoking cessation during the first trimester reduced the risk of low birth weight, the infant being small for gestational age, prematurity, and stillbirth to levels comparable with those of women who did not smoke.

Mothers-to-be are often encouraged to “reduce-if-not-quit” based on the least harm principle, which is against the official recommendations. Less research has been conducted on the quantity of cigarette consumption and its association with pregnancy outcomes. In a Finnish study, reducing smoking to below five cigarettes per day before 20 weeks of gestation reduced the risk of small for gestational age. Still, it did not obliterate the elevated risk for prematurity or perinatal death (Raatikainen et al., 2007). In another study, if the woman reduced her smoking to less than half, SIDS and all-cause deaths were still comparable to those of women who did not reduce smoking (Sun et al., 2023). Hence, it seems no safe threshold for continued smoking can be advised regarding mortality or prematurity. Graham et al. (2014) theorized that reducing the number of cigarettes was perceived as a positive change, which might further prevent smoking cessation.

2.5 Associations of Smoking During Pregnancy and Maternal Health

2.5.1 Obstetric Consultations and Hospitalizations

Pregnant women who smoke are more likely to be referred to an obstetrician compared to women who do not smoke, according to a study from the Netherlands. This association was evident regardless of the duration of SDP. Also, the most common reasons for a referral appeared to be similar regardless of the smoking status. (Weiland et al., 2022) Women who smoked were also more likely to be hospitalized during pregnancy than women who did not smoke, even when adjusting for several factors (e.g., maternal age, year of delivery, and social confounders) in a Danish register study (Bendix et al., 2016). The most common reason for hospitalization in their study was the threat of preterm labor, and hospitalizations due to maternal diseases increased robustly during the study period. Still, these were not assessed regarding smoking.

2.5.2 Obstetric Outcomes

Retrospective studies have reported the association between SDP and miscarriage; according to a systematic review and meta-analysis, this association seems to be dose-dependent. Women who had formerly smoked seemingly had a similar likelihood of miscarriage as women who do not smoke. (Pineles et al., 2014) According to a Danish study on recurrent pregnancy loss, current and former smoking was associated with more previous miscarriages compared to non-smoking (Hviid et al., 2024). Smoking 1–9 or 10 or more cigarettes per day was associated with spontaneous abortion, but with no apparent dose-response effect in the Swedish population. However, tobacco use and age over 30 presented a stronger association with spontaneous abortion. (Skogsdal et al., 2023)

Preterm births are also more prevalent among pregnant women who smoke, with a dose-dependent association that was more pronounced with smoking during the late pregnancy period (Jaddoe et al., 2008; Tarasi et al., 2022). Women who smoked during their first pregnancy but did not smoke during their second had a reduced incidence of preterm births in the second pregnancy (Pereira et al., 2021). Smoking has also been identified as an individual risk factor for placental abruption in cohort and case-control studies (Chen et al., 2025). In a European multinational case-control study, SDP was associated with preterm birth and premature rupture of membranes (Nabet et al. 2007). However, Lin et al's (2024) recent systematic review and meta-analysis, found no association between SDP and premature rupture of membranes but the authors concluded that this requires more quality data to draw conclusions. Women who smoked during pregnancy are also more likely to have intensive care interventions after delivery (Kern-Goldberger et al., 2022).

Inverse associations between SDP and hypertensive disorders of pregnancy have been described across various studies. According to Conde-Agudelo et al.'s (1999) systematic review, about a 30% risk reduction for hypertensive disorders was observed with smoking, regardless of the study type or quality. Hypertensive disorders during pregnancy also showed a negative association in a systematic review and meta-analysis of 13 studies, with a suggestion of possible differences among nationalities (Wang et al., 2022). The inverse association of SDP and pre-eclampsia remains without a definitive explanation for other contributing factors. Ethnicity may influence the likelihood of hypertensive disorders during pregnancy; for example, in a Japanese cohort study, smoking more than ten cigarettes per day was associated with a higher prevalence of hypertensive disorders during pregnancy (Tanaka et al., 2019). Smoking might also entail some comorbid risks, as early-pregnancy body mass index for overweight or obesity with SDP might associate with no lower risk or even with an elevated risk for hypertensive disorders (Gudnadóttir et al., 2016; Ness et al., 2008). Also, no inverse association between smoking and pre-eclampsia was found among women of above-average height in a Finnish register study (Ekblad et al., 2022).

2.5.3 Infections

2.5.3.1 Urinary Tract Infections

The immune response during pregnancy is modulated to tolerate the "foreign fetus". Changes in progesterone and estradiol levels result in varying levels of cytokines, leading to a shift towards a humoral rather than cell-mediated immune response (Piccinni et al., 2000). These alterations in immune response may also explain the reduced incidence of autoimmune symptoms during pregnancy (Pazos et al., 2012). Research indicates that pregnant women are more susceptible to severe infections related to certain diseases; however, evidence for a general increased susceptibility to infections is relatively weak (Kourtis et al., 2014). Lower urinary tract symptoms are very common during pregnancy (Kara, 2025). These include nocturia, urgency, stress incontinence, and increased urinary frequency. The latter is believed to be related to the impact of a growing uterus on the bladder; both urgency and stress incontinence are mediated via pressure on the bladder in addition to hormonal changes. Increased water and sodium intake are likely to be partially responsible for nocturia. Hydronephrosis can be present in up to 80% of pregnant women, further predisposing them to bacteriuria and urinary tract infections (UTIs). (Iliodromiti & Neophytou, 2022) Hormonal changes during pregnancy also cause the urinary bladder to relax and dilate more. The uterus occupies the space in the lower abdominal cavity, which may compress the ureters, causing pronounced vesicoureteral reflux. Changes in the tubular exchange of nutrients also occur; for example, glucose reabsorption is less effective during pregnancy, resulting in variable glucose excretion in the urine. Hence, normal blood glucose levels may lead to glucosuria. (Soma-Pillay et al., 2016) These changes, in addition to a modulated immune response during pregnancy, contribute to the increased likelihood of UTIs (Habak & Griggs, 2021), as well as the presence of glucosuria (Iliodromiti & Neophytou, 2022). Several predisposing factors have also been recognized for UTIs during pregnancy, including prior UTIs, diabetes, medically indigent status, and neurogenic bladder (Gilstrap & Ramin, 2001; Johnson et al., 2021). UTIs were more prevalent among younger pregnant women and those with low education and income in an extensive US study (Johnson et al., 2021).

During pregnancy, the prevalence of asymptomatic bacteriuria has been estimated to be 2%–10%, whereas the prevalence of cystitis is significantly lower, ranging from 1% to 2% (Glaser & Schaeffer, 2015). However, in a US study, the prevalence of self-reported UTI during pregnancy was as high as 18% (Johnson et al., 2021). According to a systematic review, the prevalence of symptomatic or asymptomatic UTI was almost one-fourth among pregnant women (Salari et al., 2023). UTI is also one of the most common reasons for antibiotic treatment during pregnancy (Schilling et al., 2022). If asymptomatic bacteriuria remains untreated, approximately one in every four pregnant women will present with a UTI (Gilstrap & Ramin, 2001). Pregnant women are also at a 20-to-30-fold higher risk for developing a pyelonephritis later during pregnancy due to asymptomatic bacteriuria compared to the non-pregnant population (Nicolle et al., 2005). The prevalence of acute pyelonephritis is estimated to be up to 1% during pregnancy (Glaser & Schaeffer, 2015). In addition, other maternal complications of UTI, such as acute respiratory distress syndrome, septicemia, and anemia, have been described (Grette et al., 2020).

SDP does not seem to affect the prevalence of bacteriuria (Greve et al., 2020). Nevertheless, in Denmark, pregnant women who smoke received more antibiotic treatment for UTIs during pregnancy than women who do not smoke (Stokholm et al., 2013). In studies on women who are not pregnant, this association between smoking and UTIs has not been apparent (Vessey et al., 1987). Inpatient care due to pyelonephritis was more common in a US sample of pregnant women who smoked compared to women who did not smoke (Roelands et al., 2009). UTIs during pregnancy have also been associated with pre-eclampsia, especially during the last trimester (Easter et al., 2016). A recent systematic review also proposes a connection to preterm birth (Wang et al., 2024). Especially, pyelonephritis can increase the risk of preterm birth (Jolley & Wing, 2010).

According to the Finnish guidelines, diagnosing and treating a UTI during pregnancy should always be based on a urine culture. Bacterial cultures of urine from asymptomatic pregnant women indicate antibacterial treatment according to Finnish treatment guidelines (Current care guidelines: Urinary tract infections [Virtsatieinfektiot], 2024a). THL (n.d.-d) also recommends screening all pregnant women for bacteriuria via urine culture during pregnancy.

2.5.3.2 Other infections

Pregnant women who smoke appear to have a higher likelihood of respiratory infections during pregnancy than pregnant women who do not smoke (Roelands et al., 2009). Pregnant women were more likely to be admitted to the hospital for respiratory illness during the influenza season in all three trimesters compared to the year before pregnancy. The rates were significantly higher among pregnant women with comorbidities. (Dodds et al., 2007) During the pandemic in 2009–2010, pregnant women who smoked were more likely to be hospitalized or admitted to the intensive care unit due to a novel influenza A virus (Varner et al., 2011; Yates et al., 2010). Also, severe coronavirus disease in 2019 was more prevalent among pregnant women who smoked (Lassi et al., 2021). The higher susceptibility to severe influenza during pregnancy is supposedly mediated by prenatal physiological changes in the respiratory and cardiovascular systems, as well as alterations in the immune system.

Also, sexually transmitted infections (e.g., chlamydial or gonococcal infections) are more common among pregnant women who smoke (Gregory & Ely, 2020; Gulersen et al., 2022). According to self-reported data, a higher prevalence of non-respiratory infection symptoms exists among pregnant women who smoke compared to non-smoking women (Collier et al., 2009). Women who smoke are also more likely to have received antibiotic treatment during pregnancy than women who do not smoke (Schilling et al., 2022).

2.5.4 Cardiovascular and Respiratory Health

Several changes related to the cardiovascular system occur during pregnancy. Cardiac output increases by approximately 40% due to an increase in stroke volume and heart rate (Iliodromiti & Neophytou, 2022). The increase in stroke volume is considered to result from physiological cardiac dilatation, where ventricular mass and end-diastolic volumes increase, as well as myocardial contractility (Soma-Pillay et al., 2016). Palpitations are frequently reported during pregnancy, and pregnant women may suffer from extrasystoles or sinus tachycardia. Often, this is a combination of hormonal, hemodynamic, and autonomic neural changes, which might heighten awareness of palpitations. (Jarvis & Nelson-Piercy, 2020)

Smoking is considered a risk factor for hypertension in general (National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health, 2014). Women might be more susceptible to the elevation of blood pressure, as a Korean study demonstrated a positive correlation between cotinine-verified smoking and hypertension in the female population, but not in the male one (Kim & Lee, 2019). The relationship between smoking and hypertension in the pregnant population remains controversial. A physiological decrease in blood pressure is evident during the first and second trimesters, but later, an increase occurs during the third trimester, reaching non-pregnant levels by term (Iliodromiti & Neophytou, 2022). According to a meta-analysis of 13 studies, SDP was associated with a lower likelihood of hypertension during pregnancy, especially in the European and North American populations (Wang et al., 2022). However, smoking cessation before or during pregnancy appears not to have this protective effect (England et al., 2002;

Wang et al., 2022). In a longitudinal cohort, smoking was not associated with hypertension, whereas repeated blood pressure measures were higher among primiparas, especially with higher baseline BMI (Strevens et al., 2002). Smoking has been inversely associated with pre-eclampsia and hypertensive disorders, as described in the previous chapter 2.5.2.

Stroke is a rare reason for prenatal hospitalization, but smoking is more prevalent among women who have experienced a stroke during pregnancy (Elgendy et al., 2020; James et al., 2005, Roelands et al. 2009). In a Finnish register study, smoking after the first trimester was associated with a higher likelihood of stroke during pregnancy or puerperium in multivariate analysis (Karjalainen et al., 2021). Smoking has also been associated with myocardial infarction during pregnancy. (Roelands et al. 2009)

Breathlessness can occur in up to 70% of pregnant women, especially towards the end of the pregnancy. During pregnancy, the ventilation rate remains unchanged, but the tidal volume and, consequently, the minute ventilation increase by 40%–50% by the end of pregnancy. The forced vital capacity maneuver (FEV1) is not affected during pregnancy. (Jarvis & Nelson-Piercy, 2020) Progesterone may promote hyperventilation, and the growing uterus also causes mechanical changes. In a study on pregnant women, women who smoked had lower values in spirometry investigations than women who did not smoke (Das et al., 1991). Smoking pre-pregnancy among healthy pregnant women had a negligible effect, and dyspnea was not associated with changes in spirometry values (Hirnle et al., 2013). Although obesity may affect breathing, pre-pregnancy overweight or excessive weight gain were not associated with lower values in repeated spirometry testing during pregnancy (Grindheim et al., 2012).

Additionally, the physiological drop in hemoglobin level may contribute to the symptoms of dyspnea. Hemodilution is a result of a proportionally larger increase in the plasma volume that occurs compared to the total red blood cell mass increase throughout the pregnancy (Iliodromiti & Neophytou, 2022). Nevertheless, older and pregnant women who smoked had lower hemoglobin values than women who did not smoke (Rasmussen et al., 2005). Smoking is also a risk factor for asthma exacerbations during pregnancy (Murphy et al., 2010; Robijn et al., 2022).

2.5.5 Thromboembolisms

The time of pregnancy and puerperium presents a hypercoagulable condition, aiming to minimize blood loss during delivery. Sequentially, the risk for thrombotic diseases (such as pulmonary embolism and deep venous thromboembolisms) is elevated as the amount of various procoagulants increases, contrary to a reduction in anticoagulant count. (Iliodromiti & Neophytou, 2022) A common symptom of deep venous thromboembolisms in lower extremities is swelling (mainly unilateral); as peripheral edema is a universal symptom among pregnant women, these symptoms might sometimes be difficult to distinguish from a disease. Plasma colloid osmotic pressure is lower during pregnancy, resulting in frequent peripheral edema of varying degrees. Additionally, peripheral vasodilation may contribute to these effects. (Iliodromiti & Neophytou, 2022)

Pregnancy is considered a weak transient risk factor for thromboembolism, with a three-to-ten-fold risk for deep venous thromboembolism (Kearon et al., 2016; Khan et al., 2021). Smoking has also been associated with a higher likelihood of venous thromboembolisms in the general population; however, a meta-analysis concluded an association in case-control studies but not in cohort studies (Mi et al., 2016). In a Danish population-based study, smoking in early pregnancy resulted in a higher prevalence of deep venous thromboembolism and pulmonary embolism during pregnancy and puerperium. Still, when considering timing, only deep venous thromboembolism during pregnancy was associated with smoking. (Larsen et al., 2007) In an American case-control study, smoking was associated with deep venous thromboembolism and pulmonary embolism both during pregnancy and puerperium. The association between former smoking and venous thromboembolism was not statistically significant. (Danilenko-Dixon et al., 2001) In a Swedish register study, only heavy smoking was associated with venous thromboembolism during pregnancy (Lindqvist et al., 1999).

2.5.6 Mental Health

Previous studies have reported varying prevalences of depressive symptoms among pregnant women who smoke during their pregnancy (Ludman et al., 2000; Pritchard, 1994; Räisänen et al., 2014c). However, in the study by Ludman et al. (2000), the association between smoking and depressive symptoms attenuated after adjusting for demographic factors. Also, a review concluded that smoking did not associate with depressive symptoms during pregnancy in a multivariate model, although bivariate models suggested a mild association (Lancaster et al., 2010). Nevertheless, in many studies, current depressive symptoms are more likely to be reported among pregnant women who smoke compared to women who do not (Reynolds et al., 2020; Smedberg et al., 2015). Similarly, women who were formerly or currently smoking were more likely to screen positive for depression (Zhu & Valbo, 2002).

Continued SDP was associated with more anxiety and depressive symptoms compared to women who quit during the first trimester or did not smoke (Míguez et al., 2019). According to Ludman et al. (2000), smoking and self-reported stress were also unrelated. In a Spanish cohort, continued SDP was associated with high anxiety and depression scores compared to women who quit smoking or were not smoking

(Pereira et al., 2020). In a US study, nicotine dependency during pregnancy significantly predicted any mental health disorder, any mood disorder, major depression, dysthymia, and panic disorder during the past year (Goodwin et al., 2007).

According to a meta-analysis of 13 studies, prenatal smoking was associated with postpartum depression compared to women who do not smoke (Chen et al., 2019). Pre-pregnancy smoking was associated with a new depression diagnosis two years postpartum in a Korean retrospective cohort, where women with pre-existing conditions were excluded (Yook et al., 2022). Unlike a Japanese nationwide cohort study, smoking before pregnancy was not associated with postpartum depression, but quitting smoking or SDP was (Cui et al., 2020). Also, sole postpartum smoking after a smoke-free pregnancy has been associated with postpartum depression (Barber & Shenassa, 2021). The direction of the relationship between smoking and mental health remains a mystery.

2.5.7 Other Health Outcomes

During pregnancy, several physiological changes occur, which might contribute to the interplay of smoking and the prenatal health outcomes. Progesterone appears to be responsible for many of these physiological changes (Iliodromiti & Neophytou, 2022). Taken together, these factors might impact healthcare utilization. About 80%–90% of pregnant women experience nausea and vomiting (Einarson et al., 2013). These symptoms are most prevalent during the early stages of pregnancy and are allegedly due to various factors; the etiology is not totally clear. Hormonal changes, such as elevated levels of estrogen and introduction of human chorionic gonadotropin (hCG), have been proposed to mediate these symptoms (Iliodromiti & Neophytou, 2022). Hyperemesis gravidarum, a severe form of nausea and vomiting, is a common reason for hospitalization during pregnancy. According to a meta-analysis, the results are fairly unanimous that smoking seems to lower the likelihood of hyperemesis gravidarum (Jenabi & Fereidooni, 2017). Smoking also appears to be associated with a lower risk of hospitalization due to hyperemesis gravidarum (Fell et al., 2006). In a more recent Finnish register study, smoking was associated with a lower likelihood of hyperemesis. When comparing the pregnancies of the same women, where hyperemesis was present in only one of the pregnancies, only continued smoking was associated with a lower likelihood of hyperemesis. (Nurmi et al., 2020) A longitudinal Dutch cohort study found no association between SDP and general nausea and vomiting during pregnancy (Dekkers et al., 2019).

Pelvic girdle pain is another common symptom among up to 76% of pregnant women (Vleeming et al., 2008). Increasing progesterone levels, as well as relaxin hormone, lead to the laxity of various ligaments (Jarvis & Nelson-Piercy, 2020). In addition to hypermobility of the sacroiliac joint and pubic symphysis, pelvic and lower back pain can result from a changed posture, such as pronounced lordosis and muscle weakness (Iliodromiti & Neophytou, 2022; Soma-Pillay et al., 2016). Women who smoked or quit smoking are more likely to report pelvic girdle pain during pregnancy, especially severe pain (Biering et al., 2010), which is a significant reason for self-reported sick leave during pregnancy in Norway (Dørheim et al., 2013). Also, in a Danish study, smoking was associated with symphysiolysis but not other types of pelvic pain, with self-reported and objectively assessed pain among pregnant women at 33 weeks of gestation (Albert et al., 2006). However, smoking was not associated with lower back pain in a survey study on self-reported back pain during pregnancy (Wang et al., 2004).

Pregnancy primarily influences the endocrine system via the introduction of placental hormones and increased binding of proteins. The main placental hormones include hCG, estrogen, progesterone, human placental lactogen, placental growth hormone, relaxin, and kisspeptin. In addition, the placenta produces corticotropin-releasing hormone, which stimulates the production of maternal adrenocorticotropic hormone. Early-pregnancy subclinical hyperthyroidism is common; however, the levels of free triiodothyronine and thyroxine may decrease slightly due to an increase in binding proteins. (Iliodromiti & Neophytou, 2022) Smoking seems to affect thyroid function during pregnancy, and continued smoking was associated with slightly lower thyroid-stimulating hormone and free thyroxine values during early pregnancy in an extensive Norwegian cohort study (Andersen et al., 2021). In a Danish study, pregnant women who smoked were less likely to develop prenatal hypothyroidism and more likely to develop hyperthyroidism postpartum (Andersen et al., 2014).

Gestational diabetes has received particular attention as it is a growing obstetric problem, but a systematic review and meta-analysis of 12 studies found no association between SDP and gestational diabetes (Wang et al., 2020). However, an extensive study in the US concluded an association between smoking and gestational diabetes, especially among normal or overweight women, or women with excessive weight gain, compared to women who do not smoke (Bar-Zeev et al., 2020). Table 4 summarizes the associations of SDP and maternal health outcomes.

Table 4. Summary of the associations between smoking during pregnancy and prenatal health.

OUTCOME	WOMEN WHO SMOKE	REFERENCES
Obstetric	More likely referred to obstetric care	Weiland et al. 2022, Bendix et al. 2016
	Higher likelihood of preterm birth	Jaddoe et al. 2008, Tarasi et al. 2022, Nabet et al. 2007
	Higher likelihood of placental abruption	Chen et al. 2025
	Lower likelihood of hypertensive disorders	Conde-Agudelo et al. 1999
	More intensive care interventions after delivery	Kern-Goldberger et al. 2022
Infections	More respiratory infections, more severe infections, and hospitalizations	Roelands et al. 2009, Lassi et al. 2021, Varner et al. 2011, Yates et al. 2010
	More sexually transmitted infections and urinary tract infections	Gregory & Ely 2020, Gulersen et al. 2022, Stokholm et al. 2013
	More non-respiratory antibiotic treatment	Collier et al. 2009, Schilling et al. 2022
Cardiovascular and respiratory	Stroke, myocardial infarction	Karjalainen et al. 2021, Roelands et al. 2009
	Lower likelihood of hypertension during pregnancy	Wang et al. 2022
	More asthma exacerbations	Murphy et al. 2010, Robijn et al. 2022, Roelands et al. 2009
Thromboembolisms	Increased likelihood of pulmonary embolisms and deep venous thromboembolisms	Larsen et al. 2007, Lindqvist et al. 1999, Roelands et al. 2009
Gastrointestinal	Lower likelihood and fewer hospitalizations for hyperemesis	Jenabi & Fereidooni 2017, Fell et al. 2006, Nurmi et al. 2020
	Peptic ulcers, malnutrition	Roelands et al. 2009
Musculoskeletal	Report pelvic girdle pain more often	Biering et al. 2010, Albert et al. 2006
Endocrinological	Lower likelihood of prenatal hypothyroidism	Andersen et al. 2014
	Obesity	Roelands et al. 2009
Mental health	Higher likelihood for depressive, stress, and anxiety symptoms and disorders, postpartum depression	Reynolds et al. 2020, Smedberg et al. 2015, Zhu & Valbo 2002, Míguez et al. 2019, Pereira et al. 2020, Chen et al 2019, Cui et al. 2020, Goodwin et al. 2007

2.6 The Use of Other Nicotine-containing Products and Health Outcomes during Pregnancy

The use of other nicotine-containing products during pregnancy and their health outcomes are not well documented. Previous human studies concerning the use of electronic cigarettes during pregnancy are scarce (Cardenas et al., 2019). People tend to perceive electronic cigarettes as a less hazardous option, including during pregnancy (Baeza-Loya et al., 2014; Mark et al., 2015). In a US study, the dual use of electronic and traditional cigarettes increased the likelihood of small for gestational age newborns; the dual users who stopped SDP but continued electronic cigarette use had a threefold risk for small for gestational age infants compared to women who quit smoking (Cardenas et al., 2020). In an RCT of pregnant women who smoked, abstaining from smoking but using nicotine patches or electronic cigarettes delivered higher birth weight infants than women who continued SDP (Pesola et al., 2024). Sole vaping resulted in lower levels of various harmful substances that were similar to those of women who did not use any products. These levels were lower than those of women who used electronic and traditional cigarettes. (Ussher et al., 2025)

According to a systematic review, sole vaping seems to have similar outcomes compared to non-users. However, they concluded that the content and amount of vaping should be better assessed in these studies. (Ussher et al., 2024b) The exclusive use of electronic cigarettes has been associated with low birth weight (Ammar et al., 2023; Shittu et al., 2022) and preterm birth (Ammar et al., 2023). Electronic cigarette use was not associated with having a small for gestational age infant compared to non-use, but quitting electronic cigarette use was associated with reduced risk for having a low birth weight or small for gestational age infant compared to continued use of electronic cigarettes (Ammar et al., 2023). Also, hospital stay following birth was more extended among women who smoked electronic cigarettes than among women who did not (Galbo et al., 2022). Some maternal outcomes have also been studied, and the use of electronic cigarettes before or during pregnancy did not show an increased risk for postpartum depression compared to women who did not use electronic cigarettes (Choi et al., 2024). Vaping itself may also possess risks that have not been associated with traditional cigarette smoking.

Daily use of Swedish snus was associated with reduced gestational length and birth weight in newborns compared to women who had never used snus in a Norwegian cohort. However, the association with birth weight was weaker compared to women who smoked cigarettes during pregnancy. (Lie et al., 2024) Current research lacks data regarding the use of nicotine pouches and health outcomes during pregnancy.

2.7 Prenatal Care in Finland

In Finland, the organization of prenatal care is based on legislation (Valtioneuvoston asetus 338/2011, 2011). Pregnant women do not automatically see an obstetrician during a normal pregnancy; instead, a public health nurse or, in some cases, a midwife mainly monitors pregnancy in primary care prenatal clinics. All these visits are free of charge. Women attend the clinic approximately eight to ten times during pregnancy and twice after pregnancy. Scheduled visits for prenatal clinic GP are at 13–18 weeks and 35–36 weeks of gestation (THL, n.d.-d). Formerly, the second postpartum visit, 8–12 weeks after delivery, was scheduled for a GP, but currently these can be performed by a GP, a midwife, or a nurse. Additional visits to a nurse or GP are offered if considered necessary. About 2% of primiparous women attended the prenatal clinic 16 times or more during their pregnancy (Klemetti et al., 2014).

Almost all women attend the clinic at least once during pregnancy because to receive the pregnancy and parental allowance from the government, a prenatal care visit is required (Social Insurance Institution of Finland, n.d.). Most women view the prenatal clinic services positively (Kojo-Austin et al., 1993). According to the latest nationwide surveys of child and maternity clinic patients, clients rated these services as valuable, with an average score of 4.7 on a scale of one to five (strongly disagree – strongly agree), showing minimal variation between Wellbeing Services Counties. THL organizes the survey (THL, n.d.-a)

All pregnant women are offered two voluntary ultrasound screenings, typically organized in secondary or tertiary care obstetric clinics, including a general early pregnancy ultrasound at the end of the first trimester and a second ultrasound during the second trimester to detect fetal anomalies (Ministry of Social Affairs and Health, Finland, n.d.). Specially trained midwives perform these ultrasounds in normal pregnancies. In some high-risk pregnancies, a gynecologist performs these screenings.

If an obstetrician or gynecologist's expertise is needed, a GP or public health nurse refers the pregnant woman to specialized care (secondary or tertiary care hospital). According to a Finnish study, pregnant women attended a consultation approximately 3.2 times during their pregnancy, with over half being for a routine ultrasound, such as for a post-term pregnancy or planning of the delivery method (Kojo-Austin et al., 1993). Hospitalizations during pregnancy have decreased from 22% to 11% between 1991 and 2008 (Klemetti et al., 2014).

2.8 Smoking Cessation Support in Finnish Prenatal Care

No structured smoking cessation protocols exist in most prenatal clinics in Finland, despite the establishment of national guidelines based on the 5A approach. The principles of the approach are presented in Table 5. The Finnish Institute of Health and Welfare has produced special material for prenatal clinics. (THL, 2017) Nurses are also instructed to guide smoking parents to other free-of-charge support that is available by phone or online (Finnish Heart Association, n.d.; The Organisation for Respiratory Health in Finland, n.d.). Pregnant women visit prenatal clinics multiple times during their pregnancy. Therefore, the most accessible cessation support would be from the midwives or nurses. Some clinics use CO meters, which show maternal exhaled CO values and an estimate for fetal value, for smoking cessation support.

Table 5. The execution of the 5A approach for smoking cessation intervention in a primary care setting. Modified from WHO Toolkit for Delivering the 5A's and 5R's Brief Tobacco Interventions in Primary Care (WHO, 2014).

5A´S	ACTION AND IMPLEMENTATION DURING PREGNANCY
Ask	Ask pregnant women systematically about tobacco use and other nicotine-containing products and document it. This should be done routinely in every visit.
Advise	Emphasize the importance and necessity of smoking cessation. Counsel about the harmful effects of smoking on the fetus and pregnancy. The communication should be clear, strong, and personalized in the patient's context.
Assess	Assess the patient's preparedness to quit, for example, using the following two questions: 1. Would you like to be a person who does not smoke? 2. Do you think you have a chance of quitting successfully? Assess the possible obstacles.
Assist	Help a pregnant woman create a quit plan by providing the means and support (e.g., social support) and assess whether NRT is an option. Provide the materials and resources. Offer a guide to support groups, which can also be web-based.
Arrange	Arrange a follow-up plan, and schedule control visits or phone calls. Refer to another healthcare worker if needed. Also, provide support after cessation or relapse and make new arrangements.

In Finland, some regional treatment chains have also been established to improve recognition and provide intensive cessation support during pregnancy and lactation. A pro gradu thesis investigated the nurses' perceptions of implementing these new strategies. Based on its results, in practice, the use of guidelines varied substantially, and prenatal clinic nurses wished for more tools than just electronic resources (e.g., web pages) (Vuorenmäki, 2018). These included brochures, and their theoretical frame originated from the 5A approach. A New Zealand study reported that midwives face challenges in addressing SDP and feared that smoking cessation advice might negatively impact the patient relationship (McLeod et al., 2003). This is also often the perception in clinical work as a prenatal clinic GP in Finland.

More tangible tools have been sought to enhance nurses' ability to address smoking and offer cessation support (e.g., breath CO measures) that can be incorporated into routine prenatal clinic care. According to a recent review, the evidence regarding CO measurements is scarce, and it is unclear whether there is a benefit in smoking cessation or if it is an effective tool for more accurately identifying smoking only (Gaudron & Davis, 2024). A financial reward campaign (coupons for local stores) has also been conducted in a Finnish prenatal clinic project to promote smoking cessation. However, at the moment, such campaigns or projects are reportedly not in use in Finland.

The Finnish guidelines for smoking cessation recommend that NRT can be used in some cases, with low-dose and short-acting products (Current care guidelines: Prevention and treatment of tobacco and nicotine dependence [Tupakka- ja nikotiiniriippuvuuden ehkäisy ja hoito], 2024b). According to a Finnish review, NRT's goal should be smoking cessation, lowering fetal exposure (Ekblad & Vähäkangas, 2020). Thus, a structured intervention and quit plan should be prepared with NRT's initiation. NRT use in prenatal care appears to be quite rare, but no research data is available from Finland.

Usually, no special interventions in secondary care are available for smoking cessation during pregnancy in Finland if no other risk behaviors are present in addition to smoking. If a pregnant woman smokes throughout the pregnancy, no special actions are undertaken. Special policlinics in specialized care, HAL (derived from the Finnish words for illicit drugs, alcohol, and pharmaceuticals), have been constituted in Finland to follow the pregnancies of women needing more support and intense pregnancy follow-up. Typically, these women have prior or former use of illicit drugs or heavy alcohol consumption. THL issued recommendations on referral criteria in the fall of 2023, and daily use of nicotine is listed as among them. One criterion is "the use of ten or more daily cigarettes, or Swedish snus or other nicotine-containing products". (THL, 2023b) The different well-being service counties have incorporated this with some variations into their referral criteria (Kainuun hyvinvointialue, n.d.; Keski-Suomen hyvinvointialue, n.d.). Some well-being service counties have listed smoking as only a contributory factor for referrals when other social problems or substance use exist (Satakunnan hyvinvointialue, 2025; Pirkanmaan hyvinvointialue, n.d.).

3 Aims

This dissertation examines the association of prenatal smoking and maternal health care utilization during pregnancy. It aims to increase knowledge about different aspects contributing to SDP and aspires to offer new insights about factors contributing to continued smoking after one pregnancy.

The specific aims of this dissertation are:

1. To study SDP and its association with maternal outpatient and inpatient specialized care due to different diagnoses during pregnancy (Study I)
2. To investigate the role of maternal smoking regarding the prevalence of different urinary tract infections during pregnancy in specialized care (Study II)
3. To acquire more knowledge about the relationship between psychiatric morbidity and smoking habits in consecutive pregnancies among women who smoked during their first pregnancy (Study III)

4 Materials and Methods

4.1 Data Sources

The data for Studies I–III were obtained from two national registers: the Finnish Medical Birth Register and the Finnish Care Register for Health Care. The data concerning maternal smoking were derived from the Medical Birth Register and combined with information about diagnoses during pregnancy using the mothers' identification numbers. THL, the current register keeper, carried out the data integration.

4.1.1 Finnish Medical Birth Register

The Finnish Medical Birth Register includes data regarding all live births, as well as stillbirths of newborns with birthweights over 500 grams or from the gestational age of 22 weeks onwards. These data are derived from delivery hospitals or from health personnel assisting in home births, which are relatively infrequent in Finland. The register contains identification numbers for the mother and child, as well as information about the maternal background, pregnancy, obstetric care, and delivery. Some information (pre-pregnancy BMI, information about infertility treatments, and diagnoses during pregnancy and delivery) has been collected since 2004; this information has been available from all delivery hospitals since 2006.

Data on SDP are based on mothers' self-reported information and are collected by midwives and nurses in prenatal clinics. The smoking information is recorded in the following three categories: 1) non-smoking, 2) smoking during the first trimester, and 3) smoking after the first trimester. From January 2017 onwards, the latter has been further divided into two separate categories: daily smoking and occasional smoking after the first trimester. The information on whether the smoking was daily or only occasional during the first trimester has not been collected during the study period.

The Medical Birth Register collects dichotomous information (yes/no) of inpatient specialized care during pregnancy from the prenatal clinic records. The number of prenatal clinic visits, specialized care outpatient control visits (e.g., fetal ultrasound screenings), and the total number of specialized control visits are also collected. The data about diagnoses during pregnancy are collected according to the Tenth Revision of the International Classification of Diseases and Related Health Problems (ICD–10) codes. These have been recorded since January 2004, excluding births in Helsinki University Hospital, where the diagnoses have been collected since January 2005. This information is collected directly from delivery hospitals and may include information from primary healthcare providers and specialized care hospitals. According to data quality studies, the Medical Birth Register data corresponds well or satisfactorily with hospital records (Gissler et al., 1995; Teperi, 1993).

Several maternal background factors are recorded: maternal age at delivery, parity, marital status, socioeconomic status, the level of urbanity of the place of residence, preceding infertility treatments, and pre-pregnancy BMI. In the national statistical municipal classification, the degree of the municipality's urbanity is divided into three categories: urban municipalities (at least 90% of the population lives in urban settlements or the population of the largest urban settlement is at least 15,000), semi-urban municipalities (at least 60% but less than 90% of the population lives in urban settlements, and the population of the largest urban settlement is at least 4,000 but fewer than 15,000), rural municipalities (less than 60% of the population lives in urban settlements and the population of the largest urban settlement is under 15,000, as well as those where 60% to 89.9% of the population lives in urban settlements and the population of the largest urban settlement is under 4,000). The national classification for socioeconomic status is based on maternal occupation: (1) upper white-collar workers, such as teachers, physicians, and journalists; (2) lower white-collar workers, such as secretaries, nurses, and shop assistants; (3) blue-collar workers, such as dressmakers, cooks, and cleaners; and (4) others including students, homemakers, unemployed, and those with unclassified occupations.

4.1.2 Finnish Care Register for Health Care

The Finnish Care Register for Health Care collects information about specialized care in Finland. Since 1969, it has included information regarding all episodes of inpatient care at public and private specialized care hospitals. From 1998 onwards, information on outpatient visits to public specialized care is also included. The register contains information on the patient's background, dates of admission and discharge, the number of hospitalization days, and procedures undertaken. Each entry is provided with a primary diagnosis and possible additional diagnoses (maximum of two). Information about diagnoses is collected according to the ICD classification, and the tenth version (ICD-10) has been in use since 1996. The information regarding outpatient visits primarily includes physician visits, but may also include visits to nurses or midwives. Nurses or midwives record also ICD-10 diagnoses, which are precededly recorded by a physician. Physician confirms these

ICD-10 diagnoses. A systematic review showed that the completeness and accuracy of the register range from satisfactory to very good (Sund, 2012).

4.2 Study Populations and Variables

4.2.1 Study I

4.2.1.1 Study Population

The study population comprises all women who gave birth between January 1999 and December 2015 in Finland (n = 975,633). This time period was chosen because, during this period, the register included all outpatient visits, and the ICD-10 classification was consistently used throughout the study period. Multiple pregnancies (twin or triplet pregnancies) (n = 14,506, 1.5%) were excluded. The final study sample consisted of 936,113 pregnancies (95.9% of all births during the study period).

4.2.1.2 Variables

4.2.1.2.1 Smoking (Exposure)

The smoking information was retrieved from the Medical Birth Register, and three categories were formed based on the duration of smoking: 1) no smoking (82.4%), 2) smoking during the first trimester only, later referred to as ‘quit smoking’, (4.3%), and 3) smoking after the first trimester, later referred to as ‘continued smoking’, (10.7%). The information on smoking status was missing for 25,014 singleton pregnancies (2.6%), which were excluded from the statistical analysis.

4.2.1.2.2 Diagnosis from Prenatal Care (Outcome)

Inpatient specialized care due to bleeding, threatened premature birth, elevated blood pressure, and “other” (not further specified reason) were obtained from the Finnish Medical Birth Register, as well as the numbers of different control visits in prenatal and related specialized care. In addition, the available ICD-10 diagnoses from the Finnish Medical Birth Register were combined with the Care Register data.

4.2.1.2.3 Diagnosis from Specialized Care (Outcome)

Diagnoses from specialized care were acquired from the Care Register for Health Care. They were analyzed according to the ICD-10 diagnosis chapters, based on the different codes. The analysis was performed separately for inpatient and outpatient specialized care across 18 ICD-10 chapters (Table 6). The following exclusions were made: codes for special purposes (codes U00–U99), external causes of morbidity and mortality V01–Y98), congenital anomalies (codes Q00–Q99), and certain conditions originating in the perinatal period (codes P00–P96), as they were considered non-eligible in the scope of this study. We chose to analyze the data by ICD-10 diagnosis chapters, organized by organ systems, because the aim of this study was to investigate the association between SDP and health outcomes across larger sets, rather than as individual diagnoses, to provide a representative picture of SDP's associations with maternal health. The total number of each individual diagnosis might have been too low to perform statistical analysis. One care episode could consist of up to three diagnosis codes, and each was studied separately rather than as a single episode. Women with psychiatric problems might have more substance use and be more prone to other illnesses during pregnancy (Havens et al., 2009). Therefore, we performed additional sensitivity analyses for inpatient and outpatient care with only women who never had psychiatric inpatient care.

Table 6. List of diagnosis chapters according to the Tenth Revision of the International Classification of Diseases (ICD-10). Modified from Wallin et al. (2020).

CHAPTER	CODES	TITLE
I	A00–B99	Certain infectious and parasitic diseases
II	C00–D48	Neoplasms
III	D50–D89	Diseases of the blood and blood-forming organs, immune mechanism
IV	E00–E90	Endocrine, nutritional, and metabolic diseases
V	F00–F99	Mental and behavioural disorders
VI	G00–G99	Diseases of the nervous system
VII	H00–H59	Diseases of the eye and adnexa
VIII	H60–H95	Diseases of the ear and mastoid process
IX	I00–I99	Diseases of the circulatory system
X	J00–J99	Diseases of the respiratory system
XI	K00–K93	Diseases of the digestive system
XII	L00–L99	Diseases of the skin and subcutaneous tissue
XIII	M00–M99	Diseases of the musculoskeletal system and connective tissue
XIV	N00–N99	Diseases of the genitourinary system
XV	O00–O99	Pregnancy, childbirth, and the puerperium
XVI	P00–P96	Certain conditions originating in the perinatal period
XVII	Q00-Q99	Congenital malformations, deformations, and chromosomal abnormalities
XVIII	R00–R99	Symptoms, signs, and abnormal clinical and laboratory findings
XIX	S00–T98	Injury, poisoning, and certain other consequences of external causes
XX	V01–Y98	External causes of morbidity and mortality
XXI	Z00-Z99	Factors influencing health status and contact with health services
XXII	U00–U99	Codes for special purposes

4.2.1.2.4 Confounding Variables and Covariates

Maternal age was considered as a confounding variable as it has been associated with SDP and can be related to maternal morbidity as well. The year of delivery was included, as differences in diagnostics and changes in the organization of maternity and specialized care may occur across years. However, the collection of smoking data has remained constant throughout the study period. Marital status and socioeconomic status have been associated with SDP and were thus incorporated into the analysis. The preceding infertility treatments might reflect maternal health challenges, which might result in more specialized care during pregnancy. It can also be associated with smoking, and was thus selected as a confounding variable. Also, maternal pre-pregnancy BMI can be associated with higher morbidity and was therefore included as a covariate. The degree of urbanity of the place of residence was included, as regional differences in smoking prevalence have been described, with smoking more prevalent in rural areas. The degree of urbanity may also affect access to care, which is more readily available in urban settlements and may hence be reflected in the frequency and documentation of care.

4.2.2 Study II

4.2.2.1 Study Population

The study population consisted of all pregnant women who gave birth in Finland between January 2006 and December 2018 (n = 744,532). Women with multiple pregnancies (n = 21,099, 2.8%) were excluded. Thus, the final study sample consisted of 723,433 pregnant women (97.2% of all births during the study period). Some women had more than one pregnancy during the study period; hence, the study population consisted of 429,929 women.

4.2.2.2 Variables

4.2.2.2.1 Smoking (Exposure)

The smoking data were derived from the Medical Birth Register. This data was categorized into the following three groups: 1) women who do not smoke (82.5%); 2) women who quit smoking during the first trimester (5.7%); and 3) women who continued smoking after the first trimester (8.8%). The information on smoking status was missing from the record for 21,800 singleton pregnancies (3.0%).

4.2.2.2.2 Urinary Tract Infection Diagnosis (Outcome)

UTI diagnoses during pregnancy were acquired from the Finnish Care Register for Health Care and the Finnish Medical Birth Register. The participants were most likely to have been diagnosed in primary care facilities or prenatal clinics if the Care Register for Health Care did not include this information. The diagnoses were analyzed according to the ICD-10 diagnosis codes. We included pregnancy-related UTI diagnoses (from the ICD-10 Chapter XV) and UTI diagnoses from the ICD-10 Chapter XIV for genitourinary diseases to ensure as complete coverage of UTI diagnoses as possible, as codes from either chapter might be used during pregnancy. These UTI diagnoses were combined to form the analysis set (any UTI), which was subsequently divided into lower UTI and upper UTI groups based on the level of infection (Table 7). The non-specific symptom code R82.7, for abnormal findings in the microbiological examination of urine, was excluded from our analysis. The number of such diagnoses was small, and including cases would not have altered the results.

Table 7. The included diagnosis codes in the analysis for any urinary tract infection, according to the Tenth Revision of the International Classification of Diseases (ICD-10). Table reproduced from Wallin et al. (2023).

ANALYSIS SET	ICD-10 CODE	DIAGNOSIS
Lower urinary tract infection (lower UTI)	N30	Cystitis
	N39.0	Urinary tract infection, site not specified
	O23.1	Infections of bladder in pregnancy
	O23.4	Unspecified infection of urinary tract in pregnancy
	O23.9	Other/unspecified genitourinary tract infection in pregnancy
	N34	Urethritis and urethral syndrome
	O23.2	Infections of urethra in pregnancy
Upper urinary tract infection (upper UTI)	N10	Acute tubulo-interstitial nephritis
	N11	Chronic tubulo-interstitial nephritis
	N12	Tubulo-interstitial nephritis, not specified as acute or chronic
	O23.0	Infections of kidney in pregnancy

4.2.2.2.3 Pregnancy-pair Analysis

The pregnancy-pair design was established to study the association between smoking and UTIs during pregnancy in more detail. This allowed us to control for possible underlying intrinsic maternal factors that might contribute to UTIs during pregnancy. The pregnancy-pair analysis included only women who had changed their smoking status in their consecutive pregnancies: from smoking to non-smoking or vice versa. Altogether, 27,246 women had smoked during one but not during both of their consecutive pregnancies (Figure 6). Another smoking variable, 'any smoking', was computed for the pregnancy-pair analysis. It included both women who quit smoking during the first trimester or continued thereafter in one pregnancy.

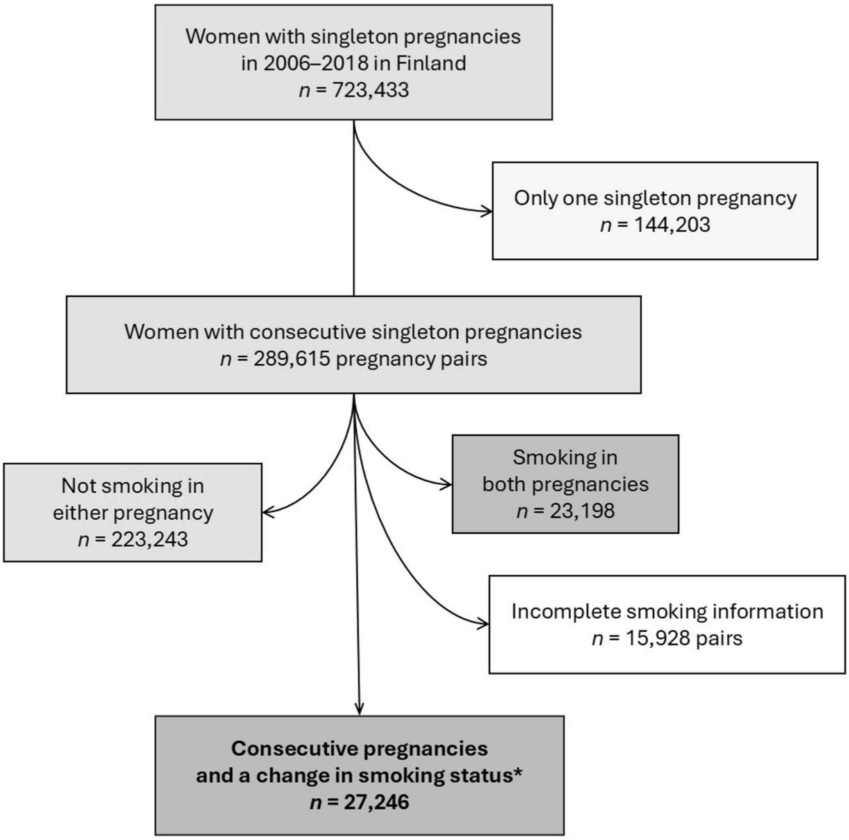

Figure 6. The study design of pregnancy pair analysis in Study II. Modified from Wallin et al. (2023). *Any smoking to no smoking, or no smoking to any smoking.

4.2.2.2.4 Confounding Variables and Covariates

The following confounding variables were used: the year of delivery, maternal age, parity, and socioeconomic status. Maternal pre-pregnancy BMI was included as a covariate, as it can be associated with morbidity. UTIs have been reported to be more frequent among younger women. The same confounding variables and covariates were included as in the pregnancy-pair analysis.

4.2.3 Study III

4.2.3.1 Study Population

The study population consisted of all primiparous women who gave birth to their first and second child (n = 185,147) between January 2006 and December 2019 in Finland (Figure 7). Only singleton pregnancies resulting in a live birth and child alive at the age of one were included. Pregnancies where the smoking data were missing in one or both were excluded.

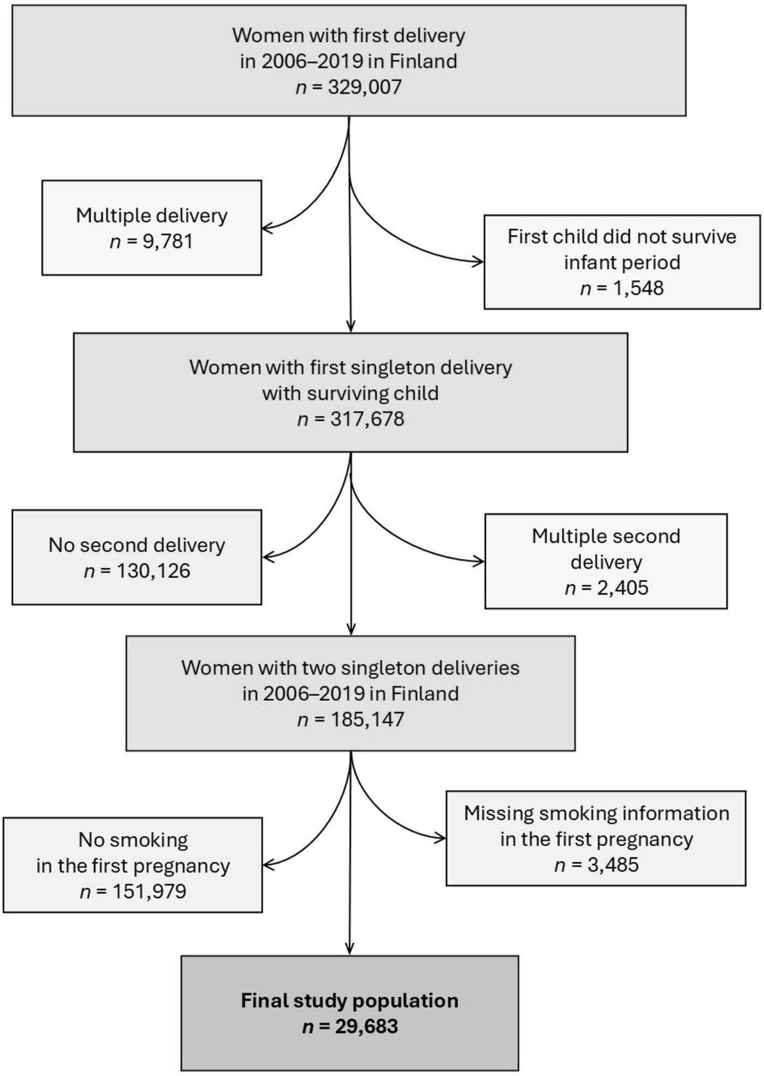

Figure 7. The study design in Study III.

4.2.3.2 Variables

4.2.3.2.1 Lifetime Psychiatric Diagnosis and Burden (Exposure)

Chapter V of the ICD-10 encompasses mental, behavioral, and neurodevelopmental disorders, comprising ICD-10 diagnosis codes F00–F99. During pregnancy, O99.3 for mental disorders and diseases of the nervous system complicating pregnancy, childbirth, and the puerperium can also be used. The primary variable was ‘any lifetime psychiatric diagnosis’, and the ICD-10 diagnoses that were included for this variable are presented in Table 8. Information on psychiatric diagnoses for the lifetime psychiatric diagnosis variable included inpatient care episodes from 1996 onwards, and diagnoses from outpatient specialized care visits from 1998. The variable included only diagnoses received after age 15, up to the birth of the second child. We also analyzed mood disorders (F30–F39); anxiety, dissociative, stress-related, somatoform, and other nonpsychotic mental disorders (F40–F48); and disorders of adult personality and behavior (F60–62, F68–F69) as separate variables. The ‘any lifetime psychiatric diagnosis’ variable included all the chosen psychiatric diagnoses with dichotomized categorization (yes/no).

Table 8. The diagnoses included in the analysis derived from the Tenth Revision of the International Classification of Diseases (ICD-10), chapter V for mental, behavioral, and neurodevelopmental disorders (F00–F99) and chapter XV for pregnancy, childbirth, and the puerperium (O00–O99). Modified from Wallin et al. (2023).

ICD-10 CODES	DIAGNOSES
F10–F16, F18–F19	Mental and behavioral disorders due to psychoactive substance use
F20–29	Schizophrenia, schizotypal, and delusional disorders
F30–39	Mood (affective) disorders
F40–F48	Anxiety, dissociative, stress-related, somatoform, and other nonpsychotic mental disorders
F53	Mental and behavioral disorders associated with the puerperium, not elsewhere classified
F60–62, F68–F69	Disorders of adult personality and behavior
F90, F91–F98	Behavioral and emotional disorders with onset usually occurring in childhood and adolescence
O99.3	Mental disorders and diseases of the nervous system complicating pregnancy, childbirth, and the puerperium

Furthermore, we formed a continuous ‘lifetime psychiatric disease burden’ variable, which represents the number of different psychiatric diagnosis groups from which the woman has received a psychiatric diagnosis (classification 0–5). The diagnosis groups for 1) mental and behavioral disorders due to psychoactive substance use (F10–F16, F18–F19); 2) schizophrenia, schizotypal, and delusional disorders (F20–29); 3) mood disorders (F30–F39); 4) anxiety, dissociative, stress-related, somatoform, and other nonpsychotic mental disorders (F40–F48); 5) disorders of adult personality and behavior (F60–62, F68–F69); and 6) behavioral and emotional disorders with onset usually occurring in childhood and adolescence (F90, F91–F98) were included as psychiatric diagnosis groups in the psychiatric disease burden variable.

We excluded diagnosis groups that were considered ineligible in the scope of this study. Such diagnoses were those concerning organic (including symptomatic) mental disorders (F00–09), behavioral syndromes associated with physiological disturbances and physical factors (F50–52, F54–59), mental retardation (F70–79), and disorders of psychological development (F80–89), as they were considered having separate etiologies compared to the included ones and might not be relevant concerning SDP. Documentation of nicotine addiction (F17) for women who smoke is deficient in these registers and was thus not included in the analysis.

4.2.3.2.2 Smoking during the Second Pregnancy (Outcome)

Most women did not smoke during their first pregnancy (n = 151,979, 82.1%); these pregnancies were excluded from the analysis. The final study sample consisted of women who had smoked at any time during their first pregnancy (n = 29,683, 16.0%). Of these women, 52.5% (n = 15,588) had continued smoking after the first trimester during their first pregnancy, and 47.5% (n = 14,095) had quit smoking during the first trimester of the first pregnancy. Both of these smoking groups were then further divided into three subgroups according to the smoking status in the subsequent pregnancy: 1) no smoking, 2) quit smoking during the first trimester, and 3) continued smoking after the first trimester.

4.2.3.2.3 Confounding Variables and Covariates

The following confounding variables were used: the year of the second delivery, maternal age during the second delivery, the time between deliveries (rounded to the nearest year), socioeconomic status, and marital status. The time between deliveries was included as a longer interval might affect the likelihood of smoking, but it also enables a more extensive time period for psychiatric care to take place.

4.3 Statistical Analysis

The data analysis was performed with SAS, version 9.4 (SAS Institute Inc., Cary, North Carolina). Differences in the results were evaluated using 95% confidence intervals and p-values. Non-overlapping confidence intervals and p-values <0.05 were considered statistically significant.

In Study I, the association between SDP (exposure) and diagnoses from specialized care during pregnancy was analyzed using logistic regression. The analysis was conducted separately for inpatient and outpatient care. Each diagnosis (code) was considered only once for one pregnant woman. Regarding inpatient care, we also investigated the number of care episodes and the cumulative number of hospitalization days using an independent-samples t-test.

The association between maternal smoking status (exposure) and any UTI diagnosis during pregnancy was analyzed using logistic regression in Study II (standard model). The smoking status, i.e., quit smoking or continued smoking, was compared to no smoking. A logistic regression analysis was also conducted separately for upper and lower UTIs. If the woman had more than one UTI diagnosis within the same category, it was considered only once. The amount of outpatient and inpatient care (in the latter, the number of care episodes and the cumulative number of hospitalization days were also considered) was analyzed according to the same UTI categories as noted previously. This was done using an independent samples t-test. In pregnancy-pair analysis, any smoking (exposure) was compared to no smoking, and analyzed with conditional logistic regression analysis. Different pregnancies of the same woman were grouped into a single cluster. To test our pregnancy-pair design, we conducted sensitivity analyses to examine the causal association between SDP and birthweight. The sensitivity analysis replicated the causal association between SDP and birthweight, which confirmed a difference regarding the women's smoking status.

In study III, the association between maternal psychiatric diagnoses and maternal smoking status in the second pregnancy (outcome) was analyzed using logistic regression analysis. The analysis was conducted separately for women who quit smoking and for those who continued smoking during their first pregnancy. Furthermore, women who quit smoking and women who continued smoking during the second pregnancy were separately compared to those who did not smoke during their second pregnancy. In the models, maternal psychiatric diagnoses (any psychiatric diagnosis or a diagnosis from a designated group of ICD-10 diagnosis codes) and psychiatric disease burden were analyzed separately, with the maternal smoking status in the second pregnancy as the dependent variable.

Table 9 presents the confounding variables and covariates incorporated into the logistic regression analysis, along with their classifications.

Table 9. The confounding variables and covariates in the statistical analysis of Studies I–III.

CONFOUNDING VARIABLE / COVARIATE	VARIABLE TYPE	CATEGORIES
Maternal age [I, II, III]	continuous	
Marital status [I, III]	categorized	single married or cohabiting
Parity [I, II]	categorized	0, 1–4, 5 or more
Year of delivery [I, II, III (second child)]	continuous	
Pre-pregnancy body mass index [I, II]	continuous	
Socioeconomic status [I, II, III]	categorized	upper white-collar worker lower white-collar worker blue-collar worker other
Degree of urbanity of the place of residence [I]	categorized	urban semiurban rural abroad
Infertility treatments [I]	categorized	yes no
Time between deliveries [III]	continuous*	

The superscript indicates in which of the three studies it was accounted for (I–III).
*rounded to the nearest year.

4.4 Ethical Considerations

Finnish national legislation allows the use of register-based data without a separate ethical evaluation if the study subjects are not contacted, and only unidentifiable data is provided to the researchers (Finnish National Board on Research Integrity, 2020). Hence, Studies I–III were not assessed in a separate ethical review.

5 Results

5.1 Smoking and Maternal Specialized Care (Study I)

5.1.1 Characteristics of the Study Population

The prevalence of smoking during the first trimester in Finland from 1999 to 2015 was 15.0%, and 10.7% of all women giving birth during this time continued smoking after the first trimester. Table 10 depicts the characteristics of the study population.

Table 10. Characteristics of the study population in Study I. Modified from Wallin et al. (2020).

	TOTAL	NO SMOKING	QUIT SMOKING	CONTINUED SMOKING
	n (%)	*n* (%)	*n* (%)	*n* (%)
Total	961,127 (100%)	791,995 (82.4%)	41,722 (4.3%)	102,396 (10.7%)
Age (years)				
Less than 20	24,306 (2.5%)	12,224 (50.3%)	2,535 (10.4%)	8,817 (36.3%)
20–24	153,232 (15.9%)	106,754 (69.7%)	11,885 (7.8%)	30,504 (19.9%)
25–29	301,551 (31.4%)	251,611 (83.4%)	13,748 (4.6%)	28,705 (9.5%)
30–34	300,409 (31.3%)	262,622 (87.4%)	9,268 (3.1%)	20,857 (6.9%)
35–39	147,488 (15.3%)	129,085 (87.5%)	3,579 (2.4%)	10,785 (7.3%)
40 or more	34,140 (3.6%)	29,699 (87.0%)	707 (2.1%)	2,727 (8.0%)
Marital status				
Married	561,008 (58.4%)	500,732 (89.3%)	14,367 (2.6%)	31,625 (5.6%)
Cohabiting	292,850 (30.5%)	220,460 (75.3%)	20,450 (7.0%)	45,473 (15.5%)
Single	95,189 (9.9%)	62,460 (65.6%)	6,462 (6.8%)	23,349 (24.5%)
Parity				
0	398,525 (41.5%)	319,619 (80.2%)	24,958 (6.3%)	45,746 (11.5%)
1	322,248 (33.5%)	273,392 (84.8%)	10,454 (3.2%)	29,753 (9.2%)
2	144,432 15.0%	119,759 (82.9%)	4,304 (3.0%)	15,964 (11.1%)
3	50,121 (5.2%)	40,430 (80.7%)	1,335 (2.7%)	6,668 (13.3%)
4	19,044 (2.0%)	15,480 (81.3%)	412 (2.2%)	2,486 (13.1%)
5 or more	25,913 (2.7%)	23,027 (88.9%)	254 (1.0%)	1,743 (6.7%)

	TOTAL *n* (%)	NO SMOKING *n* (%)	QUIT SMOKING *n* (%)	CONTINUED SMOKING *n* (%)
Body mass index (kg/m^2)				
< 20.0	91,274 (9.5%)	73,949 (81.0%)	4,968 (5.4%)	10,557 (11.6%)
20.0–24.9	340,547 (35.4%)	288,882 (84.8%)	16,808 (4.9%)	28,448 (8.4%)
25.0–29.9	142,637 (14.8%)	116,612 (81.8%)	8,333 (5.8%)	14,839 (10.4%)
30.0–34.9	52,949 (5.5%)	41,529 (78.4%)	3,404 (6.4%)	6,889 (13.0%)
35.0 or more	25,636 (2.7%)	19,680 (76.8%)	1,702 (6.6%)	3,679 (14.4%)
unknown	273,800 (28.5%)	225,535 (82.4%)	5,760 (2.1%)	34,613 (12.6%)
Infertility treatment				
IVF[a]	16,316 (1.7%)	15,209 (93.2%)	368 (2.3%)	486 (3.0%)
Other ART[b]	13,923 (1.4%)	12,801 (91.9%)	402 (2.9%)	539 (3.9%)
Socioeconomic status				
Upper white-collar	158,423 (16.5%)	147,996 (93.4%)	2,933 (1.9%)	3,972 (2.5%)
Lower white-collar	318,657 (33.2%)	269,328 (84.5%)	13,272 (4.2%)	28,148 (8.8%)
Blue-collar	129,561 (13.5%)	93,247 (72.0%)	7,823 (6.0%)	24,858 (19.2%)
Other	354,486 (36.9%)	281,424 (79.4%)	17,694 (5.0%)	45,418 (12.8%)
Residential area				
Urban	647,719 (67.4%)	537,998 (83.1%)	27,637 (4.3%)	66,880 (10.3%)
Semiurban	157,850 (16.4%)	127,980 (81.1%)	7,330 (4.6%)	17,740 (11.2%)
Rural	152,702 (15.9%)	123,790 (81.1%)	6,710 (4.4%)	17,629 (11.5%)
Abroad	2,856 (0.3%)	2,227 (78.0%)	45 (1.6%)	147 (5.1%)
A psychiatric diagnosis (F00-F99) during pregnancy				
No diagnosis	901,609 (96.3%)	770,711 (97.3%)	38,967 (93.4%)	91,931 (89.8%)
Any diagnosis	34,504 (3.7%)	21,284 (2.7%)	2,755 (6.6%)	10,465 (10.2%)

[a]IVF = in vitro fertilization bother; [b]ART = assisted reproductive technology, i.e., ovulation induction and intrauterine insemination. The missing smoking information is not shown in the table (total n = 25,014; 2.6%)

5.1.2 Prenatal Care Records and Specialized Maternity Care

Almost all pregnant women attended the primary care prenatal clinic at least once (99.6%), and 90.1% had at least one follow-up visit in the specialized care. Continued smoking after the first trimester was associated with the absence of prenatal care (adjusted odds ratio [aOR] = 1.83; 95% confidence interval [CI] = 1.68–1.99) (Table 11). Women who smoked had a higher mean number of control visits in specialized care maternity clinics: women who continued smoking had a mean of 3.17 visits (standard deviation [SD] = 2.94), and women who quit smoking had a mean of 3.38 (SD = 2.92) visits compared to women who did not smoke (mean = 2.93; SD = 2.68). Altogether, 12.7% of pregnant women had at least one other visit in specialized care beyond the control visit. Women who smoked had more likely had inpatient maternity care for any reason compared to women who did not smoke, but an inverse association was found for continued smoking and specialized inpatient care for elevated blood pressure (aOR = 0.79; 95% CI = 0.76–0.83). Specialized inpatient care due to bleeding was associated only with continued SDP. The association between smoking and inpatient care due to the threat of preterm labor was similar in both smoking groups.

Table 11. The association between smoking during pregnancy and primary care prenatal clinic visits and specialized inpatient maternity care. Modified from Wallin et al. (2020).

OUTCOME	NO SMOKING	QUIT SMOKING	CONTINUED SMOKING
No visits in primary care prenatal clinic n = 3,554			
Crude OR	1 [reference]	0.92 (0.77–1.09)	2.05 (1.88–2.22)
Adjusted[b] OR	1 [reference]	0.94 (0.78–1.12)	1.83 (1.68–1.99)
No visits in specialized care maternity clinic n = 92,908			
Crude OR	1 [reference]	1.43 (1.37–1.48)	1.23 (1.20–1.26)
Adjusted[b] OR	1 [reference]	1.45 (1.40–1.51)	1.48 (1.44–1.51)
Inpatient specialized maternity care due to			
Any reason n = 121,826			
Crude OR	1 [reference]	0.90 (0.87–0.93)	1.31 (1.28–1.33)
Adjusted[b] OR	1 [reference]	1.20 (1.16–1.23)	1.21 (1.19–1.24)
Bleeding n = 9,625			
Crude OR	1 [reference]	0.76 (0.68–0.85)	1.28 (1.21–1.36)
Adjusted[b] OR	1 [reference]	1.09 (0.98–1.23)	1.20 (1.13–1.27)
Blood pressure n = 26,310			
Crude OR	1 [reference]	0.92 (0.86–0.97)	0.81 (0.77–0.84)
Adjusted[b] OR	1 [reference]	1.03 (0.97–1.10)	0.79 (0.76–0.83)
Threat of preterm labor n = 20,714			
Crude OR	1 [reference]	1.06 (0.99–1.14)	1.65 (1.58–1.71)
Adjusted[b] OR	1 [reference]	1.35 (1.26–1.45)	1.40 (1.34–1.45)
Other reason n = 83,958			
Crude OR	1 [reference]	0.94 (0.90–0.97)	1.36 (1.33–1.39)
Adjusted[b] OR	1 [reference]	1.24 (1.19–1.28)	1.28 (1.26–1.31)

Odds ratio (OR), 95% confidence interval (CI)

[b]Adjusted for birth year, maternal age, parity, pre-pregnancy BMI, marital status, socioeconomic group, level of urbanity of place of residence, and infertility treatments.

5.1.3 Reasons for Outpatient Specialized Care

Pregnant women attended outpatient specialized care clinics mainly due to factors influencing health status and contact with health services (n = 434,497; 46.4%) and due to pregnancy-related conditions (n = 269,013; 28.7%). A total of 2.4% (n = 22,807) of women received outpatient specialized care due to genitourinary diseases.

SDP was associated with a higher likelihood of outpatient specialized care during pregnancy compared to women who did not smoke. Figure 8 depicts the associations between SDP and specialized outpatient care. The crude and adjusted odds ratios are presented in Table 12. The strongest association of SDP and specialized care was due to mental and behavioral disorders (aOR = 2.14; 95% CI = 2.00–2.30) for women who quit smoking and (aOR = 3.88; 95% CI = 3.71–4.06) for women who continued smoking. A more pronounced association of continued smoking and outpatient specialized care compared to quitting smoking was also observed for certain infectious and parasitic diseases (aOR = 1.48; 95% CI = 1.33–1.65) for women who quit smoking, and (aOR = 2.45; 95% CI = 2.30–2.62) for women who continued smoking compared to women who did not smoke. A similar association was also evident for respiratory and genitourinary diseases. In certain diagnosis chapters, the association was apparent only for continued smoking, such as care due to the diseases of the circulatory system (aOR = 1.21; 95% CI = 1.12–

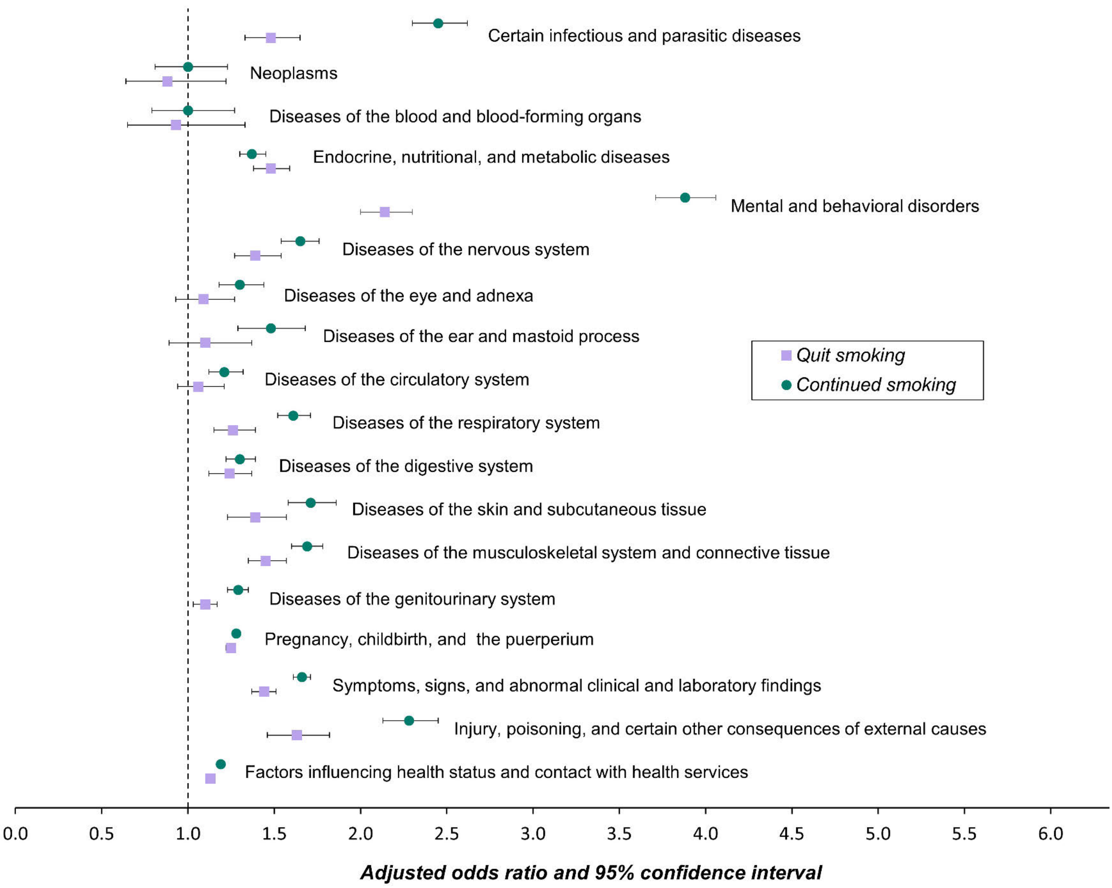

Figure 8. The association of smoking during pregnancy and maternal specialized outpatient care. Adjusted odds ratios and 95% confidence intervals. Reference = no smoking = 1. [a]Adjusted for year of delivery, maternal age, parity, pre-pregnancy BMI, marital status, socioeconomic group, level of urbanity of place of residence, and infertility treatments. Modified from Wallin et al. (2020).

1.32). SDP was associated with a higher probability for outpatient specialized care in other ICD-10 chapters as well, but no difference between the different durations of smoking was observed. The additional sensitivity analysis was conducted without women who had received inpatient psychiatric specialized care, but this did not substantially change the overall results (Table 13).

Table 12. The association between smoking during pregnancy and outpatient specialized care due to different diagnosis chapters, according to the Tenth Revision of the International Classification of Diseases (ICD-10). Modified from Wallin et al. (2020).

	CRUDE OR (95% CI)		ADJUSTED[A] OR (95% CI)		
DIAGNOSIS	Quit smoking	Continued smoking	Quit smoking	Continued smoking	*N*
A00–B99	1.58 (1.42–1.76)	2.27 (2.14–2.42)	**1.48 (1.33–1.65)**	**2.45 (2.30–2.62)**	6,266
C00–D48	0.70 (0.50–0.96)	0.72 (0.59–0.89)	0.88 (0.64–1.22)	1.00 (0.81–1.23)	1,172
D50–D89	0.72 (0.51–1.03)	0.73 (0.58–0.92)	0.93 (0.65–1.33)	1.00 (0.79–1.27)	923
E00–E90	1.55 (1.44–1.66)	1.14 (1.08–1.20)	1.48 (1.38–1.59)	1.37 (1.30–1.45)	13,601
F00–F99	2.38 (2.22–2.55)	3.39 (3.25–3.53)	**2.14 (2.00–2.30)**	**3.88 (3.71–4.06)**	11,396
G00–G99	1.39 (1.26–1.53)	1.40 (1.32–1.50)	**1.39 (1.27–1.54)**	**1.65 (1.54–1.76)**	7,917
H00–H59	1.00 (0.86–1.17)	1.08 (0.98–1.19)	1.09 (0.93–1.27)	1.30 (1.18–1.44)	3,813
H60–H95	0.98 (0.79–1.21)	1.20 (1.06–1.37)	1.10 (0.89–1.37)	1.48 (1.29–1.68)	2,090
I00–I99	0.86 (0.76–0.98)	0.94 (0.87–1.02)	1.06 (0.94–1.21)	1.21 (1.12–1.32)	6,603
J00–J99	1.08 (0.98–1.19)	1.35 (1.28–1.43)	**1.26 (1.15–1.39)**	**1.61 (1.52–1.71)**	9,801
K00–K93	1.15 (1.04–1.26)	1.09 (1.02–1.16)	1.24 (1.12–1.37)	1.30 (1.22–1.39)	8,421
L00–L99	1.39 (1.23–1.57)	1.51 (1.40–1.63)	**1.39 (1.23–1.57)**	**1.71 (1.58–1.86)**	4,842
M00–M99	1.43 (1.32–1.54)	1.40 (1.33–1.47)	**1.45 (1.35–1.57)**	**1.69 (1.60–1.78)**	11,892
N00–N99	1.01 (0.94–1.07)	0.92(0.88–0.96)	**1.10 (1.03–1.17)**	**1.29 (1.23–1.35)**	22,807
O00–O99	1.05 (1.03–1.07)	1.07 (1.05–1.08)	1.25 (1.22–1.27)	1.28 (1.26–1.30)	269,013
R00–R99	1.46 (1.40–1.53)	1.52 (1.48–1.57)	**1.44 (1.37–1.51)**	**1.66 (1.61–1.71)**	36,198
S00–T98	1.70 (1.52–1.89)	2.05 (1.92–2.20)	**1.63 (1.46–1.82)**	**2.28 (2.13–2.45)**	5,394
Z00-Z99	1.03 (1.01–1.05)	1.01 (1.00–1.02)	**1.13 (1.11–1.15)**	**1.19 (1.18–1.21)**	434,497

Reference = No smoking = 1. *OR = odds ratio; 95% CI = 95% confidence interval

[a]Adjusted for the year of delivery, maternal age, parity, pre-pregnancy BMI, marital status, socioeconomic group, level of urbanity of place of residence, and infertility treatments.

Non-overlapping confidence intervals in the smoking groups in the adjusted analysis are highlighted in bold.

A00–B99 Infectious and parasitic diseases; *C00–D48* Neoplasms; *D50–D89* Diseases of the blood and blood-forming organs and immune system; *E00–E90* Endocrine, nutritional and metabolic diseases; *F00–F99* Mental and behavioural disorders; *G00–G99* Diseases of the nervous system; *H00–H59* Diseases of the eye and adnexa; H60–H95 Diseases of the ear and mastoid process; *I00–I99* Diseases of the circulatory system; *J00–J99* Diseases of the respiratory system; *K00–K93* Diseases of the digestive system; *L00–L99* Diseases of the skin and subcutaneous tissue; *M00–M99* Diseases of the musculoskeletal system and connective tissue; *N00–N99* Diseases of the genitourinary system; *O00–O99* Pregnancy, childbirth and the puerperium; *R00–R99* Symptoms, signs and abnormal clinical and laboratory findings; *S00–T98* Injury, poisoning and certain other consequences of external causes; *Z00–Z99* Factors influencing health status and contact with health services.

Table 13. The sensitivity analysis: the association between smoking during pregnancy and outpatient specialized care due to different diagnosis chapters, according to the Tenth Revision of the International Classification of Diseases (ICD-10), among women who never had psychiatric inpatient care. Modified from Wallin et al. (2020).

DIAGNOSES	*N*	ADJUSTED[a] OR (95% CI)	
		Quit smoking	Continued smoking
A00–B99	5,398	**1.35 (1.20–1.52)**	**1.88 (1.74–2.03)**
C00–D48	1,119	0.87 (0.62–1.23)	0.97 (0.77–1.21)
D50–D89	883	0.90 (0.62–1.32)	0.98 (0.76–1.26)
E00–E90	12,612	1.46 (1.35–1.57)	1.32 (1.25–1.40)
F00–F99	-	-	-
G00–G99	7,146	1.38 (1.25–1.53)	1.52 (1.42–1.64)
H00–H59	3,560	1.01 (0.85–1.20)	1.23 (1.10–1.38)
H60–H95	1,953	1.09 (0.87–1.37)	1.39 (1.20–1.60)
I00–I99	6,196	1.04 (0.91–1.19)	1.13 (1.04–1.24)
J00–J99	9,073	**1.24 (1.12–1.37)**	**1.53 (1.44–1.63)**
K00–K93	7,864	1.21 (1.08–1.34)	1.25 (1.16–1.34)
L00–L99	4,511	1.41 (1.24–1.61)	1.62 (1.48–1.77)
M00–M99	10,978	1.43 (1.32–1.56)	1.61 (1.52–1.71)
N00–N99	21,638	1.08 (1.00–1.15)	**1.25 (1.20–1.32)**
O00–O99	255,565	1.24 (1.21–1.27)	1.24 (1.22–1.26)
R00–R99	33,264	**1.41 (1.34–1.48)**	**1.61 (1.56–1.66)**
S00–T98	4,797	**1.51 (1.34–1.70)**	**1.97 (1.82–2.13)**
Z00-Z99	416,300	**1.13 (1.11–1.15)**	**1.20 (1.19–1.22)**

Reference = No smoking = 1.
OR = adjusted odds ratio; 95% CI = 95% confidence interval
[a]Adjusted for the year of delivery, maternal age, parity, pre-pregnancy BMI, marital status, socioeconomic group, level of urbanity of place of residence, and infertility treatments.
Non-overlapping confidence intervals in the smoking groups are highlighted in bold.
A00–B99 Infectious and parasitic diseases; *C00–D48* Neoplasms; *D50–D89* Diseases of the blood and blood-forming organs and immune system; *E00–E90* Endocrine, nutritional and metabolic diseases; *F00–F99* Mental and behavioral disorders; *G00–G99* Diseases of the nervous system; *H00–H59* Diseases of the eye and adnexa; H60–H95 Diseases of the ear and mastoid process; *I00–I99* Diseases of the circulatory system; *J00–J99* Diseases of the respiratory system; *K00–K93* Diseases of the digestive system; *L00–L99* Diseases of the skin and subcutaneous tissue; *M00–M99* Diseases of the musculoskeletal system and connective tissue; *N00–N99* Diseases of the genitourinary system; *O00–O99* Pregnancy, childbirth and the puerperium; *R00–R99* Symptoms, signs and abnormal clinical and laboratory findings; *S00–T98* Injury, poisoning and certain other consequences of external causes; *Z00–Z99* Factors influencing health status and contact with health services.

5.1.4 Reasons for Inpatient Specialized Care

Obstetric and pregnancy-related diagnoses were the most common reason for inpatient specialized care, affecting 57,293 (6.1%) women during their pregnancy. The next most common diagnosis chapter in prenatal hospitalizations was factors influencing health status and contact with health services (Z00–Z99), impacting 14,698 women, followed by miscellaneous symptoms (R00–R99), which affected 6,825 women during their inpatient care.

SDP was also associated with a higher likelihood for inpatient specialized care; this association was similar in both smoking groups in most ICD-10 chapters (Table 14). However, continued smoking had a stronger association with inpatient specialized care in six ICD-10 chapters compared to quitting smoking during the first trimester (Figure 9 and Table 14). A robust association existed between the likelihood of inpatient care due to mental and behavioral disorders (aOR = 2.66; 95% CI = 2.16–3.27) for quitting smoking; this association was even more pronounced for continued smoking (aOR = 8.54; 95% CI = 7.66–9.51). A similar association was also found for injury, poisoning, and certain other consequences of external causes (aOR = 1.39; 95% CI = 1.07–1.81) and (aOR = 2.70; 95% CI = 2.33–3.12), respectively. In some diagnosis chapters, continued smoking after the first trimester was associated with the likelihood of inpatient care, but quitting smoking was not, as was the case for both diseases of the genitourinary system and certain infectious and parasitic diseases.

The sensitivity analysis was also conducted for inpatient care (Table 15). This analysis, among women who never had psychiatric inpatient care, resulted in only minor changes in the overall results. Notably, the odds for specialized inpatient care for cardiovascular diseases were no longer statistically significant in either of the smoking groups. In the chapter for respiratory diseases (J00–J99), the difference between the smoking groups was no longer statistically significant, as was the association between quitting smoking and the diagnosis chapter for injury, poisoning, and certain other consequences of external causes (S00–T98). Interestingly, the number of women who had an inpatient care episode due to the symptoms, signs, and abnormal clinical and laboratory findings (R00–R99) was halved (n = 6,825 vs. 3,196).

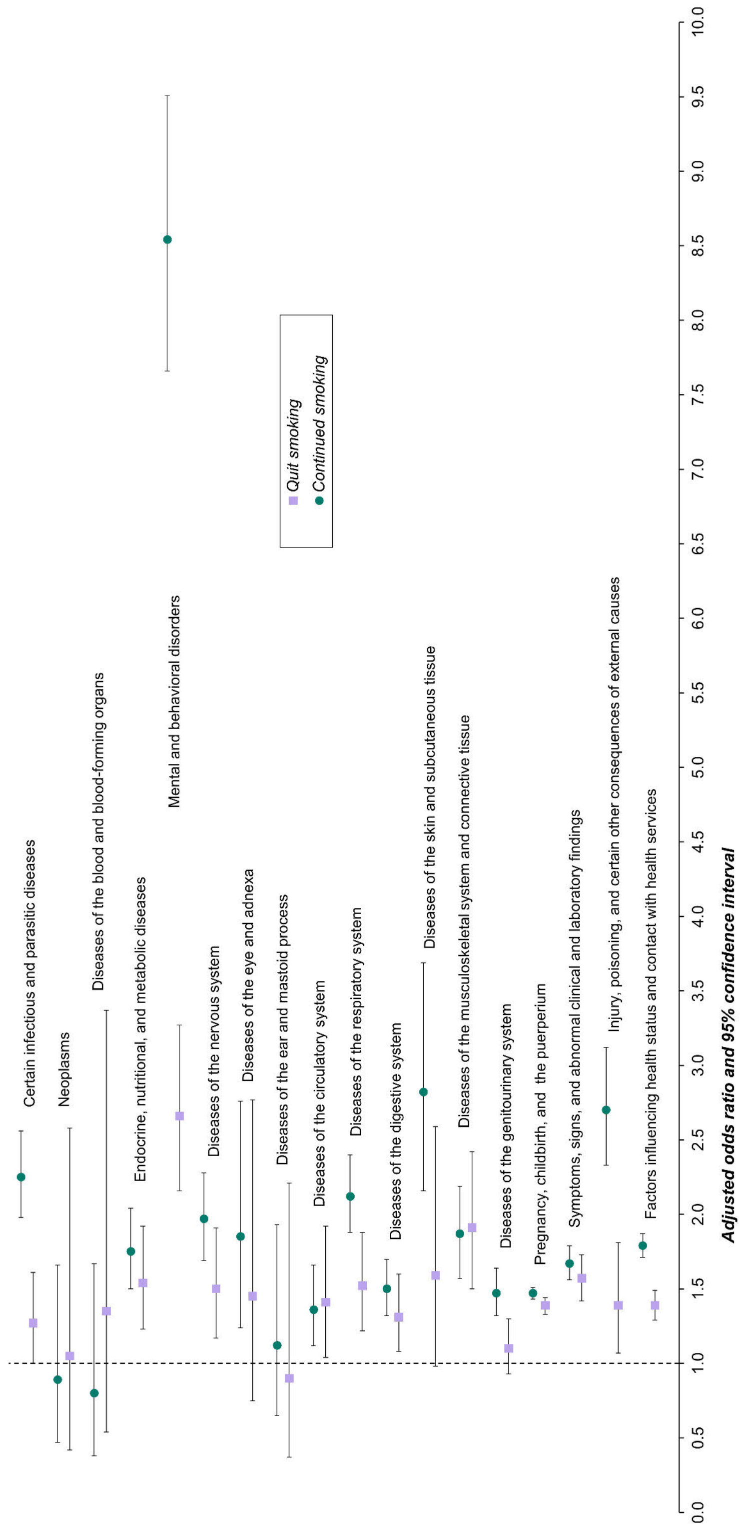

Figure 9. The association between smoking during pregnancy and maternal inpatient specialized care. Reference = no smoking = 1. [a]Adjusted for the year of delivery, maternal age, parity, pre-pregnancy BMI, marital status, socioeconomic group, level of urbanity of place of residence, and infertility treatments. Modified from Wallin et al. (2020).

Table 14. The association between smoking during pregnancy and inpatient specialized care due to different diagnosis chapters according to the Tenth Revision of the International Classification of Diseases (ICD-10). Modified from Wallin et al. (2020).

DIAGNOSES	CRUDE OR (95% CI)		ADJUSTED[a] OR (95% CI)		
	Quit smoking	Continued smoking	Quit smoking	Continued smoking	*N*
A00–B99	1.24 (0.98–1.56)	2.21 (1.96–2.50)	1.27 (1.00–1.61)	**2.25 (1.98–2.56)**	1,556
C00–D48	0.80 (0.33–1.97)	0.72 (0.39–1.34)	1.05 (0.42–2.58)	0.89 (0.47–1.66)	134
D50–D89	1.04 (0.42–2.57)	0.68 (0.33–1.40)	1.35 (0.54–3.37)	0.80 (0.38–1.67)	105
E00–E90	1.68 (1.35–2.10)	1.63 (1.40–1.89)	1.54 (1.23–1.92)	1.75 (1.50–2.04)	1,261
F00–F99	2.76 (2.25–3.38)	7.86 (7.10–8.71)	**2.66 (2.16–3.27)**	**8.54 (7.66–9.51)**	1,589
G00–G99	1.41 (1.11–1.80)	1.81 (1.56–2.09)	1.50 (1.17–1.91)	1.97 (1.69–2.28)	1,266
H00–H59	1.33 (0.70–2.52)	1.68 (1.14–2.47)	1.45 (0.75–2.77)	1.85 (1.24–2.76)	184
H60–H95	0.74 (0.30–1.80)	0.90 (0.53–1.54)	0.90 (0.37–2.21)	1.12 (0.65–1.93)	149
I00–I99	1.09 (0.81–1.48)	1.17 (0.97–1.43)	1.41 (1.04–1.92)	1.36 (1.12–1.66)	925
J00–J99	1.22 (0.99–1.51)	1.86 (1.65–2.10)	**1.52 (1.22–1.88)**	**2.12 (1.88–2.40)**	1,850
K00–K93	1.26 (1.04–1.53)	1.39 (1.23–1.58)	1.31 (1.08–1.60)	1.50 (1.32–1.70)	2,029
L00–L99	1.57 (0.97–2.54)	2.80 (2.17–3.63)	1.59 (0.98–2.59)	2.82 (2.16–3.69)	315
M00–M99	1.62 (1.28–2.04)	1.71 (1.46–1.99)	1.91 (1.50–2.42)	1.87 (1.57–2.19)	1,166
N00–N99	1.01 (0.85–1.19)	1.14 (1.03–1.26)	1.10 (0.93–1.30)	**1.47 (1.32–1.64)**	3,375
O00–O99	1.13 (1.09–1.18)	1.39 (1.36–1.43)	1.39 (1.33–1.44)	1.47 (1.43–1.51)	57,293
R00–R99	1.55 (1.40–1.71)	1.68 (1.58–1.79)	1.57 (1.42–1.73)	1.67 (1.56–1.79)	6,825
S00–T98	1.41 (1.09–1.83)	2.45 (2.13–2.82)	**1.39 (1.07–1.81)**	**2.70 (2.33–3.12)**	1,142
Z00-Z99	1.27 (1.18–1.36)	1.66 (1.59–1.73)	**1.39 (1.29–1.49)**	**1.79 (1.71–1.87)**	14,698

Reference = No smoking = 1.
*during pregnancy. OR = adjusted odds ratio; 95% CI = 95% confidence interval
[a]Adjusted for the year of delivery, maternal age, parity, pre-pregnancy BMI, marital status, socioeconomic group, level of urbanity of place of residence, and infertility treatments.
Non-overlapping confidence intervals in the smoking groups are highlighted in bold.
A00–B99 Infectious and parasitic diseases; *C00–D48* Neoplasms; *D50–D89* Diseases of the blood and blood-forming organs and immune system; *E00–E90* Endocrine, nutritional and metabolic diseases; *F00–F99* Mental and behavioural disorders; *G00–G99* Diseases of the nervous system; *H00–H59* Diseases of the eye and adnexa; H60–H95 Diseases of the ear and mastoid process; *I00–I99* Diseases of the circulatory system; *J00–J99* Diseases of the respiratory system; *K00–K93* Diseases of the digestive system; *L00–L99* Diseases of the skin and subcutaneous tissue; *M00–M99* Diseases of the musculoskeletal system and connective tissue; *N00–N99* Diseases of the genitourinary system; *O00–O99* Pregnancy, childbirth and the puerperium; *R00–R99* Symptoms, signs and abnormal clinical and laboratory findings; *S00–T98* Injury, poisoning and certain other consequences of external causes; *Z00–Z99* Factors influencing health status and contact with health services.

Table 15. The sensitivity analysis: the association between smoking during pregnancy and inpatient specialized care due to different diagnosis chapters, according to the Tenth Revision of the International Classification of Diseases (ICD-10) among women who never had psychiatric inpatient care. Modified from Wallin et al. (2020).

DIAGNOSES	*N*	ADJUSTED[a] OR (95% CI)	
		Quit smoking	Continued smoking
A00–B99	1,337	1.14 (0.88–1.48)	1.54 (1.31–1.80)
C00–D48	125	1.20 (0.49–2.97)	1.05 (0.56–1.97)
D50–D89	97	1.59 (0.64–3.98)	0.96 (0.46–2.02)
E00–E90	1,069	1.57 (1.23–2.00)	1.66 (1.39–1.98)
F00–F99	-		-
G00–G99	1,054	1.42 (1.08–1.87)	1.77 (1.49–2.11)
H00–H59	125	1.30 (0.57–2.99)	1.27 (0.72–2.24)
H60–H95	128	0.84 (0.31–2.29)	0.97 (0.52–1.82)
I00–I99	756	1.30 (0.91–1.87)	1.12 (0.87–1.43)
J00–J99	1,494	1.52 (1.20–1.94)	1.95 (1.69–2.25)
K00–K93	1,718	1.14 (0.90–1.43)	1.36 (1.17–1.57)
L00–L99	230	1.46 (0.80–2.64)	2.69 (1.95–3.72)
M00–M99	903	1.79 (1.35–2.37)	1.89 (1.57–2.26)
N00–N99	2,905	1.09 (0.91–1.32)	1.38 (1.22–1.56)
O00–O99	48,938	1.37 (1.31–1.43)	1.38 (1.34–1.42)
R00–R99	3,196	1.60 (1.38–1.85)	1.51 (1.37–1.68)
S00–T98	681	1.32 (0.94–1.86)	1.93 (1.56–2.38)
Z00-Z99	13,339	**1.34 (1.23–1.45)**	**1.59 (1.51–1.67)**

Reference = No smoking = 1.
OR = odds ratio; 95% CI = 95% confidence interval
[a]Adjusted for the year of delivery, maternal age, parity, pre-pregnancy BMI, marital status, socioeconomic group, level of urbanity of place of residence, and infertility treatments.
Non-overlapping confidence intervals in the smoking groups are highlighted in bold.
A00–B99 Infectious and parasitic diseases; *C00–D48* Neoplasms; *D50–D89* Diseases of the blood and blood-forming organs and immune system; *E00–E90* Endocrine, nutritional and metabolic diseases; *F00–F99* Mental and behavioural disorders; *G00–G99* Diseases of the nervous system; *H00–H59* Diseases of the eye and adnexa; H60–H95 Diseases of the ear and mastoid process; *I00–I99* Diseases of the circulatory system; *J00–J99* Diseases of the respiratory system; *K00–K93* Diseases of the digestive system; *L00–L99* Diseases of the skin and subcutaneous tissue; *M00–M99* Diseases of the musculoskeletal system and connective tissue; *N00–N99* Diseases of the genitourinary system; *O00–O99* Pregnancy, childbirth and the puerperium; *R00–R99* Symptoms, signs and abnormal clinical and laboratory findings; *S00–T98* Injury, poisoning and certain other consequences of external causes; *Z00–Z99* Factors influencing health status and contact with health services.

5.2 Smoking and Specialized Care for Urinary Tract Infections During Pregnancy (Study II)

5.2.1 Characteristics of the Study Population

Altogether, 14.5% (n = 104,933) of women smoked during the first trimester, and 8.8% (n = 63,529) of women continued to smoke after the first trimester. The prevalence of any UTI during pregnancy in the whole study population was 1.3%. UTIs were most common among women under age 20 (4.0%). Table 16 presents the characteristics of the study population.

Table 16. Characteristics of the study population in Study II. Modified from Wallin et al. (2023).

	PREGNANCIES	MATERNAL SMOKING DURING PREGNANCY		ANY URINARY TRACT INFECTION DURING PREGNANCY	
	n	*n*	%	*n*	%
Total	723,433	104,933	14.5%	9,416	1.3%
Maternal age (years)					
<20	14,959	7,139	47.7%	611	4.1%
20–34	566,005	85,423	15.1%	7,537	1.3%
35 or more	142,469	12,371	8.7%	1,268	0.9%
Parity (*n*)					
0	300,326	52,438	17.5%	4,965	1.7%
1	244,896	28,805	11.8%	2,513	1.0%
2 or 3	142,516	19,893	14.0%	1,583	1.1%
4 or more	35,260	3,786	10.7%	351	1.0%
Unknown	435	11	2.5%	4	0.9%
Body mass index (kg/m^2)					
<20	95,510	15,470	16.2%	1,337	1.4%
20–24.9	364,506	46,101	12.6%	4,364	1.2%
25–29.9	156,397	24,364	15.6%	2,026	1.3%
30–34.9	59,713	11,108	18.6%	916	1.5%
35 or more	30,037	6,250	20.8%	517	1.7%
Unknown	17,270	1,640	9.5%	256	1.5%
Marital status					
Married	299,841	69,186	23.1%	4,754	1.6%
Cohabiting	411,857	33,218	8.1%	4,426	1.1%
Single	8,635	2,081	24.1%	177	2.0%
Unknown	3,100	448	14.5%	59	1.9%
Socioeconomic status					
Upper white-collar	103,862	4,519	4.4%	760	0.7%
Lower white-collar	211,637	28,502	13.5%	2,285	1.1%
Blue-collar	79,365	19,889	25.1%	1,125	1.4%
Other/unknown	328,569	52,023	15.8%	5,246	1.6%

5.2.2 Any specialized Care for Urinary Tract Infections

5.2.2.1 Standard Model

SDP was associated with any UTI during pregnancy in multiple logistic regression analysis; this finding was replicated for both bladder-level infections (lower UTI) and pyelonephritis (upper UTI) when analyzed separately. The association for any UTI was stronger among women who continued smoking after the first trimester (aOR = 1.60; 95% CI = 1.51–1.70) compared to women did not smoke and among who quit smoking during the first trimester (aOR = 1.27; 95% CI = 1.18–1.37) compared to women who did not smoke (Table 17).

Table 17. The association between smoking during pregnancy and urinary tract infections. Modified from Wallin et al. (2023).

	STANDARD MODEL			PREGNANCY-PAIR	
	No smoking	Quit smoking	Continued smoking	No smoking	Any smoking
n	596,700	41,404	63,529	27,246	27,246
Any UTI					
n	6,902	786	1,420	434	465
OR (95% CI)	1 (ref.)	1.64 (1.52–1.77)	1.94 (1.83–2.05)	1 (ref.)	1.19 (0.99–1.43)
aOR[a] (95% CI)	1 (ref.)	1.27 (1.18–1.37)	1.60 (1.51–1.70)	1 (ref.)	1.16 (0.96–1.40)
Lower UTI					
n	5,316	590	1,020	76	110
OR (95% CI)	1 (ref.)	1.60 (1.47–1.74)	1.81 (1.69–1.93)	1 (ref.)	1.10 (0.88–1.37)
aOR[a] (95% CI)	1 (ref.)	1.25 (1.15–1.36)	1.55 (1.44–1.66)	1 (ref.)	1.10 (0.87–1.38)
Upper UTI					
n	1,461	185	401	339	340
OR (95% CI)	1 (ref.)	1.82 (1.56–2.12)	2.57 (2.30–2.87)	1 (ref.)	1.49 (1.05–2.12)
aOR[a] (95% CI)	1 (ref.)	1.34 (1.15–1.57)	1.85 (1.65–2.08)	1 (ref.)	1.27 (0.88–1.82)

[a]Adjusted for the year of delivery, maternal age, parity, and pre-pregnancy body mass index.
OR = crude odds ratio, aOR = adjusted odds ratio, 95% CI = confidence interval, UTI = urinary tract infection

5.2.2.2 Pregnancy-pair Analysis

Altogether, 69% of women in the study population had changed their smoking status from smoking in the first pregnancy to non-smoking in the second. In the pregnancy-pair analysis, a statistically significant difference was observed between SDP and upper UTI in the non-adjusted conditional logistic regression analysis (OR

= 1.49, 95% CI = 1.05–2.12) among women who smoked compared to those who did not. However, after adjusting for confounding factors (Table 4), this association attenuated (aOR = 1.27, 95% CI = 0.88–1.82). No difference was observed in diagnoses for any UTI or lower UTI, either. Figure 10 depicts the adjusted odds ratios for UTIs during pregnancy in traditional analysis and in the pregnancy-pair analysis.

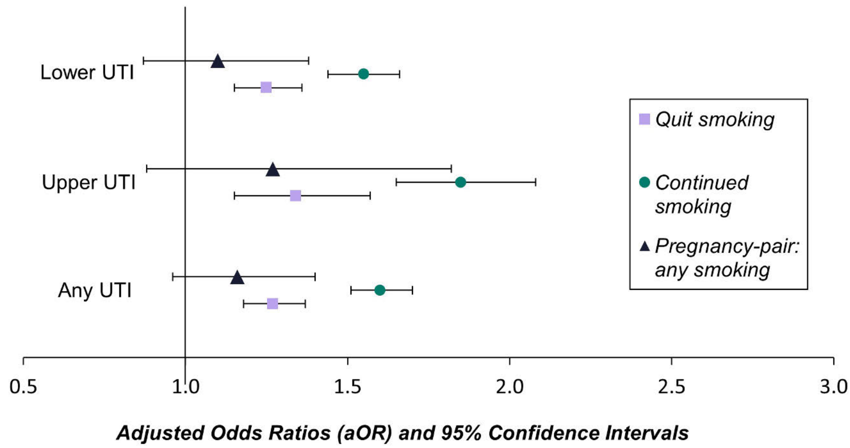

Figure 10. The association between smoking during pregnancy and urinary tract infections (UTIs) during pregnancy according to smoking groups. In the pregnancy-pair analysis, any smoking (smoking during the first or after the first trimester) was compared to no smoking. Adjusted for the year of delivery, maternal age, parity, and pre-pregnancy body mass index.

5.2.3 Inpatient Specialized Care

Pregnant women who continued smoking after the first trimester were more often diagnosed with a UTI during an inpatient care episode ($p = 0.015$) than women who were not smoking. No difference in diagnoses from inpatient care was observed when diagnoses were analyzed separately for lower UTIs and upper UTIs. Also, no difference was observed in the cumulative number of hospitalization days due to different UTIs between the smoking groups (Table 18).

Table 18. The association between smoking and specialized care episodes due to urinary tract infection, and the cumulative number of hospitalization days according to maternal smoking status during pregnancy. Modified from Wallin et al. (2023).

	NO SMOKING		QUIT SMOKING			CONTINUED SMOKING		
	Episodes	Per 100 persons	Episodes	Per 100 persons	*p*	Episodes	Per 100 persons	*p*
Any UTI								
Inpatient care	1,788	25.9	208	26.5	0.761	422	29.7	**0.015**
Inpatient days	7,906	114.5	845	107.5	0.518	1,745	122.9	0.325
Outpatient visits	6,597	95.6	741	94.3	0.665	1,376	96.9	0.625
Lower UTI								
Inpatient care	1,032	19.4	117	19.8	0.826	200	19.6	0.901
Inpatient days	4,604	86.6	474	80.3	0.622	829	81.3	0.567
Outpatient visits	5,530	104	595	100.8	0.321	1,096	107.5	0.238
Upper UTI								
Inpatient care	915	62.6	110	59.5	0.51	269	67.1	0.272
Inpatient days	3,993	273.3	445	240.5	0.139	1,124	280.3	0.74
Outpatient visits	1,493	102.2	186	100.5	0.852	396	98.8	0.65

Missing smoking information is not shown in the table.
Adjusted for the year of delivery, maternal age, parity, and pre-pregnancy body mass index.
UTI = urinary tract infection

5.3 Psychiatric Morbidity and Smoking During the Second Pregnancy (Study III)

5.3.1 Characteristics of the Study Population

Table 19 presents the characteristics of women who continued smoking after the first trimester in their first pregnancy. Table 20 depicts the characteristics of the study population among women who quit smoking during the first trimester of their first pregnancy.

Table 19. Characteristics of the study population among women who continued smoking after the first trimester in the first pregnancy (Study III). Modified from Wallin et al. (2025).

	TOTAL	NO SMOKING	QUIT SMOKING	CONTINUED SMOKING
	n (%)	*n* (%)	*n* (%)	*n* (%)
Total	15,588 (100%)	4,909 (31.5%)	1,868 (12.0%)	8,238 (52.9%)
Age (years)				
less than 20	2,852 (18.3%)	651 (22.8%)	323 (11.3%)	1,753 (61.5%)
20–24	7,393 (47.4%)	2,303 (31.2%)	925 (12.5%)	3,922 (53.1%)
25–34	5,027 (32.3%)	1,844 (36.7%)	585 (11.6%)	2,404 (47.8%)
35 or more	316 (2.0%)	111 (35.1%)	35 (11.1%)	159 (50.3%)
Marital status				
Married or cohabiting	11,490 (73.7%)	3,739 (32.5%)	1,430 (12.5%)	5,897 (51.3%)
Single	4,098 (26.3%)	1,170 (28.6%)	438 (10.7%)	2,341 (57.1%)
Socio-economic status				
Upper white-collar	502 (3.2%)	222 (44.2%)	55 (11.0%)	215 (42.8%)
Lower white-collar	3,636 (23.3%)	1,340 (36.9%)	481 (13.2%)	1,688 (46.4%)
Blue-collar	3,081 (19.8%)	982 (31.9%)	335 (10.9%)	1,644 (53.4%)
Other	8,369 (53.7%)	2,365 (28.3%)	997 (11.9%)	4,691 (56.1%)
Year of the second delivery				
2006–2009	4,632 (32.9%)	3,231 (69.8%)	838 (18.1%)	448 (9.7%)
2010–2014	7,097 (50.4%)	4,980 (70.2%)	1,434 (20.2%)	484 (6.8%)
2015–2019	2,366 (16.8%)	1,783 (75.4%)	357 (15.1%)	105 (4.4%)
Time between deliveries				
less than 2 years	8,167 (52.4%)	2,488 (30.5%)	884 (10.8%)	4,500 (55.1%)
2 to 5 years	5,453 (35.0%)	1,726 (31.7%)	691 (12.7%)	2,831 (51.9%)
more than 5 years	1,968 (12.6%)	695 (35.3%)	293 (14.9%)	907 (46.1%)
Psychiatric diagnosis*	4,023 (25.8%)	1,063 (26.4%)	473 (11.8%)	2,341 (58.2%)

* Any psychiatric diagnosis after age 15 until the birth of the second child.
The missing smoking information is not shown in the table (total n = 573, 3.7%)

Table 20. Characteristics of the study population among women who quit smoking during the first trimester in the first pregnancy (Study III). Modified from Wallin et al. (2025).

	TOTAL *n* (%)	NO SMOKING *n* (%)	QUIT SMOKING *n* (%)	CONTINUED SMOKING *n* (%)
Total	14,095 (100%)	9,994 (70.9%)	2,629 (18.7%)	1,037 (7.4%)
Age (years)				
less than 20	1,255 (8.9%)	709 (56.5%)	296 (23.6%)	205 (16.3%)
20–24	5,283 (37.5%)	3,534 (66.9%)	1,121 (21.2%)	452 (8.6%)
25–34	7,144 (50.7%)	5,424 (75.9%)	1,157 (16.2%)	364 (5.1%)
35 or more	413 (2.9%)	327 (79.2%)	55 (13.3%)	16 (3.9%)
Marital status				
Married or cohabiting	11,894 (84.4%)	8,484 (71.3%)	2,256 (19.0%)	788 (6.6%)
Single	2,201 (15.6%)	1,510 (68.6%)	373 (17.0%)	249 (11.3%)
Socio-economic status				
Upper white-collar	1,027 (7.3%)	823 (80.1%)	148 (14.4%)	31 (3.0%)
Lower white-collar	4,430 (31.4%)	3,136 (70.8%)	892 (20.1%)	283 (6.4%)
Blue-collar	2,252 (16.0%)	1,544 (68.6%)	454 (20.2%)	195 (8.7%)
Other	6,386 (45.3%)	4,491 (70.3%)	1,135 (17.8%)	528 (8.3%)
Year of the second delivery				
2006–2009	4,632 (32.9%)	3,231 (69.8%)	838 (18.1%)	448 (9.7%)
2010–2014	7,097 (50.4%)	4,980 (70.2%)	1,434 (20.2%)	484 (6.8%)
2015–2019	2,366 (16.8%)	1,783 (75.4%)	357 (15.1%)	105 (4.4%)
Time between deliveries				
less than 2 years	8,208 (58.2%)	6,062 (73.9%)	1,407 (17.1%)	502 (6.1%)
2 to 5 years	4,778 (33.9%)	3,214 (67.3%)	1,001 (21.0%)	417 (8.7%)
more than 5 years	1,109 (7.9%)	718 (64.7%)	221 (19.9%)	118 (10.6%)
Psychiatric diagnosis*	2,446 (17.4%)	1,635 (66.8%)	475 (19.4%)	243 (9.9%)

* Any psychiatric diagnosis after the age of 15 until the birth of the second child.
The missing smoking information is not shown in the table (total n = 435, 3.1%)

5.3.2 Smoking in Consecutive Pregnancies

Two-thirds of the women who continued smoking during their first pregnancy were also smoking in their second (67.3%, n = 10,106) (Figure 11). In contrast, women who succeeded in quitting smoking during their first pregnancy were most likely not to smoke during their second (73.2%, n = 9,994). Only one-fourth smoked during their second pregnancy (26.8%, n = 3,666). The information regarding smoking during the second pregnancy was missing from 3.4% (n = 1,008) of women who had smoked during the first pregnancy. Pregnant women who had continued smoking during their first pregnancy were more likely to have had a previous psychiatric diagnosis (25.8%; n = 4,023) than women who had quit smoking during their first pregnancy (17.4%; n = 2,446).

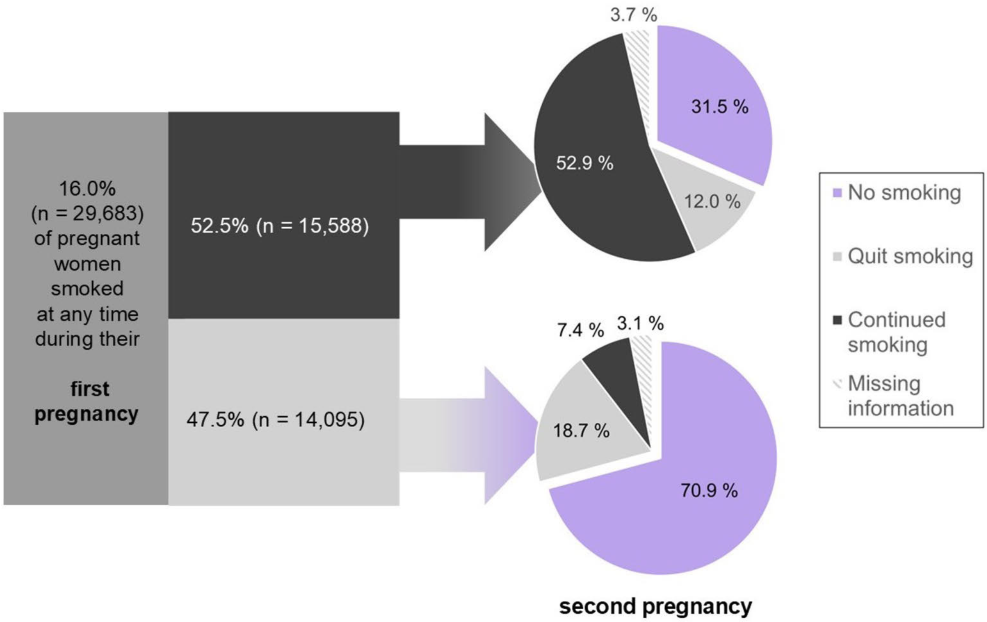

Figure 11. Smoking prevalence (%) in first and second pregnancies.

5.3.2.1 Previous Psychiatric Diagnosis

5.3.2.1.1 Women Who Continued Smoking During Their First Pregnancy

Women who had received any psychiatric diagnosis in specialized care were more likely to continue smoking during their second pregnancy during the first trimester only (aOR = 1.14; 95% CI = 1.01–1.30) or also after the first trimester (aOR = 1.44; 95% CI = 1.32–1.57) compared to women who had no prior psychiatric diagnosis (Table 21). In the separate analysis for major diagnosis groups, a lifetime diagnosis for a mood, anxiety, or personality disorder was associated with continued smoking in their second pregnancy. A prior mood disorder diagnosis was also associated with quitting smoking during the first trimester in the subsequent pregnancy, but the other diagnosis groups were not. Figure 12 depicts the main findings.

Table 21. The association between previous psychiatric diagnosis or burden and maternal smoking during the second pregnancy among women who continued smoking after the first trimester during their first pregnancy. Modified from Wallin et al. (2025).

SMOKING DURING THE SECOND PREGNANCY		ANY DIAGNOSIS	MOOD DISORDER	ANXIETY[a] DISORDER	PERSONALITY DISORDER	BURDEN[b]
Quit smoking	Crude OR (95% CI)	1.23 (1.08–1.39)	1.25 (1.08–1.45)	1.22 (1.05–1.43)	1.16 (0.85–1.57)	1.11 (1.05–1.18)
	Adjusted OR (95% CI)	1.14 (1.01–1.30)	1.17 (1.01–1.36)	1.13 (0.96–1.32)	1.12 (0.82–1.53)	1.08 (1.01–1.15)
Continued smoking	Crude OR (95% CI)	1.44 (1.32–1.56)	1.32 (1.20–1.46)	1.27 (1.15–1.41)	1.32 (1.07–1.62)	1.19 (1.14–1.24)
	Adjusted OR (95% CI)	1.44 (1.32–1.56)	1.31 (1.19–1.45)	1.30 (1.17–1.45)	1.38 (1.12–1.71)	1.19 (1.14–1.25)

No diagnosis = Reference = 1. Odds ratios (OR) and 95% confidence intervals (95% CI).
[a]Anxiety, dissociative, stress-related, somatoform, and other nonpsychotic mental disorders. [b]Psychiatric disease burden represents the number of different diagnosis groups from which the woman has received a psychiatric diagnosis (classification 0–5). *Reference = Quit smoking during the first pregnancy, not smoking during the second. **Reference = Continued smoking during the first pregnancy, not smoking during the second.
Adjusted for maternal age, time between deliveries, year of the second delivery, marital status, and socioeconomic status.

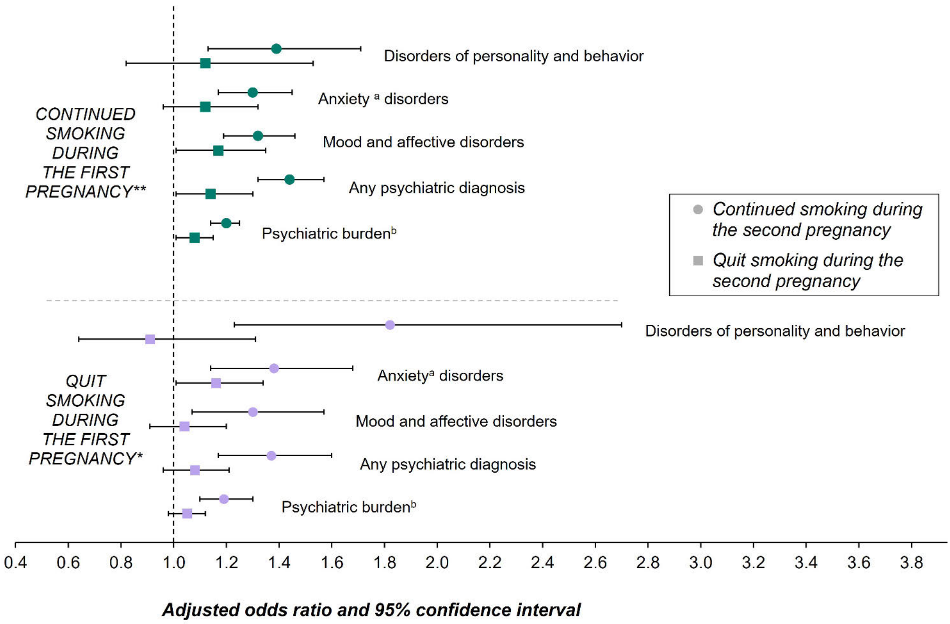

Figure 12. The association between previous psychiatric morbidity and smoking during the second pregnancy according to the smoking status in the first pregnancy. *Quit smoking during the first pregnancy, not smoking during the second; reference = 1. **Continued smoking during the first pregnancy, not smoking during the second; reference = 1. [a]Anxiety, dissociative, stress-related, somatoform, and other nonpsychotic mental disorders. [b]Psychiatric disease burden = from how many different diagnosis groups (0–5) a woman has diagnoses. Adjusted for maternal age, time between deliveries, year of the second delivery, marital status, and socioeconomic status. Reproduced from Wallin et al. (2025).

5.3.2.1.2 Women Who Quit Smoking During Their First Pregnancy

Women who had ever received any psychiatric diagnosis were more likely to also continue smoking beyond the first trimester of their second pregnancy (aOR = 1.37; 95% CI = 1.17–1.60) than women without a prior diagnosis (Table 22). No association with a psychiatric diagnosis and quitting smoking during the second pregnancy was observed in these analyses. In the separate analysis for the major diagnosis groups, a diagnosis for a mood, anxiety, or personality disorder was associated with continued smoking during the second pregnancy. Interestingly, the most profound association was observed between the diagnoses for personality disorders and continued smoking in the second pregnancy; this association was even higher among women who quit smoking in their first pregnancy (aOR = 1.82; 95% CI = 1.23–2.70), compared to women who continued smoking in their first pregnancy (aOR = 1.38; 95% CI = 1.12–1.71). Any anxiety disorder diagnosis was also associated with smoking only during the first trimester in the second pregnancy (aOR = 1.16; 95% CI = 1.01–1.34), but the other diagnosis groups were not.

Table 22. The association between previous psychiatric diagnosis or burden and maternal smoking during the second pregnancy among women who quit smoking during the first trimester in their first pregnancy. Modified from Wallin et al. (2025).

SMOKING DURING THE SECOND PREGNANCY		ANY DIAGNOSIS	MOOD DISORDER	ANXIETY[a] DISORDER	PERSONALITY DISORDER	BURDEN[b]
Quit smoking in the second pregnancy	Crude OR (95% CI)	1.13 (1.01–1.21)	1.10 (0.95–1.26)	1.21 (1.06–1.38)	0.93 (0.65–1.32)	1.07 (1.01–1.14)
	Adjusted OR (95% CI)	1.08 (0.96–1.21)	1.04(0.91–1.20)	1.16 (1.01–1.34)	0.91 (0.64–1.31)	1.05 (0.98–1.12)
Continued smoking in the second pregnancy	Crude OR (95% CI)	1.57 (1.34–1.82)	1.51 (1.26–1.82)	1.55 (1.28–1.88)	2.07 (1.42–3.04)	1.28 (1.18–1.38)
	Adjusted OR (95% CI)	1.37 (1.17–1.60)	1.30 (1.07–1.57)	1.38 (1.14–1.68)	1.82 (1.23–2.70)	1.20 (1.10–1.30)

No diagnosis = Reference = 1.
Odds ratio (OR), 95% confidence interval (95% CI).
[a]Anxiety, dissociative, stress-related, somatoform, and other nonpsychotic mental disorders. [b]Psychiatric disease burden represents the number of different diagnosis groups from which the woman has received a psychiatric diagnosis (classification 0–5). *Reference = Quit smoking during the first pregnancy, not smoking during the second. **Reference = Continued smoking during the first pregnancy, not smoking during the second.
Adjusted for maternal age, time between deliveries, year of the second delivery, marital status, and socioeconomic status.

The previously described confounders were considered in the analysis. The later the year of delivery, the lower the likelihood of continued smoking was, regardless of the first-pregnancy smoking status. Increasing maternal age lowered the odds of smoking (both quitting and continuing) during the second pregnancy among women in both first-pregnancy smoking groups. A longer inter-delivery interval was associated with a lower probability of continued smoking among women who had continued smoking during their first pregnancy, whereas a minor opposite trend was observed otherwise.

5.3.2.2 Previous Psychiatric Disease Burden

Women who continued smoking during the first pregnancy were more likely to have a prior diagnosis from more than one psychiatric diagnosis group compared to women who quit smoking during their first pregnancy (Figure 13). Of women who continued smoking and had any previous diagnosis, 17.6% (n = 709) had received diagnoses from three or more groups compared to women who quit smoking (12.4%, n = 303). Differences were also observed between smoking groups in the prevalence of different diagnoses (Figure 14). The stronger the smoking history in two pregnancies, the stronger the psychiatric disease burden (i.e. diagnoses from several psychiatric diagnosis groups). Especially, mental and behavioral disorders due to psychoactive substance use were more prevalent among women who continued smoking in both pregnancies.

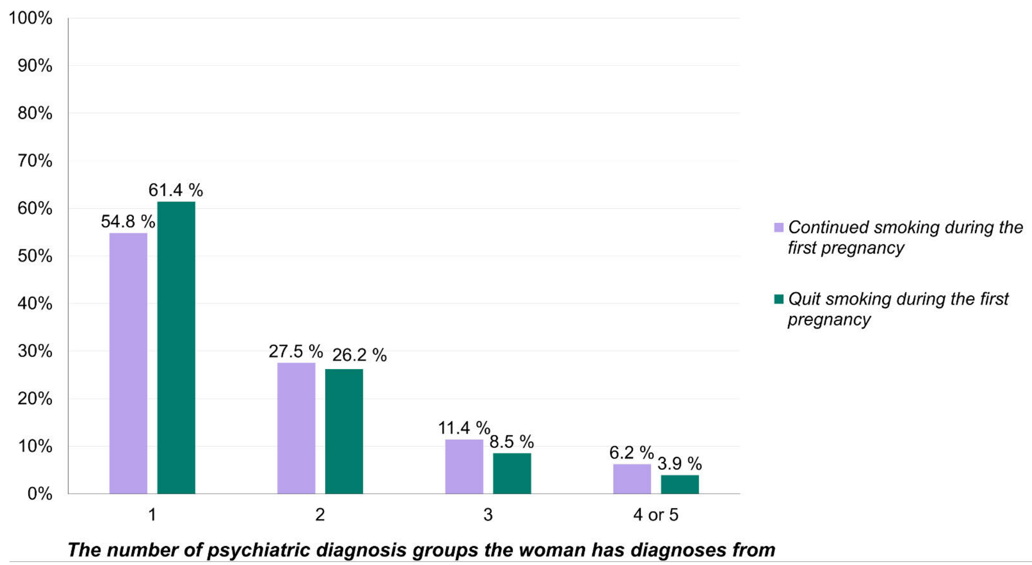

Figure 13. Psychiatric diagnosis burden according to smoking status in the first pregnancy.

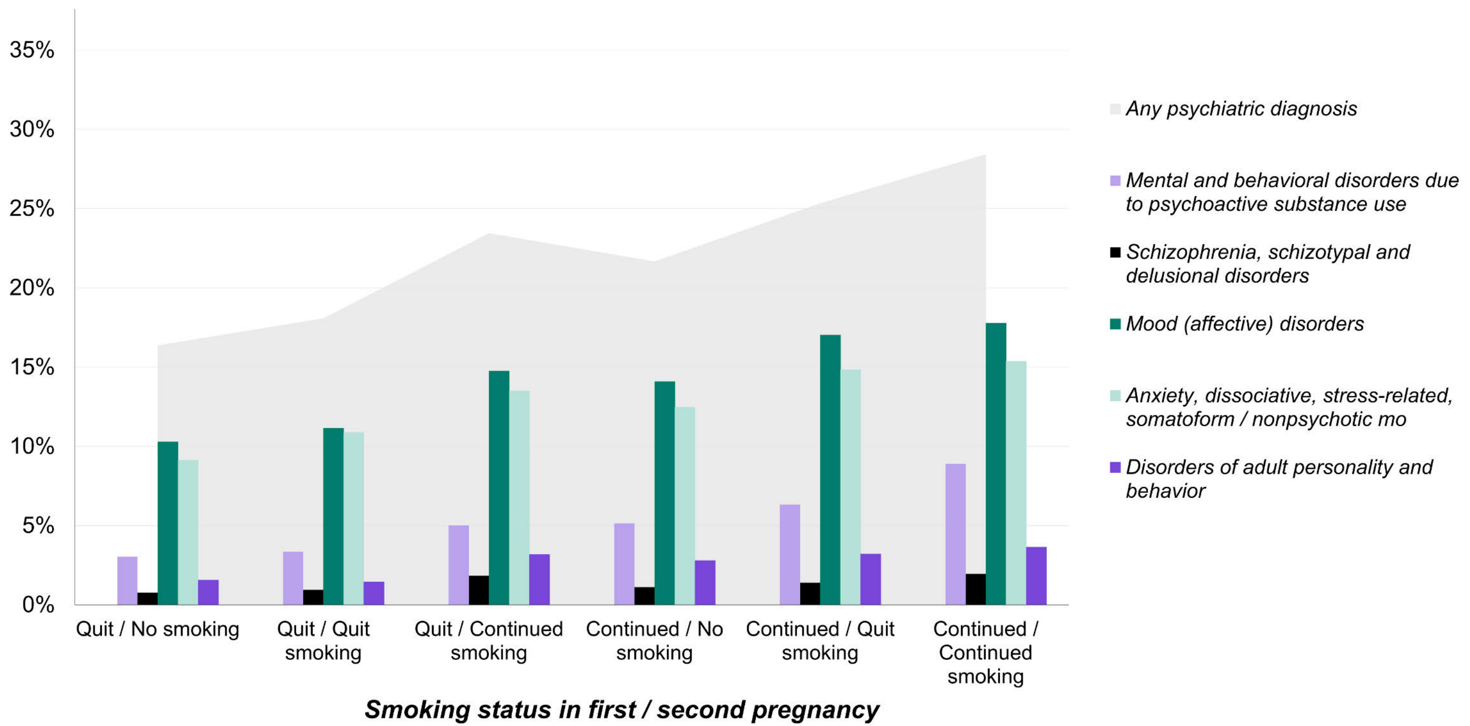

Figure 14. Prevalence of different psychiatric diagnoses according to the Tenth Revision of the International Classification of Diseases (ICD-10) classified according to the smoking statuses in the first two pregnancies. (*Quit/ No smoking = Quit smoking during the first pregnancy, did not smoke during the second; Quit/Quit smoking = Quit smoking in both pregnancies; Quit/Continued smoking = Quit smoking during the first pregnancy, and continued smoking during the second; Continued/No smoking = Continued smoking during the first pregnancy, but did not smoke during the second; Continued/Quit smoking = Continued smoking during the first pregnancy, and quit smoking during the second; Continued/Continued smoking = Continued smoking during the both pregnancies.)*

When analyzing the psychiatric disease burden for women who continued smoking during their first pregnancy, as the number of diagnosis groups grew, the likelihood of smoking during the second pregnancy grew for both continued smoking (aOR = 1.19; 95% CI = 1.14–1.25) and quitting smoking during the first trimester (aOR = 1.08; 95% CI = 1.01–1.15). Among women who quit smoking during their first pregnancy, a similar trend was apparent for psychiatric disease burden and continued smoking during the second pregnancy (aOR = 1.20; 95% CI = 1.10–1.30).

6 Discussion

6.1 Results

6.1.1 Principal Findings

The results of Study I suggest that SDP is associated with a higher likelihood of prenatal specialized care, as indicated by diagnoses across multiple ICD-10 chapters. Another factor was the duration of SDP: Women who continued smoking after the first trimester were more likely to have received specialized care, especially outpatient care, than those who quit smoking during the first trimester. Women who smoked were also more likely to be admitted to specialized maternity care from prenatal clinics.

In Study II, the standard analysis showed a strong association between smoking and UTIs during pregnancy, with a clear difference in the duration of SDP. Continued smoking after the first trimester had a stronger association with UTIs than smoking restricted to the first trimester. However, these associations were attenuated in the pregnancy-pair analysis. Hence, these results suggest that pregnant women who smoke are likely to have other risk factors for UTIs.

According to the findings in Study III, women who quit smoking during the first trimester of their first pregnancy were most likely not smoking in their subsequent pregnancy, unlike women who continued smoking beyond the first trimester. A history of any psychiatric diagnosis in specialized care was associated with continued smoking during the second pregnancy among women who smoked during their first, regardless of the duration of smoking. Also, the lifetime burden of different psychiatric diagnoses was associated with smoking during the second pregnancy.

6.1.2 Smoking and Specialized Care During Pregnancy (Study I)

Study I appears to be the first large-scale epidemiological study that investigates the association between smoking and maternal hospital care during pregnancy outside obstetric care. Women who smoked had a higher likelihood of receiving specialized care during pregnancy due to various reasons. The association was more pronounced among women who continued smoking than among women who quit smoking during the first trimester.

6.1.2.1 Obstetric Conditions

Both women who quit or continued smoking were more likely to be admitted to specialized care consultation from prenatal clinics compared to women who did not smoke. No difference was observed between the smoking groups. These results are consistent with a previous study from the Netherlands (Weiland et al., 2022). Their study population appears comparable to ours, as the Dutch sample is considered representative of the national population and includes all singleton births recorded in a midwifery register. They also assessed quitting smoking during the first trimester and continued smoking thereafter, and no difference between the two smoking groups was detected.

In our study population, quitting smoking was also associated with an increased amount of specialized care due to pregnancy-related issues, and no difference was observed between the smoking groups. This aligns with a previous study from Denmark, but their study did not account for the duration of SDP (Bendix et al., 2016). Our study populations are comparable, as they also included all births after 22 weeks of gestation in Denmark during 2003–2012. Many of the fetal effects of prenatal smoking have been described to be diminished upon smoking cessation during the first trimester, such as reduced fetal growth and risk for preterm birth (Abraham et al., 2017; Liu et al., 2020). However, this may not be true for maternal effects. Hence, maternal smoking and health hazards may not be reversed immediately upon cessation in early pregnancy.

Regarding some previously reported inverse associations of SDP, our findings of lower likelihood for specialized maternity care due to blood pressure are in agreement with previous research on smoking and lower likelihood of hypertensive disorders during pregnancy (Engel et al., 2013). However, other underlying factors that were not assessed in this dissertation might contribute to this, such as excessive weight gain (which might result from smoking cessation) (Levine et al., 2015). In another study, smoking has been associated with a lower likelihood of hypertensive disorders despite BMI (Voigt et al., 2013). In a more recent Finnish register study, smoking was not a protective factor for pre-eclampsia in taller women (Ekblad et al., 2022).

6.1.2.2 Infectious diseases

In our study population, SDP was associated with a higher likelihood of specialized inpatient care due to certain infectious diseases, especially among women who continued smoking. Our results align with the one previous study that has accounted for the association of smoking and inpatient hospital care during pregnancy due to other than obstetric reasons (Roelands et al., 2009). Notably, the smoking information in their study was based on the hospital recording of ICD-9 diagnoses, and the overall prevalence was reasonably low, which might mean their study population probably lacks a substantial number of smoking participants. However, this study might represent a similar population to the women who continued smoking beyond the first trimester in our study. Also in outpatient care, the association of smoking and specialized care due to infectious diseases was stronger among those who continued to smoke. Smoking is a risk factor for various infectious diseases, including pneumonia, influenza, and sepsis in the general population (Huttunen et al., 2011). Notably, in addition to this ICD-10 chapter, other diagnosis chapters also include diagnoses for various types of infections, e.g., respiratory and genitourinary diseases.

SDP in our study was also associated with specialized care for respiratory tract diseases, with the strongest association among women who continued smoking. Our findings coincide with those from Roelands et al. (2009), who found that inpatient care for respiratory infections is more common among pregnant women who smoke. These conditions represent a substantial burden in health care, and respiratory infections were the most common reason for antibiotic treatment during pregnancy in primary care settings (Petersen et al., 2010). The stronger association of continued smoking might reflect a cumulative dose-dependent association, and continued SDP may result in more difficult diseases (e.g., infections) requiring inpatient specialized care. Overall, our study reflects significant maternal morbidity requiring specialized care, as the results do not cover the care episodes in primary care, which often involve more banal conditions.

6.1.2.3 Psychiatric care

The most pronounced association between smoking and specialized care was observed for psychiatric conditions, especially for continued smoking and inpatient care. Inpatient psychiatric care is likely to be a part of a longer-lasting psychiatric morbidity that has probably already been treated in primary care and outpatient specialized care. However, comorbidities, rather than a direct causal effect of SDP, likely explain the association between SDP and mental and behavioral disorders. Women with psychiatric problems tend to smoke more often, which is also evident during pregnancy (Tong et al., 2016). They also have more unfavorable lifestyles than other pregnant women (Whitaker et al., 2006). Together, these could lead to increased morbidity.

The complex relationship between mental health and smoking remains a question. The secondary analysis that excluded all pregnant women with a lifetime psychiatric inpatient care confirmed that the overall findings are not solely explained by comorbidities and impaired health related to psychiatric morbidity. However, in the sensitivity analysis, the association between smoking and inpatient specialized care for diseases of the circulatory system was no longer statistically significant. Hence, lifetime psychiatric morbidity may partially explain the cardiovascular risk among pregnant women who smoke, which has previously been described among primary care patients and people with severe mental illness (Penninx & Lange, 2018; Rossom et al., 2022). It is to be noted that milder conditions (outpatient care) and primary care psychiatric patients are still included in the analysis.

Both maternal tobacco use and mental health have been described as having negative associations with pregnancy outcomes. For example, maternal depressive symptoms, stress, and anxiety have been associated with a higher likelihood of preterm birth (Fransson et al., 2011; Ibanez et al., 2012; Nordeng et al., 2012). Hence, optimal care for both tobacco use and mental health is important during pregnancy.

6.1.2.4 Injuries

One especially concerning finding in our study is the pronounced association of SDP and specialized care due to injuries, poisonings, and certain other consequences of external causes in both smoking groups for both outpatient and inpatient care. The difference was marked between women who quit and continued smoking. Different comorbidities might predispose pregnant women who smoke to accidents. Especially, a high number of daily cigarettes is associated with alcohol or substance use during pregnancy (Erickson & Arbour, 2012). Women who continued smoking might be consuming a larger number of daily cigarettes. Pregnant women who smoke more often report a history of domestic violence (Finnbogadóttir et al., 2014). Although SDP was not a risk factor for domestic violence during pregnancy, it was associated with a higher likelihood of a history of domestic violence in their study. Physical abuse in a current or previous relationship was also associated with SDP (Cheng et al., 2015).

6.1.2.5 Other

As specialized care in Finland is publicly funded, its use reflects actual need; therefore, efforts to minimize its use are also important from an economic perspective. Another economic perspective is the sick leaves during pregnancy. In clinical work, diseases of the musculoskeletal system (especially low back pain or pelvic pain) are common reasons for a prolonged sick leave during pregnancy. The association between smoking and musculoskeletal conditions was similar in both smoking groups. The current data in Finland is lacking concerning sick leaves during pregnancy, but in similar populations in Sweden, up to 70% of women who experienced lower back pain during pregnancy reported sick leave during pregnancy (Mogren, 2006). Pelvic pain and back pain were the most common reasons for sick leave among pregnant women in Sweden and Norway. (Backhausen et al., 2018; Malmqvist et al., 2015) Reducing the SDP rates might also contribute to a reduction in sick leaves due to musculoskeletal diseases during pregnancy.

6.1.2.6 Lifestyle Factors

In the current study, it cannot be differentiated whether these findings reflect readily impaired maternal health associated with SDP or a possible independent effect of SDP, as smoking is often associated with other unfavorable lifestyles. Such factors include alcohol consumption or other substance use (Alvik et al., 2006a; Havens et al., 2009), which might accumulate in smoking individuals. Other factors might exist behind unfavorable lifestyles; for example, suboptimal nutrition during pregnancy has been associated with lower education, along with smoking (Baron et al., 2015; Crone et al., 2019). According to a meta-analysis, women who smoke more often have suboptimal nutrition, especially excess energy and alcohol intake, compared to women who do not smoke (Dallongeville et al., 1998; Muscati et al., 1996) Also, inadequate folic acid supplementation has been reported among pregnant women who smoke (McDonnell et al., 2019; Smedberg et al., 2015).

SDP is often a short period of a longer-lasting smoking habit. Therefore, it also contributes to many health risks and morbidity (e.g., in cardiovascular and carcinogenic diseases) after pregnancy. Although SDP seems to have an unexplained preventative association with pre-eclampsia and hypertension during pregnancy, these conditions pose an increased risk for developing cardiovascular disease (e.g., chronic hypertension) later in life (Xu et al., 2022). SDP also resulted in a higher risk of a later cardiovascular event among women with hypertensive disorder in their first pregnancy compared to women without hypertensive disorder during pregnancy (Arnott et al., 2020). Further research is needed to disentangle the role of SDP from other underlying factors in maternal overall health and their association with health care during pregnancy.

After all, the unique period of pregnancy and the preceding time offer a favorable window for changes in unhealthy lifestyles that may endure until after the pregnancy. The importance of a healthy lifestyle should be emphasized to ensure optimal fetal development. Quitting smoking in early pregnancy reportedly diminishes harmful fetal effects. However, our results highlight that quitting SDP still offers opportunities to improve maternal health beyond pregnancy outcomes. Benefiting from a smoke-free pregnancy after quitting during the first trimester is still possible. Especially, the associations of outpatient specialized care with smoking cessation during the first trimester seem favorable compared to women who were not smoking regarding genitourinary diseases, infections, and respiratory diseases.

6.1.3 Smoking and Urinary Tract Infections During Pregnancy (Study II)

To our knowledge, this is the first study to investigate the association between SDP and UTIs during pregnancy, while considering intrinsic maternal factors, using a pregnancy-pair design. The standard analysis showed a strong association between smoking and UTIs during pregnancy. Our results align with the limited number of prior studies that have reported more antibiotic treatment for UTIs and a higher prevalence of self-reported genitourinary symptoms during pregnancy among women who smoked (Collier et al., 2009; Stokholm et al., 2013). Our results also showed a definite smoking duration dependency, as the association was stronger among women who continued to smoke after the first trimester than among women who quit smoking, compared to women who did not smoke. Smoking cessation has not been evaluated in relation to UTIs during pregnancy in previous studies.

Our results are limited to specialized care, and the prevalence of any UTI (1.3%) is lower than in previous studies, probably due to differences in data collection. According to self-reports, 17% of women had experienced a genitourinary infection during pregnancy in a US study (Collier et al., 2009). Their study population consisted of controls of a population-based case-control study (selected sites) for congenital malformations. Information on UTIs during pregnancy was based on self-reported data during postpartum interviews. In an unselected pregnancy cohort in Denmark, the prevalence of antibiotic treatment for UTI (21%) during pregnancy was retrieved from a drug register, which presents a highly reliable and representative data source (Stokholm et al., 2013). However, smoking included smoking at any time during pregnancy in their study. Our results are consistent with previous findings that SDP was associated with inpatient hospital care for pyelonephritis during pregnancy in a nationally representative US sample (Roelands et al., 2009). However, the number of women who smoked was low in their study, probably due to the collection of smoking data, as discussed earlier.

Our data is limited to specialized care only, but many UTIs in Finland are treated by GPs, and a visit to specialized care is not required. This might distort the interpretation of our results on the association between SDP and prenatal UTIs, as a significant proportion of these UTIs during pregnancy is likely not accounted for. In a Danish study, the second most common reason for pregnant women contacting their GP was ‘cystitis/urinary infection’ while the most common reason was ‘pregnancy’ (Feijen-De Jong et al., 2013). Additionally, a study using primary care data from the United Kingdom found that UTIs were the second most common reason for antibiotic prescription during pregnancy, after respiratory infections (Petersen et al., 2010). Thus, data from primary care could offer substantial insight into the relationship between smoking and UTIs, especially for lower UTIs, as initiating pyelonephritis treatment usually requires a visit to specialized care, according to the Finnish national treatment guidelines for UTIs (Current care guidelines: Urinary tract infections [Virtsatieinfektiot], 2024a).

The associations of smoking and UTIs were attenuated at both bladder and kidney levels in the adjusted model in the pregnancy-pair analysis. Thus, women who smoke are likely to possess other risk factors for UTIs that smoking does not entirely explain. In this analysis, most women smoked during their first rather than their second pregnancy (69%). Previous literature agrees with this finding, and initiating smoking during the second pregnancy is rare, at only 2%–5% (Hauge et al., 2013; Hoff et al., 2007; Tran et al., 2014). We hypothesized that smoking could have some long-term consequences and provide a predisposition to UTIs also in later pregnancies. The effects of smoking are known not to be discarded immediately upon cessation. For example, the risk for cardiovascular events seems to reach the level of nonsmokers only until 10 to 15 years after smoking cessation, although risk reduction compared to people who smoke is already visible during the first five years (Duncan et al., 2019).

6.1.4 Psychiatric Morbidity and Smoking During Pregnancy (Study III)

6.1.4.1 Smoking in Consecutive Pregnancies

According to the findings in Study III, women who quit smoking during the first trimester of their first pregnancy were most likely not to smoke in their subsequent one. On the contrary, women who continued smoking during their first pregnancy were also likely to smoke in their second (67%). Previous studies have reported similar rates: Approximately one-third of women who smoke during their first pregnancy quit before their second (Cnattingius et al., 2006; Hauge et al., 2013; Tran et al., 2014). These women who quit smoking in our study are more likely to be spontaneous quitters and have been described as more likely to stay abstinent (Su & Buttenheim, 2014). In contrast, a systematic review reported a high postpartum relapse rate (40%) following a successful cessation intervention (Jones et al., 2016). In previous studies, the women who quit smoking between pregnancies were likely to smoke fewer cigarettes or smoke only occasionally (Cnattingius et al., 2006; Reynolds et al., 2020). Unfortunately, the heaviness of smoking could not be studied, as the number of cigarettes is not recorded in the Medical Birth Register.

6.1.4.2 Lifetime Psychiatric Morbidity and Smoking during the Second Pregnancy

In our study population, one-fourth of women who continued smoking during their first pregnancy had been diagnosed with any psychiatric diagnosis, and the prevalence of any psychiatric diagnosis among women who quit smoking was lower (17%). Studies that have accounted for SDP and previous mental health have reported higher numbers—up to half of the women self-reporting previous schizophrenia, depression, or bipolar disorder (Holtrop et al., 2010). Differences in the study population's socioeconomic characteristics might account for some of these differences, as might differences in the collection of prior diagnoses. Another study reported that pregnant women who smoked met the diagnostic criteria for a psychiatric diagnosis for the past 12 months twice as likely as women who did not smoke (Flick et al., 2006).

A history of any psychiatric diagnosis in specialized care before the second delivery was associated with continued smoking during the second pregnancy. Similar associations were observed regardless of the duration of smoking in the first pregnancy when different diagnosis groups were separately analyzed. Only one prior study has examined the relationship between SDP and previous mental health and smoking in more than one pregnancy. An Irish follow-up study (n=6,647) disclosed that women who persisted in smoking during two pregnancies were more likely to report both current depression and a history of depression, compared to women who did not smoke or quit smoking in between pregnancies (Reynolds et al., 2020). Their data also included any two consecutive singleton pregnancies in a tertiary care hospital, which may not be nationally representative, and applied to the Finnish population. A US study (n=2,203) reported that any self-reported medical history of depression, bipolar, & schizophrenia predicted continued smoking during (one) pregnancy (Holtrop et al., 2009). Their study population included only Medicaid-eligible participants; hence, the sociodemographic factors may differ from ours. The prevalence of previous mental disorder among women who continued to smoke during pregnancy was high

(47.6%) compared to women who did not smoke (25.5%). Also, smoking (any self-reported smoking during pregnancy) was more prevalent (26.2%) compared to our study population.

Studies on consecutive pregnancies have accounted for different measures of mental health. In a Norwegian cohort study, lower psychological distress measured during the first pregnancy predicted quitting smoking between two pregnancies (Hauge et al., 2013). Although smoking at two different time points was collected, they did not assess distress in terms of quitting smoking during the second pregnancy. The authors reported that young single women were underrepresented compared to the national sample of pregnant women at that time; otherwise, their study population is similar to ours, comprising only primiparous women. A study from a random sample of pregnant women in the US reported that postpartum smoking relapse after a smoke-free third trimester was more likely with the presence of postpartum depressive symptoms (Allen et al., 2009). However, this study did not have access to diagnosed cases, but information in the depressive symptoms variable was based on screening of self-reported symptoms. In a study concerning postpartum smoking relapse prevention, the absence of a history of mental disorder did not predict better success, but low current symptoms did (Kolko et al., 2017). We theorized that this type of previously diagnosed psychiatric condition might demonstrate the relationship of smoking and mental health more concisely than self-report or screening (structured questionnaires or interviews), which study settings often use.

Contrary to our expectations, the lifetime psychiatric disease burden of different diagnoses does not appear to have a stronger association with continued smoking in subsequent pregnancy than any lifetime psychiatric diagnosis. Current knowledge is lacking regarding the psychiatric disease burden. The psychiatric disease burden variable lacks data on primary care psychiatric diagnoses, which may also contribute to psychiatric burden.

6.2 Strengths and Limitations

6.2.1 Strengths

The strengths of this dissertation include the use of reliable nationwide register data, which yield a large-scale, representative study population. According to a review, over 95% of discharges could be identified from the Finnish Care Register for Health Care. The primary weakness was the inadequate recording of subsidiary diagnoses. (Sund, 2012) Diagnoses in secondary and tertiary care are systematically collected and recorded throughout the study period. The Finnish Medical Birth Register also covers a substantial number of maternal covariates, and a study on data quality found that most variables were of good or satisfactory quality (Teperi, 1993). The use of register data also avoids recall bias, which is often present in self-reported data and is common in study settings.

As the Finnish specialized care is publicly funded, the treatment in specialized care outpatient and inpatient units is based on an assessed need. A referral from a GP or prenatal clinic nurse is needed for specialized care; women can rarely see an obstetrician directly. Therefore, our results reflect the actual need for specialized care for more complex health concerns, which health care professionals have already previously evaluated. When examining previous psychiatric morbidity and burden, Study III presents diagnoses from the secondary and tertiary care only, reflecting a reliable source of more complex psychiatric morbidity compared to screening or self-reported data. The study setting of the present dissertation could offer an aspect of the unexplained and intertwined association between mental health and smoking.

The present studies offer more detailed information about maternal smoking as the duration of smoking is considered, unlike many previous studies that used dichotomized smoking information from one time point only. In those studies, smoking information might be confounded with first-trimester quitters, distorting the overall results. Although the exact duration of smoking is not collected in the Medical Birth Register, the collection has been consistent throughout the study periods, improving the validity and comparability of smoking information across different periods. Also, Studies II and III apprehend the SDP beyond one pregnancy, providing a more in-depth perspective on maternal prenatal smoking.

Furthermore, to our knowledge, Study II is the first study to use this type of pregnancy-pair analysis in a smoking-related epidemiological study in a register setting. This study provides more detailed insight into the evaluation of the relationship between smoking and health outcomes, which could also be incorporated into other epidemiological studies.

6.2.2 Limitations of This Dissertation

6.2.2.1 Register Studies

Diagnostic criteria are available for various conditions, but the register data in these studies lack details on how diagnoses were made across conditions. It does not contain the results of laboratory testing either (e.g., for UTIs).

6.2.2.2 Smoking Data

One major limitation of these register studies is reliance on self-reported smoking data, which has not been verified by another method, as other data are not available in the registers. According to a review, a reasonable variation exists in the underreporting of smoking (Russell et al., 2004). People tend to underestimate their smoking and the number of cigarettes in self-reports compared to cotinine validation (George et al., 2006; Walsh et al., 1996). In a Finnish cohort, 8% of women who self-reported not smoking had detectable levels of cotinine (Männistö et al., 2016). This underestimation may distort and diminish the detected differences between women who smoked and women who did not, as the population of women who do not smoke might include several women who smoked. The validity of self-reported smoking data may also vary across individuals. Women in less deprived areas were more likely to self-report their smoking incorrectly compared to the most deprived areas (Shipton et al., 2009). However, the collection of smoking data has been consistent during the study period, diminishing the effect of self-reporting. In addition, a systematic review found no meaningful differences in predictors for smoking cessation between studies with and without biochemical validation of smoking, supporting the choice of our study setting (Riaz et al., 2018).

In all the studies, we refer to ‘continued smoking’ as smoking after the first trimester, but in the Finnish Medical Birth Register data, it is not differentiated whether the woman quit or continued smoking during the second or third trimesters; hence, the exact duration of smoking could not be assessed using these data sources. However, smoking cessation after the second trimester in studies elsewhere is reportedly low, 3%–7% (Blatt et al., 2015; Soneji & Beltrán-Sánchez, 2019; Vila Candel et al., 2015). The accuracy of SDP data on the Finnish Medical Birth Register has been assessed as sufficient for research (Gissler et al., 1995). We also lacked access to smoking information before pregnancy. According to previous research, a significant variation exists in pre-pregnancy smoking cessation, with studies reporting quit rates ranging from 24% to 57% (Cruvinel et al., 2022; Curtin SC & Matthews TJ, 2016; Ekblad et al., 2021; Scheffers-Van Schayck et al., 2019). These studies vary according to how long before pregnancy smoking was accounted for (three to 12 months). In a British study, most women who smoked pre-pregnancy but quit at some point quit smoking after learning they were pregnant (41%); only 9% had already quit while planning to conceive (Cooper et al., 2017).

Based on this register, separating women who never smoked from those who might have recently quit smoking is impossible. The group of women who do not smoke might actually contain several women who quit smoking before pregnancy while trying to conceive. Smoking has also been documented to have longer-lasting effects that do not reverse upon cessation. Thus, this type of effect could theoretically distort our results. In addition, when considering Studies II and III, we did not have access to information on smoking between pregnancies, as this might also have some explanatory effect on our health outcome measures.

The register does not include information about the amount of daily tobacco exposure, as the number of daily cigarettes is not collected. The distinction between occasional and daily smoking was not separately collected until recently; hence, in our studies, these classes were combined. Unfortunately, we did not have access to information concerning the use of other nicotine-containing products, such as electronic cigarettes or nicotine pouches. However, according to the latest national reports from 2023, the prevalence of using snus, electronic cigarettes, and nicotine pouches has been low (under 1%–2%) among Finland's adult female population (THL, 2024).

6.2.2.3 Confounding Factors and Covariates

Although the recording of maternal covariates is rather extensive, some essential information concerning SDP is missing. Unfortunately, information regarding the smoking habits of pregnant women's partners is unavailable in the Finnish Medical Birth Register. A smoking partner is a major contributor to smoking continuation during one or consecutive pregnancies (Hauge et al., 2013; Román-Gálvez et al., 2018; Scheffers-Van Schayck et al., 2019; Voutilainen et al., 2024). The register also lacks exposure to secondhand smoke (e.g., smoking inside the house or car). Unfortunately, recording paternal background factors is also not permitted in the Medical Birth Register.

Various lifestyle factors might be associated with or comorbid with SDP (e.g., maternal alcohol or illicit drug use). The numbers are estimated to be low in the Finnish population (Kahila & Kivistö, 2019). Although these are addressed in prenatal clinic visits, no national data is available. According to a European study, the prevalence of any alcohol consumption during pregnancy in Finland was 14.0%, but 78.5% of respondents reported having consumed only 1 or 2 units during their whole pregnancy (Mårdby et al., 2017). In a Finnish study, 6% of participants screened positive for any substance dependence during pregnancy, and substance dependence showed a significant association with depression during pregnancy (Pajulo et al., 2001). According to studies in the 1980s and 1990s, the prevalence of fetal alcohol syndrome (FASD) is one to two per 1000 newborns in Finland, but researchers estimate that the present numbers are higher, as overall alcohol consumption has risen (Autti-Rämö Ilona et al., 2011).

6.2.2.4 Maternal Diagnoses

Systematically collected information on outpatient care episodes in primary care health centers in Finland is lacking. However, this information would be essential, e.g., regarding the UTIs, to achieve a more thorough understanding of the relationship with SDP. In a Danish study, GP consultations were more likely to be due to urological problems during pregnancy and the postpartum period compared to non-pregnant women, with urinary infections being the primary cause (Feijen-De Jong et al., 2013). Also, about one-third of pregnant women received at least one antibiotic prescription during their pregnancy in primary care in the UK (Petersen et al., 2010). Urinary indications were more prevalent during pregnancy than the year before. These primary care study populations can be comparable to ours. Hence, reliable information on treatment for milder medical conditions and symptoms during pregnancy from primary care would provide substantial additional information, as a significant number of infections and other conditions are treated in primary care in Finland. Regarding Study III, it should also be noted that, as diagnoses from the Care Register for Health Care were available for outpatient psychiatric care only from 1998 onwards, these may not include all data prior to birth for all women, as some may lack information from early adulthood. Some of this data might have been relevant in assessing the lifetime morbidity. We also acknowledge the general limitations of retrospective register setting.

Within the scope of Studies I and II, we did not evaluate pre-existing maternal conditions regarding specialized care during pregnancy, as these data could not be reliably obtained for this study. However, prior conditions may affect our results. Given that most women also smoke outside their pregnancy, smoking may also impact the development of those disorders. In study II, the information regarding previous UTIs, which is one predisposing factor for UTI during pregnancy, should be incorporated as a covariate in the analysis (Gilstrap & Ramin, 2001). However, the pregnancy-pair design might partially control for this effect.

Study III offers information about psychiatric morbidity that reflects lifetime rather than prenatal mental health, as no measures of mental health during pregnancy were accessible in this study. Emphasis should be placed on the fact that these numbers represent cases diagnosed in specialized care only—a significantly smaller number than would be found through screening. Hence, the prevalences reported in such studies using interviews or questionnaires might not be directly comparable to those in our study population. However, they represent a more difficult degree of psychiatric conditions that have required treatment in secondary care. This study setting marks a substantial psychiatric load, as not all psychiatric conditions are ever treated in secondary or tertiary care. We did not distinguish between inpatient and outpatient lifetime diagnosis, but inpatient psychiatric care often indicates a more complex morbidity. Distinguishing between these two in future analysis would be essential, as psychiatric inpatient care is markedly different from outpatient care. Psychiatric private inpatient care is currently not available in Finland.

Also, data from private sector outpatient visits are not included in the registers. People from more privileged social groups are more likely to have access to care in the private sector. In a Finnish cohort, high income was the strongest predictor of receiving primary care in occupational care or in private sector only (Blomgren & Virta, 2020).

When interpreting these results, it is also important to consider that some diagnoses during pregnancy are classified in the ICD-10 chapter on pregnancy, childbirth, and the puerperium, as well as in the organ-specific divisions. For example, regarding UTIs, two codes can be assigned to a kidney-level infection: N10 (pyelonephritis) and O23.0 (pyelonephritis during pregnancy). Whether these diagnoses were addressed uniformly throughout the entire study period in all specialized care units remains unclear. This could be further clarified by cross-group analysis. However, this was accounted for in the design of Study II, and diagnoses of UTIs during pregnancy were retrieved from both ICD-10 chapters.

Regarding Study III, the diagnoses were collected from 15 years of age until the second delivery. The exclusion of time after the second delivery was assessed to be less meaningful than time before, considering the smoking behavior. Comparing the different decades for morbidity and smoking could also be valid, as the prevalence of SDP has been decreasing. Also, the rate of antenatal obstetric hospitalizations has been shown to have decreased from 2003 to 2012 in the Danish population (Bendix et al., 2016), and halved from 1991 to 2008 also in the Finnish population (Klemetti et al., 2014). However, the year of delivery was controlled in our analyses.

6.3 Future Considerations

A more detailed analysis of individual diagnoses within diagnosis chapters could be performed in the future, to enhance the knowledge about smoking and morbidity during pregnancy related to different organ systems. In the scope of Studies I and II, we did not consider the timing of specialized care diagnoses. Further examination of the timing of specialized care relative to smoking cessation would also be insightful. For example, during the first trimester or after it, differentiation could be conducted.

Additional information regarding the relationship between SDP and UTIs during pregnancy could be obtained, e.g., concerning the antibiotic treatment for UTIs during pregnancy, from registers for drug use. The pregnancy-pair analysis did not differentiate between women who quit or continued SDP. An enhanced analysis would take smoking duration into account. A similar pregnancy-pair analysis could also be incorporated into Study I to control maternal factors, as previous maternal morbidity was not included as a covariate.

6.4 Practical Implications in Primary Care

This dissertation provides new insights into the relationship between SDP and maternal health, building on the previously reported health hazards to the developing fetus and pregnancy. The observed associations between smoking and pregnant women's health care utilization highlight the importance of addressing these issues in prenatal care and cessation support materials. Such information may further encourage smoking cessation during pregnancy. Our findings indicate that women who quit smoking are just as likely to require specialized care during pregnancy as non-smokers, across multiple diagnostic categories. This evidence should be utilized as both an informative and motivational resource to strengthen smoking cessation support in prenatal clinics.

Although many women succeed in quitting smoking during the first trimester, an urgent need for better smoking cessation support in prenatal clinics remains. Based on our findings, this support should be more targeted, for example, for women with previous mental health challenges. As a meta-analysis of cessation trials concluded, only a small proportion of participants were able to quit (87% were smoking at the end of pregnancy) (Jones et al., 2016). Hence, more efficient ways are needed to support pregnant women who smoke. This support needs to be continued also in child health clinics after delivery, to prevent smoking exposure in more than one pregnancy.

In the future, for example, non-invasive CO measures could be easily incorporated into prenatal care. Exhaled CO measurements have been evaluated as a feasible method for verifying tobacco smoking (Gaudron & Davis, 2024). This could be a valuable and accessible tool for Finnish prenatal clinics. Measuring the cotinine level is considered the gold standard for smoking verification in clinical studies. Measuring urinary cotinine is another useful method for verifying SDP (Aurrekoetxea et al., 2013). The benefits include its usefulness in revealing the use of other nicotine-containing products. The collection would be straightforward, as repeated urine samples are routinely collected during prenatal care visits. The use of a verification method could enhance the reliability of smoking data in the Medical Birth Register and future register studies.

In various studies, smoking has been connected to lower socioeconomic status and education, and often other suboptimal health behaviors (Alvik et al., 2006a; De Wolff et al., 2019; Scheffers-Van Schayck et al., 2019; Smedberg et al., 2015). In practice, smoking often appears to be part of other challenges in pregnant women's lives. A large-scale UK study demonstrated that heavy smoking (over 15 cigarettes) was associated with several self-reported psychosocial challenges, and the accumulation of several factors resulted in a higher (heavier) smoking rate during pregnancy (Pickett et al., 2009). Similarly, SDP is reportedly more prevalent among women with low perceived social support than among those with high perceived social support (Elsenbruch et al., 2007). Despite recognition of these factors, they have not yet been effectively integrated into smoking cessation support within prenatal care.

Infectious diseases had the second strongest association after psychiatric care in outpatient care, and inpatient care was also substantial for continued smoking. In the literature, it has been estimated that infections account for up to 50% of very preterm births (Stock & King, 2022). UTIs are one of the most common infections during pregnancy (Petersen et al., 2010); they also seem to be linked to preterm birth (E. Wang et al., 2024). Hence, their recognition and prevention would be vital and have also clinical significance in pregnancy care. Recognizing these UTIs remains challenging, despite routine screening being offered for every pregnant woman in Finland, according to Finnish Institute for Health and Welfare guidelines (THL, n.d.-d). Evidence shows that antibiotic treatment of asymptomatic bacteriuria might reduce the incidence of pyelonephritis and preterm birth (Smaill & Vazquez, 2019). Healthcare personnel should be aware that women who smoke might more often have UTIs during pregnancy. However, this association is probably explained by other risk factors that pregnant women who smoke have.

As most women who continue smoking during their first pregnancy also smoke in their subsequent one, cessation support should be continued in child health clinics. The time of pregnancy offers a unique window of opportunity to reach these fertile-aged women for improving their health via smoking cessation. Smoking cessation during the fertile years could also prevent later excess mortality. According to a prospective study in the UK, smoking cessation before age 30 could prevent up to 97% of excess mortality among women, and stopping before 40 could prevent up to 90% of excess mortality caused by smoking. This excess mortality from cardiovascular diseases was related to the intensity of smoking. (Pirie et al., 2013) Prenatal lifestyle interventions may result in more permanent changes, such as diet and smoking habits, one year postpartum (Geyer et al., 2021).

Continued SDP should be addressed as a serious health hazard, and specialized care maternity clinics should participate more actively in cessation interventions, alongside primary care prenatal clinics. Going forward, the increasing number of young women using other nicotine-containing products will further challenge cessation programs in prenatal clinics. One way to signal the serious harms of SDP could be to invite women who smoke and cannot quit to specialized care clinics and incorporate smoking cessation support into specialized maternity care also. Smoking during pregnancy is harmful to pregnancy and maternal health and should be avoided; this should be communicated clearly and continuously in both primary and specialized care.

7 Summary/Conclusions

This dissertation draws the following conclusions regarding SDP and maternal health:

1. Women who smoke during pregnancy demonstrate higher use of specialized care during pregnancy compared to women who do not smoke. SDP is linked to increased utilization of both outpatient and inpatient specialized care across a range of diseases and conditions. The most substantial disparity between women who quit smoking and those who continued smoking was observed in psychiatric specialized care. (Study I)
2. SDP appears to be associated with a higher incidence of diagnosed urinary tract infections in specialized care, although the association was no longer evident in pregnancy-pair analysis. The relationship between UTIs and SDP requires more detailed investigation, as women who smoke seem to have other factors predisposing them to UTIs. (Study II)
3. Lifetime psychiatric morbidity and psychiatric disease burden are associated with continued smoking during the second pregnancy among women who smoked during their first. This association was evident despite the duration of smoking during the first pregnancy, compared to women without a prior psychiatric diagnosis. However, it remains unclear how smoking and psychiatric morbidity are interconnected. (Study III)

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