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# Tobacco consumption from the 1st trimester of pregnancy to 7 months postpartum: Effects of previous tobacco consumption, and depression and anxiety symptoms

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ABSTRACT

*Objective:* Previous tobacco consumption, and depression and anxiety symptoms are major predictors of women's tobacco consumption during pregnancy and the postpartum period. However, the joint effect of these predictors is still unexplored. This study aimed to analyse the effects of previous tobacco consumption, and depression and anxiety symptoms on women's tobacco consumption status and quantity from the 1st trimester of pregnancy to 7 months postpartum.

*Method:* A sample of 803 Spanish women was assessed at the 1st and the 3rd trimester of pregnancy, and at 2 and 7 months postpartum. Previous tobacco consumption, and depression and anxiety symptoms were self-reported. Pregnancy and postpartum tobacco consumption were confirmed with biochemical tests.

*Results:* Women with more previous tobacco consumption or more anxiety symptoms presented a steeper decrease in the number of cigarettes smoked per week from the 1st trimester of pregnancy to the childbirth, although smoking more cigarettes than women with less previous tobacco consumption or less anxiety symptoms. Women with more depression symptoms showed a higher tendency to relapse smoking during the first 2 months postpartum.

*Conclusions:* Previous tobacco consumption and anxiety symptoms were associated with higher smoking quantity during pregnancy, while depression symptoms were associated with consumption relapse during postpartum period.

## 1. Introduction

Smoking is one of the main causes of premature morbidity and mortality, and therefore an important public health problem (World Health Organization, 2015). Smoking during pregnancy increases the risk of complications during pregnancy (Gould, Havard, Lim, & Kumar , 2020; Homer, Bernard & Collet, 2014; Shobeiri & Jenabi, 2017; U.S. Department of Health and Human Services, 2001). Besides, active and passive smoking shows negative effects on maternal and infant health in the postpartum period (Adibelli & Kirca, 2020; Míguez & Pereira, 2020).

Although the harmful effects of tobacco are widely known, the percentage of smoking women during pregnancy remains high (Lange, Probst, Rehm, & Popova, 2018). Nevertheless, women tend to reduce their tobacco consumption or try to quit smoking during pregnancy (Erlingsdottir, Sigurdsson, Jonsson, Kristjansdottir, & Sigurdsson, 2014; Lauria, Lamberti & Grandolfo, 2012; Míguez, Pereira & Figueiredo, 2017; Míguez, Pereira, & Figueiredo, 2019), and tend to relapse during the postpartum period (Correa-Fernández et al., 2012; Lauria et al., 2012; Míguez & Pereira, 2021; Park et al., 2009). To understand the factors associated with smoking during pregnancy and with postpartum relapse is an important issue, namely to design preventive interventions since it is necessary to know what to intervene on and which are the appropriate times.

The number of cigarettes smoked before pregnancy is a relevant predictor to continuing or relapsing smoking. A greater previous tobacco consumption is associated with continuing smoking (Erlingsdottir et al., 2014; Jiménez-Muro, Samper, Marqueta, Rodríguez, & Nerín, 2012; Mateos-Vílchez et al., 2014) and difficulties to spontaneously quitting

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smoking during pregnancy (Anderka et al., 2010; Rozas et al., 2008; Vaz et al., 2014), and higher tobacco relapse during the postpartum period (Lauria et al., 2012; Míguez & Pereira, 2021; Solomon et al., 2007).

On the other hand, psychological factors play a fundamental role in smoking, highlighting the role of depression and/or anxiety during pregnancy (Irfan et al., 2016; Míguez, Pereira, Pinto, & Figueiredo, 2019; Tong et al., 2016). An association between depression (De Wilde et al., 2013; Gyllstrom, Hellerstedt, & Henrikus, 2012; Lauria et al., 2012; Maxson, Edwards, Ingram, & Miranda, 2012; Orr, Blazer & Orr, 2012; Smedberg, Lupattelli, Mårdby, Øverland, & Nordeng, 2015) and/or anxiety (Correa-Fernández et al., 2012; Goedhart, van der Wal, Cuijpers, & Bonsel, 2009; Míguez & Pereira, 2021; Orton et al., 2018; Park et al., 2009; Tong et al., 2016) and continuing smoking during pregnancy or postpartum relapse was largely observed. Nevertheless, this association was not found in all studies about the subject (e.g., Beijers et al., 2014; Bull, Burke, Walsh, & Whitehead, 2003; Meghea et al., 2012).

Most of the studies have focused on analysing separately these factors, without considering that the effects appearing concurrently (e.g., Beijers et al., 2014; Correa-Fernández et al., 2012; Orton et al., 2018), and have adopted a cross-sectional perspective and usually during pregnancy (Beijers et al., 2014; De Wilde et al., 2013; Gyllstrom et al., 2012). So, while evaluating the effect of depression or anxiety symptoms at one moment (Goedhart et al., 2009; Maxson et al., 2012; Meghea et al., 2012; Orr et al., 2012; Tong et al., 2016), the possible effects of other individual variables contributing to tobacco consumption may not have been controlled. Tobacco consumption, depression and anxiety symptoms present large changes during pregnancy and the postpartum period (Dietz et al., 2007; Figueiredo & Conde, 2011; Lee et al., 2007). Therefore, take into account these changes at the possible impact of these factors to continuing and/or to relapse smoking is necessary.

Moreover, previous literature (e.g., Beijers et al., 2014; Tong et al., 2016) focused on investigating the risk factors regarding smoking status exclusively. However, special characteristics of consumption during the perinatal period make the evaluation of smoking quantity a very relevant issue. First, because dose-effects of tobacco consumption on negative pregnancy outcomes occur (Murphy, Dunney, Mullally, Adnan, & Deane, 2013; Salihu & Wilson, 2007). Second, because, despite social pressure suffered by women not to smoke, most of the women continue smoking during pregnancy, reducing significantly the number of cigarettes smoked (Taghavi, Arger, Heil, Higgins, & Tyndale, 2018).

The present study aimed to analyse the effect of previous tobacco consumption, and depression and anxiety symptoms on women's tobacco consumption status and quantity, from the 1st trimester of pregnancy to 7 months postpartum. The novelties of this study are: (1) to analyse the jointly effect of previous tobacco consumption, and depression and anxiety symptoms on women's tobacco consumption; (2) to analyse the effect of these factors on the women's smoking quantity and not only on the smoking status; and (3) to analyse the effect of women's depression and anxiety symptoms, considering them as time-varying factors over pregnancy and the postpartum period and not only as fixed factors.

## 2. Materials and methods

### 2.1. Participants

The sample of this study comprises 803 pregnant women assessed from the 1st trimester of pregnancy to 7 months postpartum. Participants' age ranged between 18 and 46 years old ($M = 32.70$ years; $SD = 4.35$). The majority were married or cohabiting (83.9%). More than half were primiparous (66.0%), had university studies (53.4%), were employed (71.1%), had a medium-low economic level (57.4%) and (87.7%) had planned their pregnancy (see Table 1). Of the total sample, 28.3% smoked before seeking or confirming their pregnancy, while 71.7% were non-smokers. Among women who were smokers before pregnancy (occasional and daily smokers), the average of previous tobacco consumption was 10.89 daily cigarettes ($SD = 6.75$), and 75.42 weekly cigarettes ($SD = 47.26$).

**Table 1**
Women's socio-demographic characteristics at the baseline (1st trimester of pregnancy).

| | *n* | % |
|---|---|---|
| Age | | |
| >30 | 576 | 71.7 |
| ≤ 30 | 227 | 28.3 |
| Marital status | | |
| *Single* | 129 | 16.1 |
| *Married/living with partner* | 674 | 83.9 |
| Parity | | |
| *Primiparous* | 530 | 66.0 |
| *Multiparous* | 273 | 34.0 |
| Educational level | | |
| *Non-university* | 374 | 46.6 |
| *University* | 529 | 53.4 |
| Occupational status | | |
| *Unemployed* | 232 | 28.9 |
| *Employed* | 571 | 71.1 |
| Socioeconomic level | | |
| *Medium- low* | 461 | 57.4 |
| *Medium- high* | 266 | 33.1 |
| Planned Pregnancy | | |
| *Yes* | 704 | 87.7 |
| *No* | 99 | 12.3 |
| Smoking before pregnancy | | |
| *Non-smoker* | 581 | 71.7 |
| *Smoker* | 222 | 28.3 |

### 2.2. Procedure

This study was conducted in according with the Helsinki Declaration and received previous approval from the Ethical Commission of all the institutions involved (Ethical Board consent number 2010/299). Pregnant women attending primary public health care services in the Northwest of Spain were recruited during the 1st trimester of pregnancy ($N = 901$). The aims and procedures were explained and pregnant women who were willing to participate provided a written informed consent form. Two trained psychologists conducted the interviews individually. This longitudinal study had four assessment waves: 1st ($M = 9.86$ weeks of gestation, $SD = 4.17$) and 3rd trimester of pregnancy ($M = 33.29$ weeks of gestations, $SD = 1.99$), and 2 ($M = 7.40$ postpartum weeks, $SD = 0.86$) and 7 months postpartum ($M = 28.42$ postpartum weeks, $SD = 3.04$). Women were assessed with a questionnaire on socio-demographic and tobacco consumption information, and self-measures of depression and anxiety symptoms in the four assessment waves. The average time for individual assessment of each participant was 20 min.

From the 901 pregnant women recruited at the 1st trimester of pregnancy, 98 women were lost at 7 months postpartum (10.9%): 28 had suffered a miscarriage, 29 could not be contacted, 4 refused to continue participating in the study, and 37 were excluded. Women who consumed other substances (n = 10) were excluded from the analyses because could become confounding variables. Likewise, those women who hid their consumption (n = 27) were excluded because there was a lack of information regarding the consumption quantity. The final sample comprise 803 pregnant women (89.12%).

### 2.3. Measures

#### 2.3.1. Socio-demographic and tobacco consumption information

Information regarding socio-demographic characteristics (e.g., age, marital and professional status, educational and socioeconomic level, parity and planned pregnancy) and consumption information (e.g., consumption status and number of cigarettes smoked before and during pregnancy and postpartum) were obtained for this study.

#### 2.3.2. Depression symptoms

The Edinburg Postnatal Depression Scale (EPDS) is a 10-item self-reported questionnaire designed to assess the intensity of depression symptoms within the previous 7 days (Cox, Holden & Sagovsky, 1987). Higher scores indicate more intensity of depression symptoms. In Spain, validation of the EPDS showed good psychometric properties (Garcia-Esteve, Ascaso, Ojuel, & Navarro, 2003; Vázquez & Míguez, 2019). In the present study, the EPDS showed good internal consistency (Cronbach's α range = 0.77 – 0.85).

#### 2.3.3. Anxiety symptoms

The State Anxiety Scale (STAI-S) of State-Trait Anxiety Inventory (Spielberger, Gorsuch, & Lushene, 1970) consists of a 20-item scale designed to assess the current state of anxiety. Higher scores indicate higher anxiety symptoms. In the present study, the STAI-S showed good internal consistency (Cronbach's α range = 0.84 – 0.93).

#### 2.3.4. Smoking status and consumption quantity (number of cigarettes)

The number of cigarettes smoked per week during each assessment wave was self-reported by women. Smoking status was defined for each assessment wave, considering both self-report and the result of a biochemical test. Pregnant women were classified into three groups: women who reported never smoking or who reported quit before trying to get pregnancy were classified as non-smoker; women who reported quit and whose biochemical test confirmed abstinence were classified as quitters; those women who claimed to smoke were classified as smokers. Women whose self-report did not match the biochemical test were excluded. Self-reports of smoking abstinence were biochemically verified at the 1st trimester through urinary cotinine by Cotinine Test Medimarketing (cut-off 200 ng/mL) and at 3rd trimester and at 2 and 7 months postpartum through the expired air carbon monoxide (CO) (cut-off of 5 ppm), using a Carbon Monoxide Monitor (Model Smokerlyzer Pico Simple; Bedfont Technical Instruments Ltd., Sittingbourne, Kent, UK). Biochemical measurement and self-report were combined to establish smoking status.

### 2.4. Data analysis

Descriptive statistics were performed for all the studied variables. Likewise, bivariate correlations between the different variables were also calculated.

Piecewise growth curve models were estimated using multilevel modelling (Heck, Thomas, & Tabata, 2010) to analyse the effect of previous tobacco consumption, and depression and anxiety symptoms on tobacco consumption (status and quantity) from the 1st trimester of pregnancy to 7 months postpartum. This analysis allows evaluating the effect of each variable of interest bearing in mind the effect of the others, likewise, analyses the changes in the variables over time. Two models were estimated, one for the smoking status (non-smoker or smoker at each time), and another for the smoking quantity – number of cigarettes smoked per week (outcome variables). Data of women who did not smoke were excluded from both models.

The time variable was scored in weeks and three different times were calculated: time 1 was defined from the 1st trimester of pregnancy to childbirth, time 2 was defined from childbirth to 2 months postpartum, and time 3 was defined from 2 to 7 months postpartum. Fixed effects for previous tobacco consumption (number of cigarettes smoked before pregnancy) and depression and anxiety symptoms (time-varying moderators) were included in the models. Standard deviation of each independent variable (previous tobacco consumption, depression and anxiety) was used to stablish what were high and low values for those variables. High depression or anxiety symptoms or high previous tobacco consumption were present when the womeńs score in that variable was a standard deviation above the mean at the time of the assessment. Low symptoms were noted in those women whose scores on depression, anxiety or previous smoked cigarettes were at least one standard deviation below the mean.

Statistical analyses were performed using the IBM SPSS 23.0 Windows version (PASW Statistics for Windows, SPSS Inc, Chicago). Statistical significance level was considered at $p < 0.05$.

## 3. Results

### 3.1. Preliminary analysis

Descriptive statistics for the study variables were performed at all assessments (see Table 2). Statistically significant positive correlations were found between the independent (number of cigarettes smoked per week before pregnancy, depression and anxiety symptoms) and dependent (smoking status and number of cigarettes smoked per week) variables of the study at all assessment waves ($r$'s range = 0.092–0.962).

### 3.2. Smoking status from the 1st trimester of pregnancy to 7 months postpartum: Effects of previous tobacco consumption, and depression and anxiety symptoms

Main effects of time from childbirth to 2 months postpartum ($b = 0.002$, $p = 0.018$) and of time from 2 to 7 months postpartum ($b = 0.001$, $p = 0.016$) were found on smoking status. The number of women who smoke increased from childbirth to 2 months postpartum and from 2 to 7 months postpartum.

Main effects of previous tobacco consumption and depression symptoms were found on smoking status (quitters vs. smokers). Smoking more cigarettes per week before pregnancy was associated with being a smoker at the 1st trimester of pregnancy ($b = 0.005$, $p < 0.001$). Likewise, at the 1st trimester, more depression symptoms ($b = 0.011$, $p = 0.028$) were associated with being a smoker (see Table 3).

Interaction effects between depression symptoms and time from childbirth to 2 months postpartum and between depression symptoms and time from 2 to 7 months postpartum were found on smoking status, as shown by Table 3 and by Fig. 1. Women with more depression symptoms revealed higher tendency to relapse during the first 2 months postpartum ($b = 0.001$, $p = 0.011$), than women with less depression symptoms. Fig. 1 shows, through a higher and slightly steeper line, how women with more depression symptoms tend to smoke status, especially, at 2 months postpartum. After 2 months postpartum, those women with less depression symptoms tend to relapse ($b = 0.001$, $p = 0.022$).

### 3.3. Smoking quantity (number of cigarettes smoked per week) from the 1st trimester of pregnancy to 7 months postpartum: Effects of previous tobacco consumption, and depression and anxiety symptoms

Main effects of time from the 1st trimester of pregnancy to childbirth ($b = -0.307$, $p = 0.001$) and of time from childbirth to 2 months postpartum ($b = 0.216$, $p < 0.001$) were found on the number of cigarettes smoked per week. The number of cigarettes smoked per week decreased from the 1st trimester to childbirth and increased from the childbirth to 2 months postpartum. Main effects of previous tobacco consumption and anxiety symptoms were found on the number of cigarettes smoked per week. Women who smoked more cigarettes per week before pregnancy smoked more cigarettes at the 1st trimester of pregnancy ($b = 0.228$, $p < 0.001$). At the 1st trimester, women with more anxiety symptoms ($b =$

**Table 2**
Descriptive statistics of study variables at each assessment wave.

| | | 1st trimester of pregnancy | | 3rd trimester of pregnancy | | 2 months postpartum | | 7 months postpartum | |
|---|---|---|---|---|---|---|---|---|---|
| | | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| Depression symptoms | | 5.03 | 4.34 | 4.49 | 3.59 | 5.47 | 4.15 | 5.03 | 3.92 |
| Anxiety symptoms | | 14.79 | 10.25 | 13.25 | 8.96 | 16.93 | 8.12 | 16.96 | 8.15 |
| Number of cigarettes smoked by week | | 4.73 | 14.44 | 2.92 | 9.37 | 5.02 | 15.90 | 4.95 | 15.88 |
| | | *n* | % | *n* | % | *n* | % | *n* | % |
| Smoking status | *Non Smokers* | 581 | 72.4 | 581 | 72.4 | 581 | 72.4 | 581 | 72.4 |
| | *Quitters* | 103 | 12.8 | 116 | 14.4 | 98 | 12.2 | 82 | 10.2 |
| | *Smokers* | 119 | 14.8 | 106 | 13.2 | 124 | 15.4 | 140 | 17.4 |

Notes. *M* = Mean; *SD* = Standard deviation.

**Table 3**
Effects of previous tobacco consumption, and depression and anxiety symptoms on smoking status and on smoking quantity (number of cigarettes smoked by week) from the 1st trimester of pregnancy to 7 months postpartum.

| | Smoking status | | | | Number of cigarettes | | |
|---|---|---|---|---|---|---|---|
| | *b* | *SE* | *95%CI* | | *b* | *SE* | *95%CI* |
| Intercept | 0.536 | 0.023 | [0.492, 0.580]*** | Intercept | 17.058 | 1.154 | [14.792, 19.325]*** |
| Time from 1st trimester to childbirth | −0.003 | 0.002 | [−0.007, 0.001] | Time from 1st trimester to childbirth | −0.307 | 0.096 | [−0.495, -0.119]* |
| Time from childbirth to 2 months postpartum | 0.002 | 0.001 | [0.001, 0.004]* | Time from childbirth to 2 months postpartum | 0.216 | 0.048 | [0.122, 0.311]*** |
| Time from 2 to 7 months postpartum | 0.001 | 0.001 | [0.001, 0.003]* | Time from 2 to 7 months postpartum | −0.015 | 0.031 | [−0.077, 0.046] |
| Previous tobacco consumption | 0.005 | 0.001 | [0.004, 0.006]*** | Previous tobacco consumption | 0.228 | 0.022 | [0.184, 0.272]*** |
| Depression symptoms | 0.011 | 0.006 | [0.001–0.022]* | Depression symptoms | 0.035 | 0.232 | [−0.421, 0.491] |
| Anxiety symptoms | 0.002 | 0.002 | [−0.002, 0.005] | Anxiety symptoms | 0.300 | 0.115 | [0.074, 0.526]* |
| Previous tobacco consumption × Time from 1st trimester to childbirth | −0.001 | 0.001 | [−0.001, 0.001] | Previous tobacco consumption × Time from 1st trimester to childbirth | −0.005 | 0.002 | [−0.008, -0.001]*** |
| Depression symptoms × Time from 1st trimester to childbirth | −0.001 | 0.001 | [−0.001, 0.001] | Anxiety symptoms × Time from 1st trimester to childbirth | −0.015 | 0.007 | [−0.029, -0.001]* |
| Previous tobacco consumption × Time from childbirth to 2 months postpartum | 0.001 | 0.001 | [−0.001, 0.001] | Previous tobacco consumption × Time from childbirth to 2 months postpartum | 0.001 | 0.001 | [ -0.001, 0.003] |
| Depression symptoms × Time from childbirth to 2 months postpartum | 0.001 | 0.001 | [0.001, 0.002]* | Anxiety symptoms × Time from childbirth to 2 months postpartum | 0.010 | 0.006 | [−0.0002, 0.021] |
| Previous tobacco consumption × Time from 2 to 7 months postpartum | −0.001 | 0.001 | [−0.001, 0.001] | Previous tobacco consumption × Time from 2 to 7 months postpartum | −0.001 | 0.001 | [−0.001, 0.001] |
| Depression symptoms × Time from 2 to 7 months postpartum | 0.001 | 0.001 | [0.001, 0.002]* | Anxiety symptoms × Time from 2 to 7 months postpartum | 0.001 | 0.004 | [−0.006, 0.007] |
| Random effects | | | | | | | |
| Intercept + Time | 0.001 | 0.001 | [0.001, 0.002]*** | Intercept + Time | 0.593 | 0.076 | [0.462, 0.761]*** |
| Residuals | 0.094 | 0.005 | [0.084-0.104]*** | Residuals | 252.291 | 13.909 | [226.450,281.079]*** |

*SE* = Standard error; CI = Confidence interval.
* $p < 0.05$.
*** $p < 0.001$.

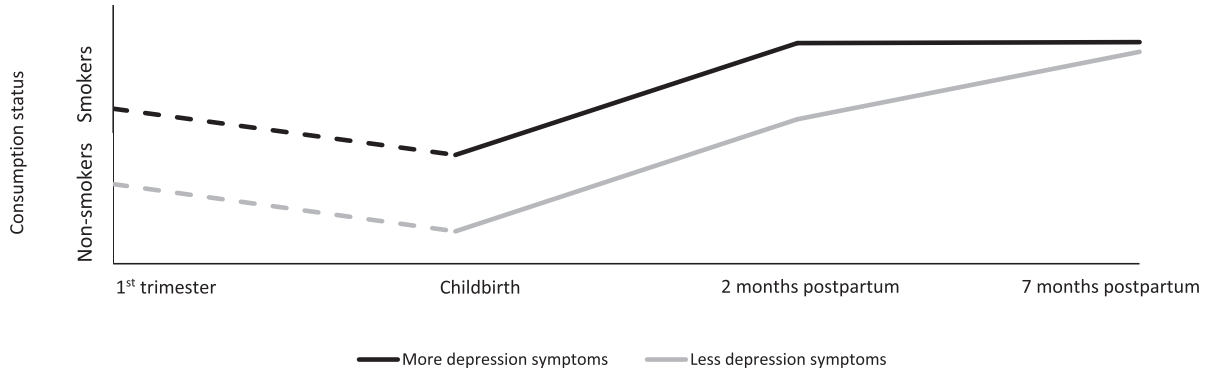


**Fig. 1.** Estimated smoking status in women with more and less depression symptoms.

0.300, $p = 0.009$) smoked more cigarettes per week.

Interaction effects of previous tobacco consumption, anxiety symptoms and time from the 1st trimester of pregnancy to childbirth were found on the number of cigarettes smoked per week, as shown by Table 3 and by Fig. 2. Women with more previous tobacco consumption presented a steeper decrease in the number of cigarettes smoked per week from the 1st trimester to childbirth ($b = -0.005$, $p = 0.008$), than women with less previous tobacco consumption. Likewise, women with more anxiety symptoms showed a steeper decrease in the number of cigarettes smoked per week from the 1st trimester to childbirth, than women with less anxiety symptoms ($b = -0.015$, $p = 0.047$). Fig. 2 shows, through a slightly steeper continuous line, how women with more previous tobacco consumption (Fig. 2A) or with more anxiety symptoms (Fig. 2B) tend to reduce the number of cigarettes smoked per week during pregnancy the most.

## 4. Discussion

The present study aimed to analyse the effect of previous tobacco consumption, and depression and anxiety symptoms on women's tobacco consumption status and quantity, from the 1st trimester of pregnancy to 7 months postpartum.

### *4.1. Smoking status from the 1st trimester of pregnancy to 7 months postpartum*

Although no changes were observed in women's smoking status from the 1st trimester of pregnancy to childbirth, since most of the women quitted tobacco consumption before being evaluated, the number of smoking women increases during the postpartum period. Results showed no significant effects of time from the 1st trimester to childbirth, while significant effects of time were found from childbirth to 2 months postpartum and from 2 to 7 months postpartum. These results are in line with previous studies (Correa-Fernández et al., 2012; Gilbert, Nelson, & Greaves, 2015; Lauria et al., 2012). Therefore, postpartum is highly vulnerable period for smoking relapse.

Smoking more cigarettes before pregnancy was associated with more likely to be a smoker at the 1st trimester of pregnancy. A higher consumption of cigarettes could be related to a higher level of nicotine dependence (Dierker et al., 2007), which can difficult women to quit smoking. Additionally, depression symptoms were associated with smoking status at the 1st trimester of pregnancy. Specifically, women with more depression symptoms were associated with more likely to be smokers at 1st trimester of pregnancy. High depression symptoms could make difficult to quit smoking, as they could be related to addicted to nicotine (Orr et al., 2012). Nicotine may have an antidepressant action, and smoking could be a coping strategy used to reduce the discomfort associated with depression symptoms (De Wilde et al., 2013; Flemming, Graham, Heirs, Fox, & Sowden, 2013; Goedhart et al., 2009; Smedberg et al., 2015). Furthermore, depressed women could have less confidence in their ability to quit smoking (Zhu & Valbø, 2002).

Although no significant effects of depression symptoms were found on smoking status from the 1st trimester of pregnancy to childbirth, effects of depression symptoms were found during the postpartum period. Women with more depression symptoms revealed higher tendency to relapse, specifically during the first 2 months postpartum. This result suggested that depression symptoms are associated with a higher likelihood of smoking relapse during the early postpartum period (De Wilde et al., 2013; Gyllstrom et al., 2012; Lauria et al., 2012).

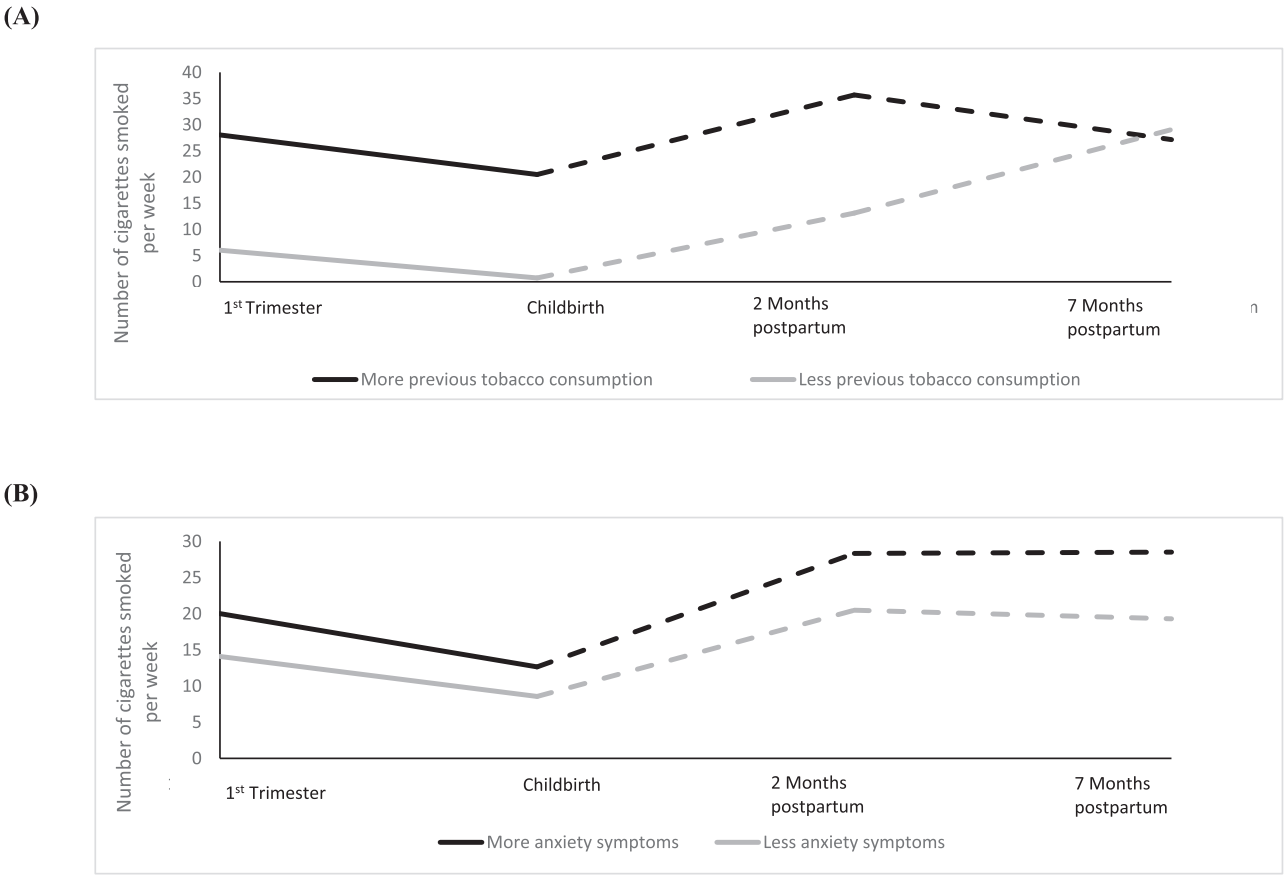


**Fig. 2.** Estimated smoking quantity (number of cigarettes smoked per week) from the 1st trimester of pregnancy to 7 months postpartum in women with more and less previous tobacco consumption (Fig. 2A) and women with more and less anxiety symptoms (Fig. 2B).

### 4.2. Smoking quantity from the 1st trimester of pregnancy to 7 months postpartum

Regarding smoking quantity, the number of cigarettes smoked was found to decrease during pregnancy and to increase during the early postpartum period, while no significant changes were observed from 2 to 7 months postpartum. Pregnancy is a period in which those women, who have not achieved abstinence, tend to reduce their tobacco consumption maybe trying to protect themselves and their future infant from the adverse effects of tobacco. Meanwhile, the postpartum period is associated with an increase in tobacco consumption, being a period of great vulnerability to smoking relapse (Gilbert et al., 2015; Lauria et al., 2012; Taghavi et al., 2018).

Results also showed that women who smoked more cigarettes before pregnancy had a higher likelihood of smoked more cigarettes at the 1st trimester of pregnancy. More previous tobacco consumption is related to greater dependence of nicotine and greater difficulty to reduce and to quit smoking (Anderka et al., 2010; Rozas et al., 2008; Vaz et al., 2014).

Likewise, women with more anxiety symptoms had a higher likelihood of smoked more cigarettes at the 1st trimester of pregnancy. A possible hypothesis for this relationship is that women with high anxiety could use smoking as a coping strategy against the anxiety symptoms, due to the popular belief that tobacco helps to relax (Irwin, Johnson & Bottorff, 2005; Parrot, 1999).

Results also showed significant association between anxiety symptoms and women's smoking quantity from the 1st trimester of pregnancy to childbirth. Although women with more anxiety symptoms had a higher likelihood of smoked more cigarettes during pregnancy, they presented a steeper decrease in the number of cigarettes smoked from the 1st trimester to childbirth than women with less anxiety symptoms. This steeper decrease could be related to the popular belief that quitting smoking can increase anxiety symptoms, and it may be more convenient to reduce tobacco consumption than to quit. Therefore, women with more anxiety symptoms may not try to quit smoking but rather try to control and reduce their quantity of tobacco consumption during pregnancy (Taghavi et al., 2018). Women with more anxiety symptoms try to reduce the consumption to reach a "suitable consumption" for pregnancy compared to women with low anxiety, whose consumption reduction is not so abrupt. Likewise, during the postpartum period, women tend to return to their previous tobacco consumption (Solomon et al., 2007), regardless of their anxiety symptoms. This may be because the awareness of postpartum smoke damage is diluted, and smoking is no longer a social taboo (Rattan, Mamun, Najman, Williams, & Doi, 2013).

This study has certain limitations. Previous tobacco consumption, and depression and anxiety symptoms were self-reported, which could affect the results due to biases such as social desirability. Although, should be noted that the self-reported instruments used to assess depression and anxiety symptoms are those of international reference. This same limitation makes difficult the establishment of cause-effect relationships. Likewise, some strengths should also be pointed out. This is a longitudinal study that was conducted with a large sample of women assessed in 4 assessment waves, from early pregnancy to 7 months postpartum, with low dropout rate. In addition, to our knowledge, this was the first longitudinal study that jointly analysed the effects of previous tobacco consumption, and depression and anxiety symptoms on tobacco consumption during pregnancy and the postpartum period, considering the changes that can occur in these variables over these periods. Also, another strength refers to the fact that this study tried to identify which of these relevant variables have more effects on women's smoking status, but also quantity, a variable that had been forgotten within this population.

This study's results have important implications for clinical practice. First, the screening of the different risk factors that can affect smoking status and quantity can help to design more effective interventions to increase women's tobacco consumption cessation during pregnancy and decrease women's relapse during the postpartum period. Secondly, knowing the associations between the risk factors and the different times over the perinatal period will facilitate the implementation of the intervention in the most vulnerable times, thus hoping to increase its effectiveness.

These results also have implications for research. Previous tobacco consumption, and depression and anxiety symptoms changes were associated with women's tobacco consumption during pregnancy and the postpartum period. Future studies could explore the underlying mechanisms (e.g., biological, psychological, and social) of these relationship. Exploring the causal and/or bidirectional effects between depression and anxiety and tobacco consumption during pregnancy and the postpartum period could also be a major advance to the literature in this field.

### 4.3. Conclusions

Women's tobacco consumption during pregnancy and the postpartum period is affected by both previous tobacco consumption, and depression and anxiety symptoms. The influence of these factors varies depending on time (pregnancy or postpartum) and on tobacco consumption dimension (status or quantity). Overall, these findings suggested that depression symptoms play a fundamental role on smoking status during the postpartum period, while anxiety symptoms explain better the consumption quantity during pregnancy.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## References


Adibelli, D., & Kirca, N. (2020). The relationship between gestational active and passive smoking and early postpartum complications. *Journal of Maternal-Fetal & Neonatal Medicine, 33*(14), 2473–2479. https://doi.org/10.1080/14767058.2020.1763294.

Anderka, M., Romitti, P. A., Sun, L., Druschel, C., Carmichael, S., & Shaw, G. (2010). The national birth defects prevention study. Patterns of tobacco exposure before and during pregnancy. *Acta Obstet. Gynecol. Scand., 89*(4), 505–514. https://doi.org/10.3109/00016341003692261.

Beijers, C., Ormel, J., Meijer, J. L., Verbeek, T., Bockting, C. L. H., Burger, H., & Franken, I. HA. (2014). Stressful events and continued smoking and continued alcohol consumption during midpregnancy. *PLoS ONE, 9*(1), e86359. https://doi.org/10.1371/journal.pone.0086359.

Bull, L., Burke, R., Walsh, S., & Whitehead, E. (2003). Smoking in pregnancy and parenthood: What is the role of depression, anxiety and nicotine addiction? *Early Child Development & Care, 173*(2-3), 349–356. https://doi.org/10.1080/03004430303090.

Correa-Fernández, V., Ji, L., Castro, Y., Heppner, W. L., Vidrine, J. I., Costello, T. J., … Wetter, D. W. (2012). Mediators of the association of major depressive syndrome and anxiety syndrome with postpartum smoking relapse. *J. Consult. Clin. Psychol., 80*(4), 636–648. https://doi.org/10.1037/a0027532.

Cox, J. L., Holden, J. M., & Sagovsky, R. (1987). Detection of postnatal depression. Development of the 10-item Edinburgh Postnatal Depression Scale. *The British Journal of Psychiatry, 150*(6), 782–786. https://doi.org/10.1192/bjp.150.6.782.

De Wilde, K., Trommelmans, L., Laevens, H., Maes, L., Temmerman, M., & Boudrez, H. (2013). Smoking patterns, depression and sociodemographic variables among Flemish women during pregnancy and the postpartum period. *Nurs. Res., 62*, 394–404. https://doi.org/10.1097/NNR.0b013e3182a59d96.

Dierker, L. C., Donny, E., Tiffany, S., Colby, S. M., Perrine, N., & Clayton, R. R. (2007). The association between cigarette smoking and DSM-IV nicotine dependence among first year college students. *Drug Alcohol Depend., 86*(2-3), 106–114. https://doi.org/10.1016/j.drugalcdep.2006.05.025.

Dietz, P. M., Williams, S. B., Callaghan, W. M., Bachman, D. J., Whitlock, E. P., & Hornbrook, M. C. (2007). Clinically identified maternal depression before, during, and after pregnancies ending in live births. *Am. J. Psychiatry, 164*(10), 1515–1520. https://doi.org/10.1176/appi.ajp.2007.06111893.

Erlingsdottir, A., Sigurdsson, E. L., Jonsson, J. S., Kristjansdottir, H., & Sigurdsson, J. A. (2014). Smoking during pregnancy: Childbirth and Health Study in Primary Care in Iceland. *Scand. J. Prim. Health Care, 32*(1), 11–16. https://doi.org/10.3109/02813432.2013.869409.

Figueiredo, B., & Conde, A. (2011). Anxiety and depression symptoms in women and men from early pregnancy to 3-months postpartum: Parity differences and effects. *J. Affect. Disord., 132*(1-2), 146–157. https://doi.org/10.1016/j.jad.2011.02.007.

Flemming, K., Graham, H., Heirs, M., Fox, D., & Sowden, A. (2013). Smoking in pregnancy: A systematic review of qualitative research of women who commence pregnancy as smokers. *J. Adv. Nurs., 69*(5), 1023–1036. https://doi.org/10.1111/jan.12066.

Garcia-Esteve, L., Ascaso, C., Ojuel, J., & Navarro, P. (2003). Validation of the Edinburgh Postnatal Depression Scale (EPDS) in Spanish mothers. *J. Affect. Disord., 75*(1), 71–76. https://doi.org/10.1016/S0165-0327(02)00020-4.

Gilbert, N. L., Nelson, C. R. M., & Greaves, L. (2015). Smoking cessation during pregnancy and relapse after childbirth in Canada. *Journal of Obstetrics & Gynaecology Canada, 37*(1), 32–39. https://doi.org/10.1016/S1701-2163(15)30360-1.

Goedhart, G., van der Wal, M. F., Cuijpers, P., & Bonsel, G. J. (2009). Psychosocial problems and continued smoking during pregnancy. *Addict. Behav., 34*(4), 403–406. https://doi.org/10.1016/j.addbeh.2008.11.006.

Gould, G. S., Havard, A., Lim, L. L., & Kumar, R. (2020). Exposure to tobacco, environmental tobacco smoke and nicotine in pregnancy: A pragmatic overview of reviews of maternal and child outcomes, effectiveness of interventions and barriers and facilitators to quitting. *Int. J. Environ. Res. Public Health, 17*(6), 2034. https://doi.org/10.3390/ijerph17062034.

Gyllstrom, M. E., Hellerstedt, W. L., & Hennrikus, D. (2012). The association of maternal mental health with prenatal smoking cessation and postpartum relapse in a population-based sample. *Matern. Child Health J., 16*(3), 685–693. https://doi.org/10.1007/s10995-011-0764-2.

Heck, R. H., Thomas, S. L., & Tabata, L. N. (2010). *Multilevel and Longitudinal Modeling with IBM SPSS*. Taylor & Francis Group: Routledge.

Homer, L., Bernard, C., & Collet, M. (2014). Management and outcomes of pregnancies complicated by preterm premature rupture of membranes before 26 weeks of gestation. *Gynécologie, Obstétrique & Fertilité, 42*, 71–77. https://doi.org/10.1016/j.gyobfe.2012.02.012.

Irfan, M., Haque, A. S., Shahzad, H., Samani, Z. A., Awan, S., & Khan, J. A. (2016). Reasons for failure to quit: A cross-sectional survey of tobacco use in major cities in Pakistan. *International Journal of Tuberculosis & Lung Disease, 20*(5), 673–678. https://doi.org/10.5588/ijtld.15.0271.

Irwin, L. G., Johnson, J. L., & Bottorff, J. L. (2005). Mothers who smoke: Confessions and justifications. *Health Care Women Int., 26*(7), 577–590. https://doi.org/10.1080/07399330591004890.

Jiménez-Muro, A., Samper, M. P., Marqueta, A., Rodríguez, G., & Nerín, I. (2012). Prevalencia de tabaquismo y exposición al humo ambiental de tabaco en las mujeres embarazadas: Diferencias entre españolas e inmigrantes [Prevalence of smoking and second-hand smoke exposure: Differences between Spanish and immigrant pregnant women]. *Gac. Sanit., 26*(2), 138–144. https://doi.org/10.1016/j.gaceta.2011.07.015.

Lange, S., Probst, C., Rehm, J., & Popova, S. (2018). Prevalence of smoking during pregnancy. *The Lancet Global Health, 6*, Article e1280. https://doi.org/10.1016/S2214-109X(18)30392-9.

Lauria, L., Lamberti, A., & Grandolfo, M. (2012). Smoking behaviour before, during, and after pregnancy: The effect of breastfeeding. *The Scientific World Journal, 2012*, 1–9. https://doi.org/10.1100/2012/154910.

Lee, A. M., Lam, S. K., Lau, S. M. S. M., Chong, C. S. Y., Chui, H. W., & Fong, D. Y. T. (2007). Prevalence, course, and risk factors for antenatal anxiety and depression. *Obstet. Gynecol., 110*, 1102–1112. https://doi.org/10.1097/01.aog.0000287065.59491.70.

Mateos-Vílchez, P. M., Aranda-Regules, J. M., Díaz-Alonso, G., Mesa-Cruz, P., Gil-Barcenilla, B., Ramos-Monserrat, M., … Luna del Castillo, J.d. D. (2014). Prevalencia de tabaquismo durante el embarazo y factores asociados en Andalucía, 2007–2012 [Smoking Prevalence and associated factors during pregnancy in Andalucía 2007–2012]. *Revista Española de Salud Pública, 88*(3), 369–381. https://doi.org/10.4321/S1135-57272014000300007.

Maxson, P. J., Edwards, S. E., Ingram, A., & Miranda, M. L. (2012). Psychosocial differences between smokers and non-smokers during pregnancy. *Addict. Behav., 37*(2), 153–159. https://doi.org/10.1016/j.addbeh.2011.08.011.

Meghea, C. I., Rus, D., Rus, I. A., Summers Holtrop, J., & Roman, L. (2012). Smoking during pregnancy and associated risk factors in a sample of Romanian women. *Eur. J. Pub. Health, 22*(2), 229–233. https://doi.org/10.1093/eurpub/ckq189.

Míguez, M. C., & Pereira, B. (2020). Effects of active and/or passive smoking during pregnancy and the postpartum period. *Anales de Pediatría*. https://doi.org/10.1016/j.anpedi.2020.07.029.

Míguez, M. C., & Pereira, B. (2021). Factors Associated with Smoking Relapse in the Early Postpartum Period: A Prospective Longitudinal Study in Spain. *Matern. Child Health J., 25*(6), 998–1006. https://doi.org/10.1007/s10995-020-03019-w.

Míguez, M. C., Pereira, B., & Figueiredo, B. (2017). Tobacco consumption and spontaneous quitting at first trimester of pregnancy. *Addict. Behav., 64*, 111–117. https://doi.org/10.1016/j.addbeh.2016.08.034.

Míguez, M. C., Pereira, B., Pinto, T. M., & Figueiredo, B. (2019). Continued tobacco consumption during pregnancy and women's depression and anxiety symptoms. *International Journal of Public Health, 64*(9), 1355–1365. https://doi.org/10.1007/s00038-019-01308-y.

Murphy, D. J., Dunney, C., Mullally, A., Adnan, N., & Deane, R. (2013). Population-based study of smoking behaviour throughout pregnancy and adverse perinatal outcomes. *International Journal of Environmental Research & Public Health, 10*, 3855–3867. https://doi.org/10.3390/ijerph10093855.

Orr, S. T., Blazer, D. G., & Orr, C. A. (2012). Maternal prenatal depressive symptoms, nicotine addiction, and smoking-related knowledge, attitudes, beliefs, and behaviors. *Matern. Child Health J., 16*(5), 973–978. https://doi.org/10.1007/s10995-011-0822-9.

Orton, S., Coleman, T., Coleman-Haynes, T., & Ussher, M. (2018). Predictors of postpartum return to smoking: A systematic Review. *Nicotine Tob. Res., 20*, 665–673. https://doi.org/10.1093/ntr/ntx163.

Park, E. R., Chang, Y., Quinn, V., Regan, S., Cohen, L., Viguera, A., … Rigotti, N. (2009). The association of depressive, anxiety, and stress symptoms and postpartum relapse to smoking: A longitudinal study. *Nicotine Tob. Res., 11*, 707–714. https://doi.org/10.1093/ntr/ntp053.

Parrot, A. C. (1999). Does cigarette smoking cause stress? *The American Psychologist, 54*, 817–820. https://doi.org/10.1037/0003-066X.54.10.817.

Rattan, D., Mamun, A., Najman, J. M., Williams, G. M., & Doi, S. A. (2013). Smoking behaviour in pregnancy and its impact on smoking cessation at various intervals during follow-up over 21 years: A prospective cohort study. *An International Journal of Obstetrics & Gynaecology, 120*, 288–295. https://doi.org/10.1111/1471-0528.12027.

Rozas, M. R., Costa, J., Francés, L., Paulí, A., León, C., & Baila, M. (2008). Modificaciones en el consumo de tabaco durante la gestación y el postparto [Changes in tobacco consumption during pregnancy and the postpartum period]. *Matronas Profesión, 9*, 13–20.

Salihu, H. M., & Wilson, R. E. (2007). Epidemiology of prenatal smoking and perinatal outcomes. *Early Human Devopment, 83*(11), 713–720. https://doi.org/10.1016/j.earlhumdev.2007.08.002.

Shobeiri, F., & Jenabi, E. (2017). Smoking and placenta previa: A meta-analysis. *Journal of Maternal-Fetal & Neonatal Medicine, 30*(24), 2985–2990. https://doi.org/10.1080/14767058.2016.1271405.

Smedberg, J., Lupattelli, A., Mårdby, A.-C., Øverland, S., & Nordeng, H. (2015). The relationship between maternal depression and smoking cessation during pregnancy–a cross-sectional study of pregnant women from 15 European countries. *Archives of Women's Mental Health, 18*(1), 73–84. https://doi.org/10.1007/s00737-014-0470-3.

Solomon, L. J., Higgins, S. T., Heil, S. H., Badger, G. J., Thomas, C. S., & Bernstein, I. M. (2007). Predictors of postpartum relapse to smoking. *Drug Alcohol Depend., 90*(2-3), 224–227. https://doi.org/10.1016/j.drugalcdep.2007.03.012.

M.C. Míguez B. Pereira Repercusiones del consumo de tabaco activo y/o pasivo en el embarazo y postparto [Effects of active and/or passive smoking during pregnancy and the postpartum period] Anales de Pediatría (Barcelona). S1695–4033 20 2020 30288 5 10.1016/j.anpedi.2020.07.029.

Spielberger, C.D., Gorsuch, R.L., & Lushene, R.E. (1970). Manual for the state-trait anxiety inventory. Consulting Psychologist Press, Palo Alto, CA. (Spanish version, 1982. Ediciones TEA, Madrid).

Taghavi, T., Arger, C. A., Heil, S. H., Higgins, S. T., & Tyndale, R. F. (2018). Cigarette consumption and biomarkers of nicotine exposure during pregnancy and postpartum. *Addiction, 113*(11), 2087–2096. https://doi.org/10.1111/add.v113.1110.1111/add.14367.

Tong, V.T., Farr, S.L., Bombard, J., ĎAngelo, D., Ko, J.Y., & England, L.J. (2016). Smoking before and during pregnancy among women reporting depression or anxiety. Obstetrics & Gynecology, 128, 562–570. https://doi.org/10.1097/AOG.0000000000001595.

U.S. Department of Health and Human Services. (2001). *Women and Smoking. A report of the Surgeon General*. Rockville: U.S Department of Health and Human Services.

Vázquez, M. B., & Míguez, M. C. (2019). Validation of the Edinburgh postnatal depression scale as a screening tool for depression in Spanish pregnant women. *J. Affect. Disord., 246*, 515–521. https://doi.org/10.1016/j.jad.2018.12.075.

Vaz, L. R., Leonardi-Bee, J., Aveyard, P., Cooper, S, Grainge, M, Coleman, T., & SNAP trial team. (2014). Factors associated with smoking cessation in early and late pregnancy in the smoking, nicotine, and pregnancy trial: A trial of NRT. *Nicotine & Tobacco Research, 16*, 381–389. https://doi.org/10.1093/ntr/ntt156.

World Health Organization. (2015). *Empower Women: Facing the Challenge of Tobacco Use in Europe*. Dinamarca: Copenague.

Zhu, S.-H., & Valbø, A. (2002). Depression and smoking during pregnancy. *Addict. Behav., 27*(4), 649–658. https://doi.org/10.1016/S0306-4603(01)00199-X.