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Research paper

Effects of smoking on perinatal depression and anxiety in mothers and fathers: A prospective cohort study

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ABSTRACT

Introduction: Considerable concern persists on tobacco use during perinatal periods. No study has simultaneously investigated the longitudinal association of paternal smoking with maternal and paternal depressive and anxiety symptoms during perinatal periods.
Methods: In this prospective study, 533 couples (pregnant women and their husbands) completed 5 self-report instruments from early pregnancy until 6 months postpartum. Generalized estimating equations were used for the analyses.
Results: We found that fathers who smoked in the mother's presence had higher depressive (regression coefficient = 1.0, 95% confidence interval (CI) 0.3–1.8) and anxiety symptoms (3.0, 95% CI = 1.2–4.7) during perinatal periods compared with nonsmoking fathers. Paternal smoking in the mother's presence also increased maternal disturbances, especially for depression during pregnancy (1.2, 95% CI = 0.1–2.3) and anxiety during the postpartum period (3.4, 95% CI = 0.6–6.3). No significant association was found between paternal smoking but not in the mother's presence and maternal emotional disturbances. Paternal smoking but not in the mother's presence affected only paternal anxiety, especially in the postpartum period (regression coefficient 2.7, 95% CI 0.7–4.7) compared with nonsmokers.
Limitations: Self-report measures were used. The effects of maternal smoking could not be estimated because of the small sample of pregnant women who disclosed their smoking status.
Conclusions: These findings imply a necessity to combine strategies for smoking cessation with interventions for affective disturbances in fathers. We also stress the importance of at least restricting the father's smoking in the presence of the pregnant wife during perinatal periods if smoking cessation is tentatively unattainable.

1. Introduction

Pregnancy and the postpartum period may be associated with mental health problems in many women. Numerous studies worldwide have indicated that postpartum depression is a common illness (Goldbort, 2006; Lee and Chung, 2007; O'Hara and Swain, 1996), as are antenatal depression and anxiety (Andersson et al., 2006; Evans et al., 2001; Heron et al., 2004; Nasreen et al., 2011). Furthermore, evidence has shown that postpartum depression in men is a considerable problem and is linked to maternal depression (Ballard et al., 1994; Goodman, 2004; Paulson and Bazemore, 2010). Studies have found that men presented with fewer anxiety and depression symptoms compared with women, but exhibited the same symptomatic patterns throughout the perinatal period (Figueiredo and Conde, 2011; Matthey et al., 2003; Wang and Chen, 2006). These parental emotional disturbances may contribute to adverse outcomes. For example, maternal depressive and anxiety symptoms during perinatal periods have been found to be associated with adverse obstetric outcomes (Chung et al., 2001), preterm delivery (Dayan et al., 2006; Grigoriadis et al., 2013), a low birth weight (Rahman et al., 2007), and newborn behavior (Diego et al., 2004). The role of prenatal and postnatal paternal mental health in child behavioral and emotional development has also been acknowledged (Ramchandani et al., 2005; van den Berg et al., 2009).

Understanding the factors that influence parental mental illnesses in perinatal periods is crucial for developing effective

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interventions. Smoking is a critical modifiable factor to consider in people's emotional status, including depression and anxiety. Both cross-sectional and longitudinal studies have reported a positive association between smoking and major depressive disorders (Michal et al., 2013; Pasco et al., 2008), but the causal direction of this association is uncertain (Fergusson et al., 2003). At present, the literature contains evidence of smoking raising the risks of panic disorder and generalized anxiety disorder (Moylan et al., 2012; Piper et al., 2011). A large population survey found a stronger association for anxiety and smoking relative to depression and smoking (Mykletun et al., 2008).

Studies on the mental health effects of passive smoking are emerging; however, the findings are currently inconsistent. Studies have shown that passive smoking is associated with poor mental health at work (Nakata et al., 2008) and in private spaces (Asbridge et al., 2013; Michal et al., 2013). Objectively measured secondhand smoke (SHS) exposure through serum cotinine has been found to increase the risks of psychological distress, future psychiatric illnesses (Hamer et al., 2010), and depressive symptoms (Bandiera, 2011). Nevertheless, findings from well-designed prospective studies have recently indicated that SHS exposure is not related to depression or anxiety in nonsmoking men and women (Bot et al., 2013; Lam et al., 2013).

An even higher level of concern persists regarding tobacco use during perinatal periods. Significant associations of active smoking with depression (Pritchard, 1994; Zhu and Valbo, 2002) and anxiety disorders (Goodwin et al., 2007) have been found during pregnancy. Furthermore, although the level may drop during pregnancy (Fu et al., 2008), SHS remains common in Chinese women (Li et al., 2011; Yang et al., 2005). One recent clinic-based study reported an elevated risk for prenatal depressive symptoms among women exposed to SHS (Mbah et al., 2013). This evidence suggests that paternal smoking may represent a potential risk factor for both maternal and paternal emotional disturbances throughout the perinatal period, through both passive and active smoking. Nevertheless, few studies have investigated the effects of passive smoking on mental health during perinatal periods. No study has simultaneously investigated the longitudinal effects of passive and active smoking on parental depression and anxiety across the critical interval spanning pregnancy to the postpartum period.

Therefore, our prospective study attempted to investigate whether the paternal smoking status is longitudinally associated with maternal and paternal depression and anxiety from early pregnancy until 6 months postpartum. Because fathers have frequently been observed to avoid smoking in the family's presence, especially around perinatal women, we categorized the paternal smoking status into nonsmoking, smoking but not in the mother's presence, and smoking in the mother's presence. The rationale for this categorization was supported by a study by Roza et al. (2009) in order to evaluate whether the association between active/passive smoking and emotional disturbances is driven by tobacco use/passive smoking inhalation or may be caused by certain psychological impacts (e.g., worry or guilt about smoking behaviors especially during maternal pregnancy/postpartum). We identified the patterns of depression and anxiety symptoms at early pregnancy (T1, <17 gestational weeks), mid-pregnancy (T2, 17–29 gestational weeks), late pregnancy (T3, >29 gestational weeks), 1 month postpartum (T4), and 6 months (T5) postpartum.

2. Methods

2.1. Study design and sample

A prospective cohort study design was adopted. Pregnant women (mothers) were approached consecutively from July 2011 until May 2014 and were invited to participate during their prenatal visits at the outpatient clinics of 5 selected hospitals in Taipei, Taiwan. Pregnant women were eligible to participate if they were undergoing their early prenatal visit (≤ 16 gestational weeks), planned to carry the baby to term, provided informed consent, and their spouse or partner (father) was available and also willing to participate. Women who were unable to read or write in Chinese were excluded. Among the 686 couples recruited, 533 ($n=1066$) successfully completed 5 assessments from T1 to T5, yielding an overall follow-up rate of 0.78. Self-report instruments were completed by both the mothers and fathers, either in the hospital or by postal mail followed by a telephone reminder. The interviewers were trained for standardization. Ethical approval for this study was obtained from the institutional review boards of the relevant hospitals.

2.2. Measures

All of the following information was gathered 5 times from T1 (early pregnancy) to T5 (6 months postpartum), except for the sociodemographic characteristics, which were collected only at T1.

2.2.1. Assessment of depression

The Edinburgh Postnatal Depression Scale (EPDS) was used for assessing depression symptoms in both mothers and fathers. The EPDS consists of 10 items used to assess how participants have been feeling in the past 7 days. Items 1, 2, and 4 are rated on a 4-point scale, ranging from 0 (*yes, most of the time*) to 3 (*no, not at all*), with a maximum score of 9. Items 3 and 5–10 have reversed scoring, from 3 (*yes, most of the time*) to 0 (*no, not at all*). The total score is calculated by summing all of the participant responses, and a higher score reflects a greater level of depressive symptoms. The Chinese version of the EPDS has appropriate reliability and validity, with Cronbach's $\alpha=0.87$ (Heh, 2001; Lee et al., 1998). In our sample, the internal consistency was 0.88 for mothers and 0.82 for fathers. Continuous scores were used to identify the depression trajectories.

2.2.2. Assessment of anxiety

Anxiety was assessed using the State-Trait Anxiety Inventory (STAI) (Spielberger et al., 1970). The 20 items of the state subscale, measuring anxiety in the present (related to a specific situation or period), were included in our questionnaire. Respondents answer items on a 4-point scale, with the scores being 1 (*not at all*), 2 (*a little*), 3 (*somewhat*), and 4 (*very much so*). The total score ranges from 20 to 80, with a greater score indicating a more severe level of anxiety. Nine of the 20 items have reversed scoring. The STAI-S, Chinese version, has a test–retest reliability of 0.74 and excellent internal consistency with a Cronbach's α value of 0.90 (Chung and Lun, 1984).

2.2.3. Paternal smoking status

Participants who currently smoked and who had consumed up to 100 cigarettes in their lifetime at the time of the interview were categorized as smokers. The fathers were also asked whether they would smoke in the mother's presence. The response was either "yes" or "no." Paternal smoking was categorized into 3 groups: nonsmoking, smoking but not in the mother's presence, and smoking in the mother's presence. Roza et al. (2009) reported that fathers who smoked indoors had higher psychopathology scores than those of fathers who smoked outside of the house. With a similar rationale, it was crucial to assess whether paternal smoking in the presence or absence of the mother may lead to varying risks of parental emotional distress. For women, because maternal smoking during pregnancy is illegal in Taiwan, few maternal

smokers were available for analysis. We thus emphasized the effect of paternal smoking in perinatal periods.

2.2.4. Other covariates

Because of the possible correlation between smoking and alcohol use and the potential negative impact of paternal alcohol consumption on parental emotional disturbances, we assessed paternal alcohol use. The fathers were required to report types (beer, wine or yellow rice wine, and strong spirits) and frequency (none, 1–3 days per month, once per week, 2–3 days per week, or more than 4 days per week) of alcohol consumption for the past month from T1 to T5. A "frequent drinker" was defined as someone who consumes any type of alcoholic beverage on more than 2 days every week.

To assess marital adjustment, the translated Chinese version of the Locke–Wallace Marital Adjustment Test (MAT) was used (Locke and Wallace, 1959). Of the 18 questions, the first item is a global adjustment question measuring the participant's general impression of marriage happiness on a 6-point Likert scale. Ten questions measure the extent of agreement or disagreement between partners on various items (e.g., managing family finances, matters concerning recreation, demonstrations of affection, and approaches to managing in-laws). The remaining 7 questions concern conflict resolution, cohesion, and communication. The total MAT score was calculated by summing all item scores, where a higher total score indicates poorer marital adjustment. Cronbach's α was reported to be 0.9, indicating satisfactory internal consistency of items (Locke and Wallace, 1959). In our study, Cronbach's α was 0.91 for mothers and 0.92 for fathers.

Parental stress was assessed using the self-report Parental Stress Scale, which contains 18 items for evaluating pleasure or the positive themes of parenthood (self-enrichment) and negative components (demands on resources and restrictions). Respondents are asked to agree or disagree with items on a 5-point scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Eight positive items are reverse coded, with a higher score indicating greater parental stress. Satisfactory internal reliability (0.83) and test–retest reliability (0.81) were reported (Berry and Jones, 1995). In our study, Cronbach's α was 0.83 for mothers and 0.85 for fathers.

Other information was also collected, including maternal and paternal age, education level, marital status, employment status, family monthly income, parity, other SHS exposure (e.g., in the workplace), and a history of depression (previous diagnosis, yes vs. no) at T1. The infant's general health status was assessed at 1 month and 6 months after birth.

3. Statistical analysis

Descriptive statistics were employed to summarize the demographic characteristics of the sample. Categorical variables are described in percentages, whereas continuous data are presented as the mean and standard deviation (SD). The maternal and paternal trajectories of depression and anxiety were depicted over time from early pregnancy (T1) to 6 months postpartum (T5) according to the paternal smoking status at the baseline (T1).

We conducted generalized estimating equation (GEE) analysis to estimate the longitudinal link between the paternal smoking status and parental depressive and anxiety symptoms across perinatal periods, because of the assumption that correlations exist for repeated measures from the same participant and are lag-independent and identical for each person. Baseline variables were parental age, marital status, education level, employment status, parity, family monthly income, and a history of depression. Time-varying variables included the main exposure of the paternal smoking status from T1 to T5, other covariates of paternal alcohol consumption, marital adjustment, parental stress, and other SHS exposure from T1 to T5, and the infant's health status at T4 and T5. The outcomes were total depression and anxiety scores from T1 to T5. Using univariate regression as a preliminary step, the variables that had been reported previously to potentially confound the exposure–outcome relationship or were associated with exposure and outcome in univariate analyses were considered in the multivariate models. Because no significant interaction term between the paternal smoking status and all other covariates at the baseline was observed, these terms were removed from the final analyses. Statistical analyses were performed using STATA software (version 12) for Windows.

4. Results

The baseline distributions of the sociodemographic and psychosocial characteristics of the mothers and fathers are listed in Table 1. The majority of the participants were married, highly educated, had a middle or upper middle class income level, had one child, and were fully employed. Approximately 2.4% of mothers and 0.8% of fathers had a history of depression. Approximately 78.8% of fathers were nonsmokers; 14.7% smoked, but not in the presence of the mother; and 6.4% of fathers smoked in the mother's presence. Approximately 13.2% of fathers consumed a type of alcoholic beverage on more than 2 days per week. The mean scores of marital adjustment and parental stress were similar between the mothers and fathers. In examining baseline (T1) differences among the fathers in the 3 smoking status groups, we found that those smoking in the mother's presence tended to be younger ($p=0.02$), with a lower education level ($p<0.001$). No significant difference in the distribution of employment status, family monthly income, parity, history of depression, marital adjustment, and parental stress was observed among the fathers in the 3 smoking status groups. A similar tendency was observed for the distributions of the maternal baseline (T1) characteristics based on the 3 paternal smoking status groups. Specifically, mothers who were younger ($p=0.03$) and had a lower education level ($p<0.001$) tended to have a partner who smoked in their presence. All other traits exhibited nonsignificantly different distributions according to the paternal smoking status.

Fig. 1 displays changes in maternal and paternal depression during the perinatal periods according to the paternal smoking status at T1. At all 5 time-point measurements, smoking in the mother's presence was found to have the highest level of perinatal depression in both genders, followed by smoking but not in the mother's presence and nonsmoking. Maternal depressive symptoms were relatively stable during pregnancy, increasing at 1 month after childbirth, and then beginning to decline sharply, regardless of the paternal smoking status.

Changes in parental anxiety from T1 to T5 are displayed in Fig. 2. Paternal smoking in the mother's presence yielded higher scores for maternal anxiety compared with smoking but not in the mother's presence and a nonsmoking status. Overall, the patterns of change in maternal anxiety during the perinatal periods were similar, irrespective of the paternal smoking status. Paternal anxiety symptoms were relatively stable across the 5 assessment phases in the nonsmokers. Although relatively consistent during pregnancy, paternal smoking in the mother's presence was associated with considerably higher levels of paternal anxiety in the postpartum period.

Table 2 lists the results of GEE modeling for the longitudinal link between the paternal smoking status and changes in parental depression from early pregnancy (T1) to 6 months postpartum (T5). In the crude univariate model, paternal smoking in the

Table 1
Baseline distributions of sociodemographic and other psychosocial factors of parents.

Variable	Mothers	Fathers
	n [a] **(%)**	***n*** [a] **(%)**
Age (y)		
< 30	57 (11.2)	30 (5.9)
30–35	304 (59.7)	236 (46.5)
> 35	148 (29.1)	242 (47.6)
Marital status		
Married	495 (96.7)	–
Other	17 (3.3)	–
Schooling (y)		
< 12	40 (7.8)	48 (9.4)
12–16	368 (71.9)	305 (59.8)
> 16	104 (20.3)	157 (30.8)
Employment status		
Full-time	381 (75.2)	484 (96.6)
Part-time/unemployed	126 (24.9)	17 (3.4)
Family monthly income (NT$)[b]		
< 30,000	11 (2.1)	–
30,000–100,000	332 (64.7)	–
> 100,000	170 (33.1)	–
Parity		
1	319 (62.3)	–
2+	193 (37.7)	–
Depression history		
No	494 (97.6)	490 (99.2)
Yes	12 (2.4)	4 (0.8)
Paternal smoking		
Nonsmoking	–	414 (78.8)
Smoking but not in the mother's presence	–	77 (14.7)
Smoking in the mother's presence	–	34 (6.4)
Paternal alcohol use status		
Nonfrequent drinker	–	426 (86.8)
Frequent drinker	–	65 (13.2)
	***Mean* (*SD*)**	***Mean* (*SD*)**
Marital adjustment	20.2 (5.6)	20.3 (5.9)
Parental stress	29.2 (5.7)	29.7 (6.3)

[a] Total counts may vary because of missing values.
[b] The exchange rate in 2014 was US$1.00 ≈ New Taiwan $30.

mother's presence was associated with a significant increase in maternal depression during the perinatal periods compared with a nonsmoking status. After adjusting for other covariates, we found smoking in the mother's presence to be independently associated with maternal depression for the perinatal period (regression coefficient = 0.9, 95% confidence interval (CI) 0.1–1.8), especially during pregnancy (regression coefficient = 1.2, 95% CI 0.1–2.3). Nevertheless, paternal smoking in the mother's presence was associated with significantly higher paternal depressive symptoms in the perinatal periods (1.0, 95% CI 0.3–1.8), especially in the postpartum period (1.3, 95% CI 0.2–2.3), compared with a nonsmoking status, after adjustment for other covariates. No statistically significant result on maternal and paternal depression was found for paternal smoking but not in mother's presence.

The GEE analysis results for parental anxiety from T1 to T5 are listed in Table 3. Compared with a nonsmoking status, paternal smoking in the mother's presence was positively associated with maternal anxiety after adjustment for other covariates, especially in the postpartum period (regression coefficient 3.4, 95% CI 0.6–6.3). No significant effect was found for paternal smoking but not in the mother's presence. By contrast, paternal smoking in the mother's presence was consistently and independently related to paternal anxiety in all 3 perinatal periods (3.0, 95% CI 1.2–4.7 for the perinatal period; 2.3, 95% CI 0.2–4.5 during pregnancy; 3.2, 95% CI 0.7–5.6 in the postpartum period). Smoking outside the mother's presence also raised paternal anxiety throughout the perinatal periods, especially in the postpartum period (regression coefficient 2.7, 95% CI 0.7–4.7), compared with a nonsmoking status.

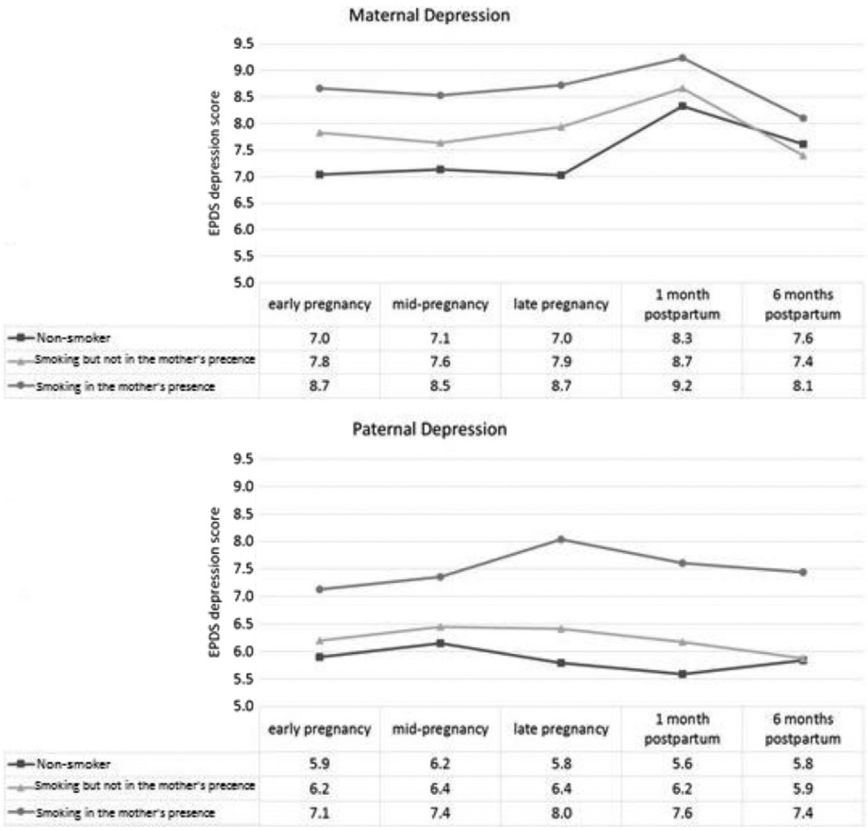
Finally, regarding the effects of the paternal drinking status, we found that frequent paternal alcohol use was significantly associated with increased depression (regression coefficient 0.9, 95% CI 0.3–1.5) and anxiety (regression coefficient 2.1, 95% CI 0.7–3.5) symptom scores during the perinatal periods among fathers, but not among mothers, compared with a nonfrequent drinking status, after adjustment for other covariates.

5. Discussion

To the best of our knowledge, this prospective cohort study is the first to specifically examine the effects of active and passive smoking on both maternal and paternal depression and anxiety throughout the perinatal period from early pregnancy to 6 months postpartum. We found that paternal smoking in the mother's presence (with the mother as a passive smoker) was independently associated with maternal emotional disturbances, especially depression during pregnancy and anxiety in the postpartum period, compared with a nonsmoking status. However, no significant effect on maternal depression or anxiety symptoms was observed if the father did not smoke in the mother's presence. For fathers, paternal smoking in the mother's presence resulted in significant increases in their own depression and anxiety symptom scores throughout the perinatal period. By contrast, paternal smoking but not in the mother's presence was significantly associated only with increased anxiety scores, especially in the postpartum period. Paternal alcohol use was also a critical concern, and we found that frequent paternal alcohol consumption was associated with increased paternal depression and anxiety symptom scores during the perinatal periods, whereas the maternal emotional status was nonsignificantly affected.

Although a null association has been observed for SHS exposure and emotional distress in certain longitudinal studies (Bot et al., 2013; Lam et al., 2013), our results were consistent with other previous studies that have reported a link between passive smoking and maternal depression during pregnancy (Brion et al., 2010; Mbah et al., 2013). For instance, a prospective study conducted in the United States found that women exposed to SHS were at an elevated risk for depressive symptoms during pregnancy (Mbah et al., 2013). Another prospective cohort study, conducted in the United Kingdom, found a significant association of paternal smoking during pregnancy with maternal prenatal and postpartum depression and prenatal anxiety (Brion et al., 2010). These conflicting results can be explained by differences in the assessments of smoking status or psychological symptoms in the various studies. It is also possible that women in the critical interval from pregnancy to the postpartum period are more seriously concerned with SHS exposure compared with when they are at other stages of life (Lam et al., 2013; Bot et al., 2013).

Most previous studies have considered only the effects of the paternal smoking or nonsmoking status on maternal psychological health (Brion et al., 2010). We further considered the possibility that maternal emotional distress could be elicited, despite fathers not smoking in the mother's presence (the mother was not a passive smoker), by certain psychological effects (e.g., mother concerned with the harmful effects of smoking on the father's or future newborn's health, or expectations that the father should quit smoking over the long term). However, the present study found no significant effect of the father not smoking in the mother's presence on maternal depression or anxiety symptoms. These findings are in line with the results of a population-based cohort study conducted in the Netherlands, which suggested that fathers who smoke outside the house may create a more favorable environment for their unborn child's health by being considerate



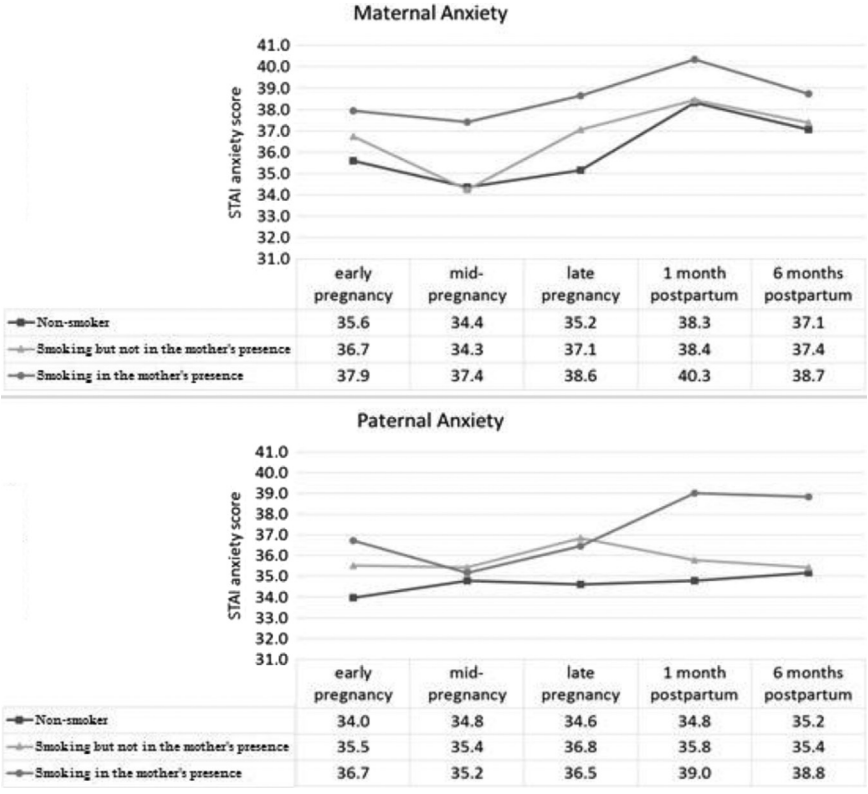
	early pregnancy	mid-pregnancy	late pregnancy	1 month postpartum	6 months postpartum
Non-smoker	7.0	7.1	7.0	8.3	7.6
Smoking but not in the mother's precence	7.8	7.6	7.9	8.7	7.4
Smoking in the mother's presence	8.7	8.5	8.7	9.2	8.1

	early pregnancy	mid-pregnancy	late pregnancy	1 month postpartum	6 months postpartum
Non-smoker	5.9	6.2	5.8	5.6	5.8
Smoking but not in the mother's precence	6.2	6.4	6.4	6.2	5.9
Smoking in the mother's presence	7.1	7.4	8.0	7.6	7.4

Fig. 1. Changes in maternal and paternal depression from early pregnancy to 6 months postpartum.

of their pregnant partner compared with fathers who smoked in the same room as their pregnant wife (Roza et al., 2009).

For fathers, we found that paternal smoking in the mother's presence significantly increased their own perinatal depression and anxiety symptom scores. Brion et al. (2010) reported a positive association of paternal active smoking with paternal depression



	early pregnancy	mid-pregnancy	late pregnancy	1 month postpartum	6 months postpartum
Non-smoker	35.6	34.4	35.2	38.3	37.1
Smoking but not in the mother's presence	36.7	34.3	37.1	38.4	37.4
Smoking in the mother's presence	37.9	37.4	38.6	40.3	38.7

	early pregnancy	mid-pregnancy	late pregnancy	1 month postpartum	6 months postpartum
Non-smoker	34.0	34.8	34.6	34.8	35.2
Smoking but not in the mother's presence	35.5	35.4	36.8	35.8	35.4
Smoking in the mother's presence	36.7	35.2	36.5	39.0	38.8

Fig. 2. Changes in maternal and paternal anxiety from early pregnancy to 6 months postpartum.

Table 2
Changes in parental depression from early pregnancy to 6 months postpartum by paternal smoking and drinking status: crude and adjusted estimates from GEE models for a longitudinal link.

	Depression_Perinatal period (From early pregnancy to 6 months postpartum)		Depression_During pregnancy (From early to late pregnancy)		Depression_Postpartum period (From childbirth to 6 months postpartum)	
	Mothers β (95% CI)	Fathers β (95% CI)	Mothers β (95% CI)	Fathers β (95% CI)	Mothers β (95% CI)	Fathers β (95% CI)
Crude model						
Father's smoking status						
Nonsmoking	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Smoking but not in the mother's presence	0.5 (−0.2, 1.2)	0.4 (−0.1, 1.0)	0.8 (−0.0, 1.5)	0.4 (−0.3, 1.0)	−0.1 (−1.1, 0.9)	0.8 (−0.0, 1.6)
Smoking in the mother's presence	1.2 (0.3, 2.1)**	1.1 (0.4, 1.8)***	1.3 (0.3, 2.3)*	0.9 (0.1, 1.8)*	1.1 (−0.2, 2.3)	1.6 (0.6, 2.5)*
Father's alcohol use status						
Nonfrequent drinker	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Frequent drinker	0.0 (−0.7, 0.8)	0.9 (0.3, 1.5)**	0.1 (−0.8, 1.0)	0.6 (−0.1, 1.4)	−0.2 (−1.4, 1.0)	1.7 (0.7, 2.7)*
Adjusted model						
Father's smoking status [a]						
Nonsmoking	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Smoking but not in the mother's presence	0.4 (−0.3, 1.1)	0.4 (−0.2, 0.9)	0.7 (−0.1, 1.5)	0.3 (−0.4, 1.0)	−0.2 (−1.3, 0.8)	0.7 (−0.1, 1.5)
Smoking in the mother's presence	0.9 (0.1, 1.8)*	1.0 (0.3, 1.8)**	1.2 (0.1, 2.3)*	0.8 (−0.1, 1.7)	0.9 (−0.4, 2.2)	1.3 (0.2, 2.3)*
Father's alcohol use status[b]						
Nonfrequent drinker	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Frequent drinker	−0.2 (−1.0, 0.5)	0.9 (0.3, 1.5)**	−0.1 (−1.0, 0.8)	0.6 (−0.2, 1.3)	−0.2 (−1.4, 1.0)	1.4 (0.4, 2.4)**

CI, confidence interval.

* $p < .05$.
** $p < .01$.
*** $p < .001$.

[a] Results were adjusted for age, marital status, education level, employment status, family monthly income, parity, other secondhand smoke exposure, marital adjustment, parental stress, history of depression, the couple's depression status, and paternal alcohol use for the "perinatal period" and "during pregnancy" models. For the "postpartum period" model, results were adjusted for all parameters mentioned, in addition to the infant's health status at up to 6 months after birth.

[b] Results were adjusted for age, marital status, education level, employment status, family monthly income, parity, other secondhand smoke exposure, marital adjustment, parental stress, history of depression, the couple's depression status, and parental smoking status for the "perinatal period" and "during pregnancy" models. For the "postpartum period" model, the results were adjusted for all parameters mentioned, in addition to the infant's health status at up to 6 months after birth.

and anxiety during perinatal periods. Roza et al. (2009) found that paternal outdoor smoking during pregnancy was associated with lower psychopathology scores in fathers compared with paternal indoor smoking and nonsmoking. Similarly, compared with smoking in the mother's presence, we observed paternal smoking but not in the mother's presence to be less strongly associated with postnatal anxiety scores. Smoking in the mother's presence may be considered more severe and heavy smoking compared with smoking but not in the mother's presence, because of the observed difficulty in refraining from smoking in undesirable spaces. Previous studies have suggested that heavier smokers develop more mental health problems compared with non-dependent smokers and nonsmokers (Breslau et al., 1991, 1994; Jamal et al., 2012; Pedersen and von Soest, 2009). Furthermore, fathers who smoke in the mother's presence may experience more psychological stress and concerns, which in turn exacerbate any emotional disturbances.

We found the impact of paternal smoking to be higher for anxiety than for depression. This was consistent with the results obtained through a survey of a larger population, which found that smoking behavior was more strongly related with anxiety than with depression (Mykletun et al., 2008). A prospective community study also reported a link between dependent smoking and generalized anxiety disorder (Isensee et al., 2003). The anxiogenic effect of nicotine in the association between smoking and panic disorder has also been suggested in longitudinal studies (Breslau and Klein, 1999; Isensee et al., 2003). During perinatal periods, parents may particularly be more anxious or concerned with the negative health impact of smoking behavior.

Certain potential pathways can be used for facilitating the explanation of the association between smoking and emotional disturbances. Exposure to various psychoactive compounds of tobacco smoke, either through active or passive smoking, may result in the dysregulation of affective states (Morrell and Cohen, 2006). The major psychoactive component is nicotine, which affects numerous neurotransmitters involved in the pathophysiology of depression (Quattrocki et al., 2000) through the activation or desensitization of nicotinic acetylcholine receptors (nAChRs) (Picciotto et al., 2002, 2008). In addition to their role in cholinergic neurotransmission, nAChRs influence the activities of the neuroendocrine system that are involved in depression and the hypothalamic–pituitary–adrenal (HPA) axis. Altered HPA axis function includes changes in the secretion of corticotropin-releasing factor, glucocorticoid receptor sensitivity, and pituitary and adrenocortical structure and function, all of which are known to be involved in the biological mechanisms of depression (Philip et al., 2010). Regarding the effects of SHS exposure on depression, in addition to the direct effect of inhaled cigarette smoke, passive smokers are more likely to have a depressed partner and have a family environment that may act as a potential pathway through which the association can be explained (Bandiera, 2011). Psychological mechanisms involving internalized stigmas, which elicit emotions of "psychological punishment" (e.g., guilt, self-blame, and regret), may have further potential of harming the father's mental health (Greaves et al., 2010). Further examination into the mechanisms underlying the relationship of active and passive smoking with psychological disturbances is recommended, especially during perinatal periods.

Frequent paternal alcohol consumption was associated with increased paternal perinatal depression and anxiety scores, but

Table 3
Changes in parental anxiety from early pregnancy to 6 months postpartum by paternal smoking and drinking status: crude and adjusted estimates from GEE models for a longitudinal link.

	Anxiety_Perinatal period (From early pregnancy to 6 months postpartum)		Anxiety_During pregnancy (From early to late pregnancy)		Anxiety_Postpartum period (From childbirth to 6 months postpartum)	
	Mothers β (95% CI)	Fathers β (95% CI)	Mothers β (95% CI)	Fathers β (95% CI)	Mothers β (95% CI)	Fathers β (95% CI)
Crude model						
Father's smoking status						
Nonsmoking	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Smoking but not in the mother's presence	0.5 (−1.0, 2.0)	1.4 (0.1, 2.7)*	1.5 (−0.2, 3.2)	1.6 (0.0, 3.1)*	0.3 (−2.0, 2.6)	2.8 (0.9, 4.7)**
Smoking in the mother's presence	2.4 (0.5, 4.3)*	2.9 (1.2, 4.5)***	1.6 (−0.7, 3.9)	2.3 (0.3, 4.4)*	3.4 (0.8, 6.1)*	3.2 (0.9, 5.5)**
Father's alcohol use status						
Nonfrequent drinker	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Frequent drinker	0.0 (−1.6, 1.7)	2.4 (1.0, 3.7)**	−1.2 (−3.1, 0.8)	1.9 (0.2, 3.7)*	0.9 (−1.7, 3.6)	2.8 (0.4, 5.1)*
Adjusted model						
Father's smoking status[a]						
Nonsmoking	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Smoking but not in the mother's presence	0.4 (−1.1, 1.9)	1.4 (0.0, 2.7)*	1.5 (−0.2, 3.3)	1.6 (0.0, 3.2)*	0.3 (−2.1, 2.6)	2.7 (0.7, 4.7)**
Smoking in the mother's presence	2.2 (0.3, 4.2)*	3.0 (1.2, 4.7)***	1.8 (−0.6, 4.2)	2.3 (0.2, 4.5)*	3.4 (0.6, 6.3)*	3.2 (0.7, 5.6)*
Father's alcohol use status[b]						
Nonfrequent drinker	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Frequent drinker	−0.6 (−2.3, 1.1)	2.1 (0.7, 3.5)**	−1.6 (−3.6, 0.4)	1.6 (−0.1, 3.4)	0.4 (−2.3, 3.1)	1.9 (−0.4, 4.2)

CI, confidence interval.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

[a] Results were adjusted for age, marital status, education level, employment status, family monthly income, parity, other secondhand smoke exposure, marital adjustment, parental stress, history of depression, the couple's depression status, and paternal alcohol use for the "perinatal period" and "during pregnancy" models. For the "postpartum period" model, the results were adjusted for all parameters mentioned, in addition to the infant's health status up to 6 months after birth.

[b] Results were adjusted for age, marital status, education level, employment status, family monthly income, parity, other secondhand smoke exposure, marital adjustment, parental stress, history of depression, the couple's depression status, and paternal smoking status for the "perinatal period" and "during pregnancy" models. For the "postpartum period" model, the results were adjusted for all parameters mentioned, in addition to the infant's health status up to 6 months after birth.

not maternal emotional disturbances, in our study. Sareen et al. (2004) used data from 2 contemporaneous surveys, and found that a drinking problem was significantly associated with mood and anxiety disorders. However, no significant association was identified between paternal alcohol consumption and depression in the postpartum period in a cross-sectional study (Ramchandani et al., 2011). The inconsistent findings reported in these studies may be attributed to differences in the samples drawn and measurements used for assessing alcohol consumption and affective illness. The present study further extended past findings for investigating the effects of paternal alcohol use on maternal and paternal perinatal emotional disturbances.

Our findings underscored significant implications because smoking and SHS exposure are potentially modifiable. Recruiting more fathers to participate in smoking cessation programs is imperative. A recent large population-based survey found that personal health concerns were the most commonly cited trigger for quitting in a Chinese population compared with interpersonal triggers such as concern with the effect of secondhand smoking on nonsmokers and disapproval of smoking by family and society (Im et al., 2015). According to our findings, smoking cessation interventions should more strongly emphasize the harmful and potentially preventable effects that smokers pose to their own mental health. Furthermore, our differentiation of paternal smoking in the mother's presence or absence was crucial. Although quitting smoking is definitely the ultimate goal, paternal smoking but not in the mother's presence may serve as a significant first step to ameliorating both paternal and maternal emotional distress during perinatal periods.

Moreover, because our findings suggested that the largest effect of paternal smoking on their affective symptoms occurred in the postnatal period, intervention targeting both paternal smoking and mood disturbances could prove most fruitful during the postpartum period. A recent meta-analysis suggested a positive effect of smoking cessation services, including nicotine replacement therapy and behavioral mood management for patients with depressive symptoms (Gierisch et al., 2012). The involvement of fathers in male-specific support groups or intervention programs with combined strategies, particularly in the postnatal period, may be beneficial for reducing their disturbances in smoking, alcohol consumption, and affective symptoms.

The major strengths of the current study were the longitudinal nature of the analysis from early pregnancy to 6 months postpartum and adjustment for a wide range of confounding variables (e.g., marital adjustment, parental stress, a history of depression, the couple's emotional distress, and infant health status). The study cohort included pregnant women as well as their spouses, whose cases were followed-up longitudinally.

This study had several limitations. First, consecutive sampling and the voluntary nature of participation may have led to a selection bias; in other words, the women and men who agreed to participation may have had fewer symptoms of depression or anxiety. Higher education and income levels were observed in the distribution of the sample characteristics.

The second limitation was the use of a self-rated screening scale for identifying probable depression and anxiety rather than clinical interviews. However, using DSM or ICD criteria to confirm a clinical diagnosis of depression and anxiety may have led to overlooking subsyndromal depressive symptoms, which are prevalent in the perinatal period (Gotlib, 2009). In our study, we used the EPDS, a widely employed research screening instrument for the perinatal period, with high sensitivity and specificity for identifying possible cases of depression. Importantly, referral of positive cases for further diagnosis and counseling was provided

for study participants.

Third, we used only self-report measures for active and passive smoking, without validation with plasma or urine cotinine levels as a biological marker of smoking exposure. Data on the levels of dependent smoking were also unavailable. Nevertheless, the results of a prospective study on pregnant women suggested that self-reporting provided more accurate information on smoking patterns during pregnancy compared with biomarkers, because of the observed significant within-person variations in smoking during pregnancy, associated with repeated attempts to quit or cut down (Pickett et al., 2005), which can also be applicable to a father's smoking behaviors during the perinatal periods.

Finally, we could not analyze the effects of maternal smoking on parental psychopathology because of the small sample of pregnant women who disclosed their smoking status, which we believe is because of Taiwanese legislation prohibiting maternal smoking during pregnancy.

This longitudinal study extends our knowledge on the association of both active and passive smoking with parental emotional disturbances during perinatal periods. Specifically, paternal smoking in the mother's presence was associated with increased perinatal depression and anxiety symptoms for both parents. However, paternal smoking but not in the mother's presence may ameliorate negative impacts on maternal emotional distress. Our findings support the importance of a smoke-free environment during perinatal periods. Our findings also have implications for further epidemiological research into the links of active and passive smoking with parental mental disorders, as well as for public health interventions regarding the necessity of at minimum restricting the father's smoking to areas outside the presence of the pregnant wife during perinatal periods, if quitting smoking is tentatively unattainable. We also underscore the importance of combining strategies for smoking cessation with interventions for affective disturbances in fathers. Further investigation into the effects of maternal smoking during pregnancy on parental mental health is warranted. Moreover, we recommend that studies examine the effects of paternal smoking on the growth and development of newborns.

Competing interests

The authors have no conflicts of interest to declare.

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