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Review article

Association of secondhand smoke and depressive symptoms in nonsmoking pregnant Women: A systematic review and meta-analysis

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ABSTRACT

Background: Globally about 30% of adult women and 40% of children are exposed to secondhand smoke (SHS) from active smokers. SHS exposure of pregnant women has been associated with postpartum depression. Unexposed women in pregnancy had lower rates of postpartum depression than women exposed to SHS. This systematic review aimed to determine the association of depressive symptoms and exposure to SHS in non-smoking pregnant women.

Method: The case-controlled, cross-sectional, and cohort studies with a comparison group were included. Studies including women who had smoking history during pregnancy were excluded. The comprehensive electronic databases, CINAHL, EMBASE, and Medline were searched.

Result: Of the 2777 records screened, seven studies were included in the review for data extraction. The bias of studies was assessed using the RoBANS. We synthesized two studies that showed depressive symptoms at any time during pregnancy and postpartum significantly increased (ORs = 1.77 [95% CI = 1.12 – 2.79]; p = 0.01; I^2 = 28%, 4103 women, two studies), and significantly increased the odds of antenatal suicidal ideation in SHS exposed women (ORs = 1.75 [95% CI = 1.14 – 2.70]; p = 0.01; I^2 = 51%, 2670 women, two studies). Lack of studies from counties with the highest smoking rates was a limitation.

Conclusions: SHS exposure during pregnancy showed a significant increase in the odds of depressive symptoms. Furthermore, research is required to clarify to association between SHS and depression.

1. Introduction

Globally, tobacco smoke is associated with six of the eight main causes of death and tobacco control is one of the common global sustainable development goals (United Nations, 2015). Those who smoke tobacco as well as those who are exposed to it as secondhand smoke inhale many harmful chemicals that negatively impact health (Mojtabai and Crum 2013). This is especially true for pregnant women who smoked as well as for their children who experienced adverse perinatal outcomes such as respiratory diseases, middle ear disease, lower respiratory illness, and sudden infant death syndrome (Jacobs et al., 2013).

Exposure to smoke during pregnancy and the postpartum period has been associated with women's untoward mental health outcomes. Smoking during pregnancy and postpartum depression (PPD) have shown a significant association (Swanson et al., 2017). Women who smoked during pregnancy had higher odds of having PPD than non-smokers or those who quit smoking (AORs = 1.48; 95% [CI = 1.26 – 1.73]) (Salimi et al., 2015). Satoh et al. (2013) using the Edinburgh Postnatal Depression Scale (EPDS), a commonly used scale that assesses postpartum depression also found that postpartum women who were active smokers scored significantly higher (< p 0.001) as well as those

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who had quit smoking scored significantly higher ($p < 0.01$) than non-smokers. Moreover, another review found smoking behavior positively associated with the risk of suicide although the mechanisms were not clear (Hughes, 2008).

Also, one systematic review found smoking cessation was related to reducing the depressive symptoms of both men and non pregnant women including: anxiety (SMD = −0.37, 95%[*CI*: −0.70 - −0.03], $p = 0.03$, $I^2 = 71\%$, 4 studies); depression (SMD = −0.25, 95%[*CI*: −0.37 - −0.13], $p < 0.001$, $I^2 = 30\%$, 10 studies), and stress (SMD = −0.27, 95%[*CI*: −0.40 - −0.13], $p < 0.001$, $I^2 = 0\%$, 3 studies) (Taylor et al., 2014).

There is a small body of research that links secondhand smoke (SHS) exposure with mental health conditions among non-pregnant women. Sobotova et al. (2011) found a Scores on the Medical Outcomes Short Form-12 (SF-12) Physical Component Scale (PCS) and Mental Component Scale (MCS) were used to assess maternal health.

Non-smoking mothers with at least one smoker in the household had an 11% (95% CI = 0.80–0.99) lower odds of scoring at or above the mean MCS score. Exposure to SHS was associated with depression and included adjusted background information of those who never smoked (adjusted β = 0.09, SE = 0.03, $p = 0.02$) (Bandiera et al., 2010). Women with SHS exposure had higher odds of suicidal ideation (OR = 1.44, 95%[*CI*: 1.14 – 1.83], $p < 0.05$ for SHS exposed women) (Gim et al., 2016). There were significantly increased odds of depressive symptoms among women who had never smoked but were exposed to SHS in the home (OR = 1.25, 95% [CI: 1.08 – 1.43] (Jung et al., 2015). SHS exposure in any place other than one's own house was related with lower health-related quality of life especially for the mental health components (regression coefficient = −1.35, 95%[*CI*: −2.1 – −0.6], $p < 0.001$ in any place) (Chen et al., 2015).

Given that previous studies indicated success with 'quit smoking interventions' the problem of SHS should be considered as a preventable risk factor. Even so, the available evidence of association between SHS exposure and depressive symptoms was limited especially for pregnant women. Therefore, the aim of this study was to provide a systematic review and meta-analysis of the existing data indicating an association of depressive symptoms and SHS in nonsmoking pregnant women. We assessed the association between SHS exposure during pregnancy and depressive symptoms including anxiety, and suicidal ideation occurring anytime, during pregnancy and after delivery. This should provide some direction for future researchers and heighten clinicians' awareness of the need to provide vigilance with regarding to protecting pregnant women against SHS.

2. Methods

2.1. Eligibility criteria

SHS exposure was defined as contact with SHS from smokers in houses, work places, or other public places. We included research on: non-smoking pregnant women who were exposed to tobacco smoke toxins by an active smoker and if the father smoked in the mother's presence and the mother answered 'exposed to SHS sometimes' . Included were case-control, cohort, and cross-sectional studies with a comparison control group where active smokers exposed pregnant women to SHS. Excluded were studies of smoking cessation in either parent. Studies of pregnant women who smoked during pregnancy were excluded, and we excluded non-comparative studies.

2.2. Search strategy and selection criteria

We searched CINAHL, EMBASE and MEDLINE via Ovid SP, and PubMed on January 29, 2017 with no date/time, language, document type, and publication status limitations. The following search terms used "secondhand smoke", "pregnant women", "case-control", "cohort", and "cross-sectional". Keywords were collected through experts' opinion, literature review, controlled vocabulary (Medical Subject Headings = MeSH, Excerpta Medica Tree = EMTREE, and CINHAL Headings), and reviewing the primary search results. Search strategies were developed with the assistance of a medical information specialist (see Appendix 1). Search results were de-duplicated using EndNote X5 prior to screening by two researchers.

2.3. Quality assessment and data extraction

Two independent authors (D.S. and M.R.) conducted the screening. Data extraction and risk of bias assessment was performed by five independent author dyads (D.S. & W.W., D.S. & M.S., D.S. & N.Y., D.S. & Y.T., and D.S. & M.R.). Dyads used the risk of bias assessment tool for non-randomized studies RoBANS (Kim et al., 2013). The five dyads plus D.S and E.O. obtained the full text report and examined the eligibility of studies using the inclusion criteria. Postpartum depression was defined as moderate to severe depression, including signs and symptoms of postpartum baby blues, within the first three months' after delivery.

2.3. Data synthesis and analysis

A meta-analysis was performed on research with similar outcomes to evaluate the association with the outcomes and SHS exposure. The outcome of dichotomous variables was evaluated using odds ratio (*OR*) and continuous variables were evaluated using weighted mean difference (*WMD*) or standardized mean difference (*SMD*), Probability (*p*) values of less than 0.05 were determined to be statistically significant. Finally, the results were shown as mean and standard deviations with 95% confidential intervals (*CI*). The data were analyzed using Review Manager (RevMan).

3. Results

3.1. Description of studies

There were 5539 records identified through the database searching and 2762 duplicates removed. A total of 2777 records were screened and 2743 were excluded during screening because they were irrelevant to our research question leaving 34 studies selected for full text assessment using inclusion and exclusion criteria. There were 27 studies excluded that did not meet the criteria for population, exposure, study design and or type. The remaining seven studies were included in the review for data extraction. One, study from Greece (Vivilaki et al., 2016) was included but was not used for data analysis due to data unavailability. Thus, seven studies were included and six were used for analysis (Alibekova et al., 2016; Khan et al., 2015; Mbah et al., 2013; Miyake et al., 2012; Tan et al., 2011; Weng et al., 2016). The process of study selection is contained in the PRISMA flow diagram (Fig. 1).

Table 1 shows the characteristics of included studies. Studies were published from 2011 to 2016. Three out of six studies were conducted in the United States of American (Khan et al., 2015; Mbah et al., 2013; Tan et al., 2011), two were conducted in the Republic of China (Taiwan) (Alibekova et al., 2016; Weng et al., 2016), and one study in Japan (Miyake et al., 2012). Six of the studies (Alibekova et al., 2016; Khan et al., 2015; Mbah et al., 2013; Miyake et al., 2012; Tan et al., 2011; Weng et al., 2016) were prospective cohort study and the USA study USA (Tan et al., 2011) was a retrospective cohort study.

3.2. Risk of bias assessment

Figs. 2 and 3 depicts the results of the risk of bias assessment. Every study was evaluated as having a high risk of blinding of outcome assessors by measuring the detection bias. Because the outcome measurement was women's depressive symptoms it was impossible to achieve blinding of the outcome measurement. A USA study by Khan et al. (2015) was assessed for the high risk of selecting

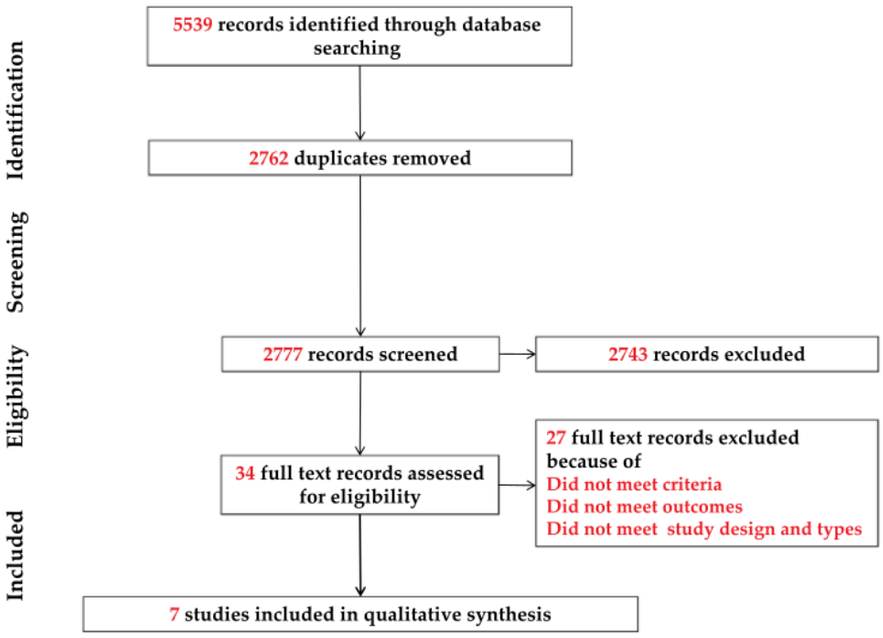

Fig 1. Process of selection of studies has been shown in PRISMA flow diagram.

participants. This section assessed selection bias and criteria for judgment of how and where participants were invited into the study. In addition, at the beginning of the study, there were no outcomes of study in participants (Kim et al., 2013). The USA study (Khan et al., 2015) also randomly selected participants from birth certificate for every month. Therefore, we could not judge the population selected as from the same population or identical institution and period. Because of this, we judged the study had a high risk of selection bias. Secondly, two studies, one from Greece (Vivilaki et al., 2016) and the other from the USA (Mbah et al., 2013) we assessed as high risk of measurement exposure measured by performance bias. If the measurement tools or source was described and was used by a structured interview or trustworthy sources, it was judged as a low risk. However, if the study did not describe the details of the measurement tools or source and there was other bias such as a recall bias or interview bias, then the study was judged high risk. In these two studies (Mbah et al., 2013; Vivilaki et al., 2016) the measurement tools were identified but the details were not described Thus, this section was judged as high risk (Table 2).

3.3. Synthesized meta-analysis and findings

Two of the six studies (Miyake et al., 2012; Tan et al., 2011) reported associations between SHS exposure and depressive symptoms during pregnancy and two other two studies (Mbah et al., 2013; Weng et al., 2016) reported associations of SHS exposure and suicidal ideation. Both associations of SHS exposure were synthesized, each with resulting ORs and 95% CIs.

3.3.1. Depression symptoms during pregnancy

There were two synthesized studies one from Japan (Miyake et al., 2012) and the other from the USA (Tan et al., 2011) that were assessed for the association of SHS exposure. The study in the USA included SHS exposure from households and the study in Japan included SHS exposure both at home and the work place. Fig. 4 shows the SHS exposure risk of depressive symptoms increase during pregnancy compared to unexposed women (ORs = 1.77 [95% CI = 1.12 – 2.79]; p = 0.01; I^2 = 28%, 4103 women, two studies).

3.3.2. Suicidal ideation

Both studies included in the meta-analysis included SHS exposure at home or work places. The USA study (Mbah et al., 2013) reported a statistically significant difference of suicidal ideation and SHS exposure based on EPDS question 10 (*[thinking] of harming oneself*) for passive smokers (ORs = 1.53,95%[*CI*: 1.33 – 1.77], n = 106, compared to active smokers, (ORs = 3.97,95%[*CI*: 3.43 – 4.60], n = 107, recalculated by RevMan). The study in Taiwan (Weng et al., 2016) also assessed the suicidal ideation also using question number of 10 the EPDS scale. Women who were exposed to high amounts of SHS had a significantly higher risk of suicidal ideation (AORs = 2.5, 95%[CI = 1.30 – 4.82] n = 3867). The result of meta-analysis indicates that women exposed to SHS were at a higher risk of suicidal ideation than those who were not exposed to SHS during pregnancy (ORs = 1.75 [95% CI = 1.14 – 2.70]; p = 0.01; I^2 = 51%, 2670 women, two studies) (Fig. 5).

3.4. Postpartum depression

Three studies (Alibekova et al., 2016; Khan et al., 2015; Mbah et al., 2013) measured the association between SHS exposure and postpartum depression. The study in United States (Khan et al., 2015) reported that women who were exposed to SHS during pregnancy had statistically significant higher odds of postpartum depression compared to women who were not expose during pregnancy (ORs = 1.49, 95%[*CI*: 1.23 – 1.80]; 1042 women, one study). Moreover, modified as maternal smoking status also showed there were significantly higher risks of postpartum depression in those who were exposed during pregnancy (ORs = 1.30, 95%[*CI*: 1.03 – 1.64]; 5770 women, one study). In Taiwan Alibekova et al. (2016) conducted a longitudinal prospective study collecting data at five time points from early pregnancy to six months after delivery using the self-report EPSD scale for assessing depression and anxiety symptoms. The study found that at all measurement time

Table 1
Characteristics of the included studies.

#	Author Year	Country	Setting	Characteristics of Participants SHS Exposure	Non-SHS Exposure	Mean age of participants Mean ± SD	Study Design	Exposure place	Outcome measurement tool	Outcome measurement time	Outcome Assessed (used assessment scale or tools)
1	Alibekova 2016	Taiwan	5 selected hospital in Taipei Participants invited from July 2011 - May 2014	77	491	–*	Prospective cohort	Home	Self-report and interview	5 times early pregnancy to 6 months postpartum	Depression & Anxiety anytime (EPDS for depression) (STAI for anxiety)
2	Khan 2015	USA	After delivery in the last 2–6 months selected randomly	1989	4754	–*	Prospective cohort	Home	Self-administered questionnaire	After delivery	Postpartum depressive symptoms (2 questions measured PPDS)
3	Mbah 2013	USA	Recruited from clinic and community health center in November 2009 to July 2011 Ages of 18–44 at less than 20 weeks of gestation	106	23	–*	Prospective cohort	–**	Questionnaire and interview Salivary Cotinine (1st and 2nd visit)	at 2, 4, 6 weeks post-delivery	Postpartum depressive symptoms (EPDS for depression)
4	Miyake 2012	Japan	5th to 39th week of pregnancy	At home: 148 At work: 123	At home: 48 At work: 73	31.2 ± 4.4	Prospective cohort	Home and work place	Self-report questionnaire Telephone interview	After delivery	Depressive symptoms during pregnancy (CES-D)
5	Tan 2011	USA	Secondary analysis of two related clinic-based RCTs 3 prenatal care site in Washington, DC	161	306	Non-Exposure 26.1 ± 5.6 SHS Exposure 24.4 ± 5.7	Retrospective cohort	Home	audio computer-assisted self-interview (ACASI)	During pregnancy	Depressive Symptoms recalled from past 2 weeks during pregnancy (Beck Depression Inventory Fast Screen)
6	Weng 2016	Taiwan	5 hospitals in Taipei and New Taipei City	3692	175	–*	Prospective cohort	Home and work place	Self-report questionnaire and interview by trained interviewers	During pregnancy and within 1 month postpartum	Depressive symptoms, Anxiety, and suicidal ideation anytime (EPDS for depression and suicide ideation, and STAI for anxiety)
7	Vivilaki 2016	Greece	2 public maternity hospitals in Athens	186	73	33.76 (range = 20–45)	Prospective cohort	Any places	Self-administered questionnaire	3rd postnatal	Postnatal depressive and anxiety (EPDS)

* Data was shown by category or mean age not described.
** Not described.

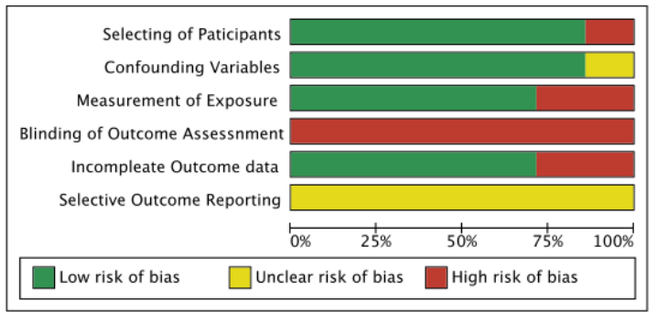

Fig 2. Risk of bias graph / review authors judgements about each risk of bias item presented as percentages across all included studies.

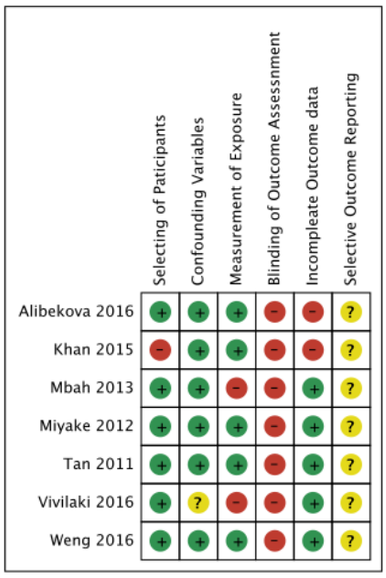

Fig 3. Risk of bias summary / review authors' judgements about each risk of bias item for each included study.

points the maternal depressive symptoms increase until one month after delivery of those who were exposed to SHS. However, there was no significant association between SHS exposure and SHS exposure at six months after delivery (regression coefficient (RC) = 0.9, 95%[*CI*: −0.4 – 2.2]).

The other study from the United States (Mbah et al., 2013) included pregnant nonsmoking women, passive smoking (SHS) women, and active smoking women. Outcome measures were: psychosocial scales (EPDS) and confirmed by salivary cotinine levels. The mean EPDS scores were: 4.8 ± 4.8 for nonsmoking women, 5.3 ± 5.5 for passive smoking women, and 7.4 ± 6.1 for active smoking women indicating women exposed to passive and active smoke had significantly higher EPDS scores (p = 0.02). Also, this study showed odds ratio of each item of the EPDS score indicating a higher risk of depressive symptoms in women exposed to SHS than nonsmoking women.

3.5. Depressive symptoms anytime during pregnancy and postpartum

Two studies from Taiwan (Alibekova et al., 2016; Weng et al., 2016) reported a relationship between SHS and depression during pregnancy and the postpartum period. Weng et al. (2016) included pregnant women and postpartum women within one month after delivery using the EPDS scale to assess depressive symptoms. They found significantly higher odds of depression (AORs = 1.55, 95%[*CI*: 1.20 – 2.01], p = 0.001, n = 3867) among those exposed to SHS. They categorized high SHS exposure and low SHS exposure but did not document the SHS exposure period.

The other study in Taiwan (Alibekova et al., 2016) described using a self-report measure at five time points. Researchers, reported a relationship between SHS exposure and depressive symptoms during the perinatal period, (RC = 0.9, 95%[CI = 0.1 – 1.8]) and during pregnancy (RC = 1.2, 95%[CI = 0.1 – 2.3]).

3.6. Anxiety in perinatal period

Two studies (Alibekova et al., 2016; Weng et al., 2016) found an association of SHS exposure and anxiety. Alibekova et al. (2016) in Taiwan showed the association of SHS exposure and anxiety, especially for the postpartum period (RC = 2.2, 95% [CI = 0.3 – 4.2] for perinatal period, and RC = 3.4, 95% [CI = 0.6 – 6.3] for the postpartum period).

Weng et al. (2016) also found an association between SHS exposure and anxiety in the perinatal period. Anxiety was assessed using the State Trait Anxiety Inventory. However, they found no statistically significant association between SHS exposure and anxiety in perinatal period (AORs = 0.88, 95%[CI = 0.25 – 3.14]).

3.6. Quality of evidence

The quality of evidence is displayed in Table 3. There were only two studies synthesized for meta-analysis based on the type of outcome. According to the results of our certainty assessment, the outcome of depressive symptoms was of low quality and the outcome of suicidal ideation was very low quality. The lower assessment resulted from the non-blinded outcome measure. It was impossible to blind the outcome because the measurement items revealed SHS exposure and mental health condition. Also, for the outcome of suicidal ideation, the study was assessed as a high risk of measurement exposure due to self-report and it might have caused performance bias.

Table 2
Judgement of risk of bias assessment.

#	Study	Bias	Author's judgement	Support for judgement
1	Alibekova 2016	Selection of Participants	Low risk	
		Confounding Variables	Low risk	
		Measurement of Exposure	Low risk	
		Blinding of Outcome Assessment	High risk	Outcome is self-report measurement.
		Incomplete Outcome Data	High risk	There were few missing data but not describe of them
		Selective Outcome Reporting	Unclear	
2	Khan 2015	Selection of Participants	High risk	Participants invited from randomly selected every month
		Confounding Variables	Low risk	
		Measurement of Exposure	Low risk	
		Blinding of Outcome Assessment	High risk	Outcome is self-report measurement.
		Incomplete Outcome Data	High risk	There were few missing data but not described the reason
		Selective Outcome Reporting	Unclear	
3	Mbah 2013	Selection of Participants	Low risk	
		Confounding Variables	Low risk	
		Measurement of Exposure	High risk	Measurement tool was used QA and interview but not described details
		Blinding of Outcome Assessment	High risk	Outcome is self-report measurement.
		Incomplete Outcome Data	Low risk	
		Selective Outcome Reporting	Unclear	
4	Miyake 2012	Selection of Participants	Low risk	
		Confounding Variables	Low risk	
		Measurement of Exposure	Low risk	
		Blinding of Outcome Assessment	High risk	Outcome is self-report measurement.
		Incomplete Outcome Data	Low risk	
		Selective Outcome Reporting	Unclear risk	
5	Tan 2011	Selection of Participants	Low risk	
		Confounding Variables	Low risk	
		Measurement of Exposure	Low risk	
		Blinding of Outcome Assessment	High risk	Outcome is self-report measurement.
		Incomplete Outcome Data	Low risk	
		Selective Outcome Reporting	Unclear risk	
6	Weng 2016	Selection of Participants	Low risk	
		Confounding Variables	Low risk	
		Measurement of Exposure	Low risk	
		Blinding of Outcome Assessment	High risk	Outcome is self-report measurement.
		Incomplete Outcome Data	Low risk	
		Selective Outcome Reporting	Unclear risk	
7	Vivilaki 2016	Selection of Participants	Low risk	
		Confounding Variables	Unclear	
		Measurement of Exposure	High risk	Measurement tool was used only QA
		Blinding of Outcome Assessment	High risk	Outcome is self-report measurement.
		Incomplete Outcome Data	Low risk	
		Selective Outcome Reporting	Unclear risk	

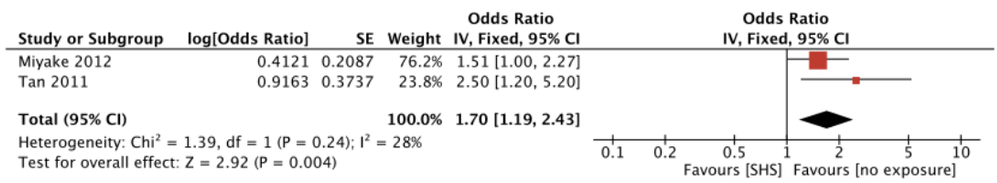

Fig 4. Impact of depressive symptoms during pregnancy.

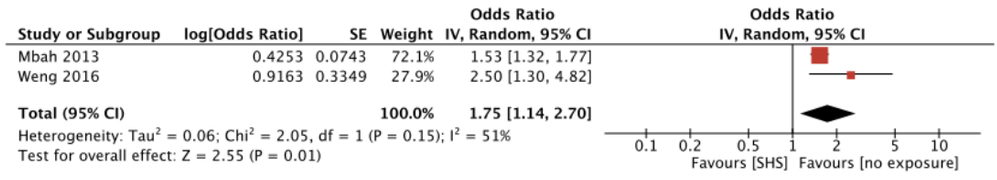

Fig 5. Impact of suicidal ideation.

5. Discussion

We included seven prospective cohorts studies in this systematic review, and found an association of SHS exposure affects on maternal mental health. Pregnant women exposed to SHS had significantly increased odds of maternal depressive symptoms and suicidal ideation during pregnancy. Overall, the two studies revealed the association between SHS exposure and postpartum depression. These two studies also found an association between SHS exposure and anxiety during the perinatal period.

Most included studies reported an association between SHS exposure and increased odds of mental health problems for women during pregnancy and the postpartum period. The WHO reported depression is the most common mental health disorder globally (WHO, 2017a). Additionally, around 10% of pregnant women and postpartum women experienced mental health problems (World Health Organization (WHO) , nd).

Suicide is the one of the most serious outcomes arising from a mental disorder. Approximately number of 800,000 people died every year by suicide(WHO, 2017b). In addition, maternal mental disorders such as anxiety were associated with an increase of the odds of suicidal ideation (OR = 1.11, 95%[*CI*: 1.01 – 1.23], $p = 0.03$) (Sit et al., 2015) A previous study reported 24% to 49% women who experienced PPD previously had a suicide attempt (Healey et al., 2013).

Non communicable diseases especially mental health problems have more attention worldwide in recent years and have been included within sustainable development goals (Votruba et al., 2016). Therefore, the reduction of mental health disorders is a high priority and requires the implementation of public health strategies. Mental disorders have an action plan to address the prevention of mental disorders (WHO, 2013a). For example, public policy for a smoke free law or tobacco prevention framework would be an effort to prevent mental disorders (Pierce et al., 2012; Rhoades and Beebe, 2015). WHO recommended the prevention of SHS for pregnant women (WHO, 2013b). WHO strongly recommended the protection of smoke-free public places and homes. There were various benefits that were cost effective and including implementation feasibility. Hence, we suggest implementing smoke free public health strategies at the governmental levels.

Furthermore, several studies previously reported the association between smoking and depressive symptoms. Therefore, we hypothesize that some chemical contained in cigarette smoke passively inhaled might have a negative impact on mental health. Mojtabai and Crum (2013) found in their prospective longitudinal study a significantly higher incidence of mood and anxiety disorders among younger individuals who began smoking, which was dose related, thus supporting our hypothesis. Therefore, those exposed to SHS may develop mental health problems similar to active smokers. However, it is not yet clear that smoking is linked to suicidal ideation (Hughes, 2008). Moreover, the relation and mechanism of smoking effects for depression may be linked to the inhibition of nicotine receptors (Dierker et al., 2002). Further research is required to clarify the relationship with SHS and mental health problems, which might also result in protection for maternal and child health.

In our systematic review, there are several limitations that should be addressed.

We found that SHS exposure during pregnancy adversely affected maternal mental health. However, the certainty of the evidence (GRADE) was low for depressive symptoms during pregnancy and very low for suicidal ideation. Because, we synthesized these outcomes using only two studies and the sample size was small we downgraded the results because of those imprecisions. Even though our results were low and had very low certainty of evidence, we considered it is as a very important message to show that the evidence was scarce and that more research is needed in this field. Moreover, the included studies in this review were conducted in the limited geographical areas of Japan,

Table 3
Summary of findings.

SHS exposure compared to Non-SHS exposure in Nonsmoking Pregnant Women:A Meta-Analysis
Patient or population: Nonsmoking Pregnant Women A Meta-Analysis**Setting**: Taiwan, USA, Japan, and Greece**Intervention**: SHS exposure**Comparison**: Non-SHS exposure

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with Non-SHS exposure	Risk with SHS exposure				
Depressive symptom during pregnancy	0 per 1,000	0 per 1,000 (0 to 0)	**OR 1.77** (1.12 to 2.79)	(2 observational studies)	⨁⨁◯◯ LOW	
Suicidal Ideation	0 per 1,000	0 per 1,000 (0 to 0)	**OR 1.75** (1.14 to 2.70)	3627 (2 observational studies)	⨁◯◯◯ VERY LOW	

CI: Confidence interval; **OR:** Odds ratio; **MD:** Mean difference

GRADE Working Group grades of evidence
High certainty: We are very confident that the effect lies close to that of the estimate of the effect
Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect
Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect
* **The risk in the intervention group** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

Taiwan, USA, and Greece. However, there is a higher prevalence of smoking in other Asian and Middle Eastern countries (WHO, 2016). If studies were conducted in higher smoking prevalence countries, the number of pregnant women exposed to SHS from active smokers would be higher and the results might be different compared to these included studies.

In addition, according to the results of the quality assessment found in Table 3, there is the possibility that participants were less than truthful if they knew the outcome measurement. In addition, the outcome measurement was asking about mental health issues and as such might have been too private a problem to share resulting in distorted answers. Finally, smoking status has been related to social economics status (Hiscock et al., 2012; Laaksonen et al., 2005; Wagenknecht et al., 1990), and also depressive symptoms have been related to lower social economics status (Hoebel et al., 2017; Lorant et al., 2007; Steptoe et al., 2007). Those associations could be confounders within the association of SHS and mental health conditions although Mojtabai and Crum (2013) adjusted for those factors. Therefore, we suggest further research is required to clarify the direct association between passive smoking and depression and anxiety. In addition, because the health consequences of SHS exposure were very similar to active smokers consideration of a public health policy as a smoke free law is also needed. While many smokers already known the harmful effects of smoking, public awareness must be heighted about how SHS is equally dangerous for health.

Hence, even though our finding assessed weak evidence, this problem is preventable and important for maternal mental health.

6. Conclusion

This systematic review showed the association between SHS exposure during pregnancy and significantly higher depressive symptoms during pregnancy. SHS during pregnancy was associated with increased odds of suicidal ideation compared to non-exposure of SHS. However, the direct association between SHS and depression is not yet clear. The quality of evidence of the meta-synthesis of two research outcomes was low and very low. Furthermore, more research is required to clarify the association between SHS and mental health conditions such as depression and anxiety. The prevention of adverse effects from SHS on maternal and child health is critical.

Role of the funding source

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Competing interests

The authors declare no competing interests. The funding was used for searching by a information specialist and ordered full text papers.

Author contribution

The author of M. R. were performed the screening and extraction of data for included studies. M.S., N.Y., Y.T., and W.W. were conducted to data extraction of included studies. W.W., M.S., N.Y., Y.T., and M.R. assessed the quality of study. E.O. contributed to support and supervise of concepts, methodology, analysis and writing manuscript. All of authors reviewed and commented the manuscript.

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Appendix 1. Search strategy

I. Search Date

January 29, 2017

II. Resources and Number of Results

Table A1
Search resources details and number of results.

Resource	Time Coverage	Search Interface	# of Hits
CINAHL [Excluding MEDLINE Records]	1937 – Search Date	EBSCOhost	86
EMBASE [Excluding MEDLINE]	1974 – 2017 Week 4	Ovid SP	603
MEDLINE	1946 – Search Date	Ovid SP	2672
PubMed	1946 – Search Date	PubMed	2178
Subtotal	5539		
Duplicates	2762		
Total (for Screening)	**2777**		

III. Search Strategies

A. CINAHL

((MH "Passive Smoking") OR TI ((Passive* OR "Second Hand" OR Secondhand) N6 (Cigar* OR Smok* OR Tobacco)) OR AB ((Passive* OR "Second Hand" OR Secondhand) N6 (Cigar* OR Smok* OR Tobacco))) AND (((MH "Fetus + ") OR (MH "Perinatal Death") OR (MH "Fetal Development + ") OR [MH "Gestational Age"] OR (MH "Maternal Exposure") OR (MH "Mothers + ") OR (MH "Pregnancy + ") OR (MH "Maternal Outcome") OR (MH "Pregnancy Complications + ")) OR TI (Embryopath* OR Fetal* OR Fetus* OR Foetus OR Foetal OR Gestation* OR Matern* OR Mother* OR Prenat* OR Perinat* OR Pregnan* OR Abort* OR Miscarr*) OR AB (Embryopath* OR Fetal* OR Fetus* OR Foetus OR Foetal OR Gestation* OR Matern* OR Mother* OR Prenat* OR Perinat* OR Pregnan* OR Abort* OR Miscarr*)) AND (((MH "Gestational Age") OR (MH "Nonexperimental Studies") OR (MH "Case Control Studies") OR (MH "Cross Sectional Studies") OR (MH "Prospective Studies + ") OR (MH "Retrospective Design") OR (MH "Odds Ratio")) OR TI ((Case N12 (Control OR Comparison)) OR Cohort* OR "Cross-Sectional" OR "Cross Section" OR "Follow-Up" OR (Follow* W1 Up) OR Followup OR Incidence* OR Longitudinal OR Observational OR "Odds Ratio" OR "Odds Ratios" OR Prevalence* OR Prospective* OR "Relative Odds" OR Retrospective* OR "Risk Ratio" OR "Risk Ratios" OR Expos*) OR AB ((Case N12 (Control OR Comparison)) OR Cohort* OR "Cross-Sectional" OR "Cross Section" OR "Follow-Up" OR (Follow* W1 Up) OR Followup OR Incidence* OR Longitudinal OR Observational OR "Odds Ratio" OR "Odds Ratios" OR Prevalence* OR Prospective* OR "Relative Odds" OR Retrospective* OR "Risk Ratio" OR "Risk Ratios" OR Expos*)) Limiters - Exclude MEDLINE records

B. EMBASE

1 Passive Smoking/ OR ((Passive$ OR Second Hand OR Secondhand) adj6 (Cigar$ OR Smok$ OR Tobacco)).ti,ab.
2 Exp Fetus/ OR Exp Fetus Death/ OR Exp Fetus Development/ OR Fetus Mortality/ OR Gestational Age/ OR Perinatal Death/ OR Maternal Exposure/ OR Exp Mother/ OR Exp Pregnancy/ OR Pregnant Woman/ OR Exp Pregnancy Complication/ OR Pregnancy Outcome/ OR Exp Pregnancy Disorder/ OR (Embryopath$ OR F?etal$ OR F?etus$ OR Gestation$ OR Matern$ OR Mother$ OR Prenat$ OR Perinat$ OR Pregnan$ OR Abort$ OR Miscarr$).ti,ab.
3 Exp Case Control Study/ OR Cohort Analysis/ OR Follow Up/ OR Cross-Sectional Study/ OR Prevalence/ OR Observational Study/ OR Odds Ratio/ OR Incidence/ OR Longitudinal Study/ OR ((Case adj12 (Control OR Comparison)) OR Cohort$ OR Cross Section$ OR Follow$ Up OR Followup OR Incidence? OR Longitudinal OR Observational OR Odds Ratio? OR Prevalence? OR Prospective$ OR Relative Odds OR Retrospective$ OR Risk Ratio? OR Expos$).ti,ab.
4 1 AND 2 AND 3
5 Exp Animals/ OR Exp Invertebrate/ OR Animal Experiment/ OR Animal Model/ OR Animal Tissue/ OR Animal Cell/ OR Nonhuman/
6 Human/ OR Normal Human/ OR Human Cell/
7 5 AND 6
8 5 NOT 7
9 4 NOT 8
10 Limit 9 to Medline
11 9 NOT 10

C. MEDLINE

1 Exp Tobacco Smoke Pollution/ OR ((Passive$ OR Second Hand OR Secondhand) adj6 (Cigar$ OR Smok$ OR Tobacco)).ti,ab.
2 Exp Fetus/ OR Exp Fetal Death/ OR Exp Fetal Development/ OR Exp Fetal Mortality/ OR Exp Gestational Age/ OR Perinatal Death/ OR Exp Maternal Exposure/ OR Exp Mothers/ OR Exp Pregnancy/ OR Exp Pregnancy Complications/ OR Exp Pregnancy Outcome/ OR Exp Pregnant Women/ OR Exp Abortion, Spontaneous/ OR (Embryopath$ OR F?etal$ OR F?etus$ OR Gestation$ OR Matern$ OR Mother$ OR Prenat$ OR Perinat$ OR Pregnan$ OR Abort$ OR Miscarr$).ti,ab.
3 Case-Control Studies/ OR Exp Cohort Studies/ OR Exp Cross-Sectional Studies/ OR Exp Observational Studies as Topic/ OR Exp Odds Ratio/ OR Observational Study.pt. OR ((Case adj12 (Control OR Comparison)) OR Cohort$ OR Cross Section$ OR Follow$ Up OR Followup OR Incidence? OR Longitudinal OR Observational OR Odds Ratio? OR Prevalence? OR Prospective$ OR Relative Odds OR Retrospective$ OR Risk Ratio? OR Expos$).ti,ab. NOT (Animals NOT (Humans and Animals)).sh.
4 1 AND 2 AND 3

D. PubMed

("Tobacco Smoke Pollution"[Mesh] OR ((Passive*[tiab] OR "Second Hand"[tiab] OR Secondhand[*tiab*]) AND (Cigar*[tiab] OR Smok*[tiab] OR Tobacco[*tiab*]))) AND ("Fetus"[Mesh] OR "Fetal Death"[Mesh] OR "Fetal Development"[Mesh] OR "Fetal Mortality"[Mesh] OR Embryopath*[tiab] OR Fetal*[tiab] OR Fetus*[tiab] OR Foetus[tiab] OR Foetal[tiab] OR "Gestational Age"[Mesh] OR Gestation*[tiab] OR "Perinatal Death"[Mesh] OR "Maternal Exposure"[Mesh] OR Matern*[tiab] OR "Mothers"[Mesh] OR Mother*[tiab] OR Prenat*[tiab] OR Perinat*[tiab] OR "Pregnancy"[Mesh] OR "Pregnancy Complications"[Mesh] OR "Pregnancy Outcome"[Mesh] OR "Pregnant Women"[Mesh] OR Pregnan*[tiab] OR "Abortion, Spontaneous"[Mesh] OR Abort*[tiab] OR Miscarr*[*tiab*]) AND ("Case-Control Studies"[Mesh] OR "Cohort Studies"[Mesh] OR "Cross-Sectional Studies"[Mesh] OR "Observational Studies as Topic"[Mesh] OR "Observational Study" [Publication Type] OR "Odds Ratio"[Mesh] OR "Case Comparison"[tiab] OR "Case Control"[tiab] OR Cohort*[tiab] OR "Cross Sectional"[tiab] OR "Cross Section"[tiab] OR "Follow Up"[tiab] OR Followup [tiab] OR Incidence*[tiab] OR Longitudinal[tiab] OR Observational[tiab] OR "Odds Ratio"[tiab] OR "Odds Ratios"[tiab] OR Prevalence*[tiab] OR Prospective*[tiab] OR "Relative Odds"[tiab] OR Retrospective*[tiab] OR "Risk Ratio"[tiab] OR "Risk Ratios"[tiab] OR Expos*[*tiab*]) AND (Humans [MeSH] NOT (Animals[MeSH] NOT (Animals[MeSH] AND Humans[*MeSH*])))

* Those references with an asterisk are included in the systematic review.

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