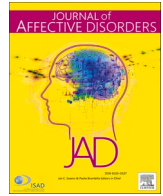




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# Psychological health status in postpartum women during COVID-19 pandemic: A systematic review and meta-analysis

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## ABSTRACT

**Background:** This systematic review and meta-analysis pooled the prevalence of psychological symptoms during the COVID-19 pandemic and examined the effects of the pandemic on psychological health in postpartum women.

**Methods:** A systematic literature search and identification were performed in PubMed, EMBASE, Web of Science, and PsycINFO databases until June 16th, 2021. The fixed or random effect models to estimate the pooled prevalence of postpartum psychological symptoms during the COVID-19 pandemic and the odds ratio (OR) of COVID-19 for psychological symptoms.

**Results:** A total of 29 articles including 20,225 postpartum women during the COVID-19 pandemic and 8312 before the COVID-19 pandemic were identified. During the COVID-19 pandemic, the prevalence of postpartum depressive, anxiety, stress, and post-traumatic stress disorder symptoms were 26.7 % (95 % CI: 22.0–31.9 %), 33.8 % (95 % CI: 21.1–49.4 %), 55.0 % (95%CI: 27.9–79.5 %), and 33.7 % (95%CI: 19.6–51.5 %), respectively. The ORs of COVID-19 pandemic for postpartum depressive and anxiety symptoms were 1.54 (95 % CI: 1.00–2.36) and 2.56 (95%CI: 1.62–4.04). Subgroup analyses revealed that women with >6 weeks after delivery, younger than 35 years old, low income, less education and without breastfeeding experienced a higher risk of depressive or anxiety symptoms after delivery.

**Limitations:** Only a few of prospective studies were included, and significant but inevitable heterogeneities were found in some analyses.

**Conclusion:** A significantly higher proportion of postpartum women were suffered from psychological symptoms during COVID-19 pandemic, particularly in those with >6 weeks after delivery, younger than 35 years old, low income, less education and formula feeding.

## 1. Introduction

Postpartum women are considered to be at high risk for psychological disorders, such as depression and anxiety (Cantwell, 2021). A previous review concluded that nearly 20 % of postpartum women suffered from depressive symptoms in the first 3 months after delivery, and around one-third had not recovered beyond the first year after delivery (Howard et al., 2014). A recent meta-analysis indicated the prevalence of anxiety symptoms was 15 % among postpartum women, and anxiety was a common comorbidity of postpartum depressive disorders (Dennis et al., 2017). Maternal psychological disorders are a serious public health concern because they have adverse effects for mothers' health

(Abdollahi and Zarghami, 2018) and for babies' behavioral, emotional, and cognitive development (Letourneau et al., 2012; Stein et al., 2014; Lebel et al., 2016; Feldman et al., 2009; Halligan et al., 2007).

Previous studies found that exposure to stressful events, such as pandemics, natural disasters, or adverse life incidents, could increase the risk for psychological disorders, particularly in postpartum women (Guintivano et al., 2018; Liu et al., 2012). The coronavirus disease 2019 (COVID-19) outbreak in 2020 rapidly became a worldwide pandemic, resulting in 239,437,517 confirmed cases and 4,879,235 deaths globally (World Health Organization, n.d.). A survey of >100 researchers reported that nearly 90 % agreed that COVID-19 could not be eliminated completely but would continue to circulate in the global population for

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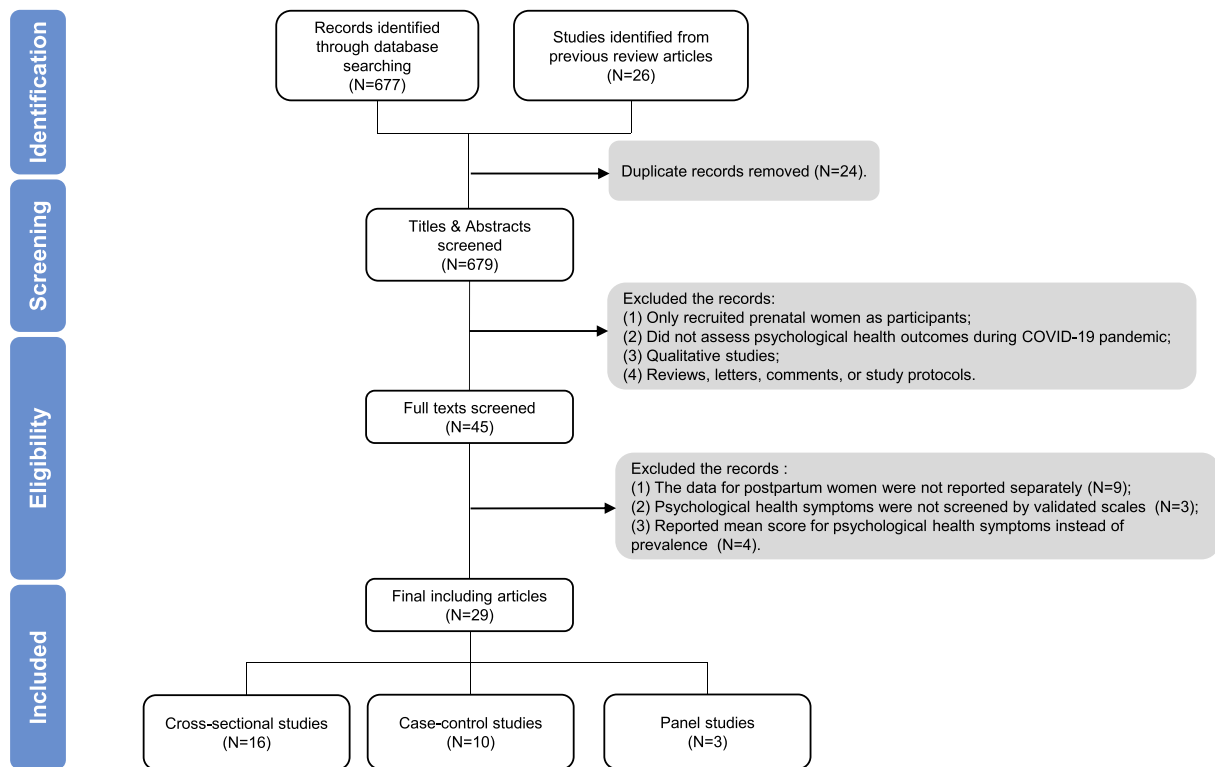


Fig. 1. Study selection process flow chart.

years (Phillips, 2021). Given that COVID-19 is a long-term adverse event that affects every aspect of an individual's life, postpartum psychological disorders may be more frequent during the pandemic. Several studies have investigated the effect of COVID-19 on the mental health of postpartum women (Loret de Mola et al., 2021; Pariente et al., 2020; Racine et al., 2021; Silverman et al., 2020). However, these studies yielded conflicting results. To our knowledge, there has been no quantitative synthesis of available results for postpartum women. Although some systematic reviews and meta-analyses focused on the psychological effects of COVID-19 among pregnant women (Fan et al., 2021; Chmielewska et al., 2021; Hessami et al., 2020), evidence in postpartum women is lacking. Therefore, we performed this systematic review and meta-analysis to pool the prevalence for postpartum adverse psychological symptoms during the COVID-19 pandemic and examine the effects of the pandemic on the psychological health in postpartum women. Our results could provide new evidence for the prevention of postpartum psychological disorders.

## 2. Method

### 2.1. Search strategy

This review was registered with PROSPERO (CRD42022332382) and conducted based on the Meta-Analysis of Observational Studies in Epidemiology (MOOSE) guidelines (Stroup et al., 2000). Two researchers identified relevant studies independently in PubMed, EMBASE, Web of Science, and PsycINFO databases from their inception until June 16th, 2021. The following search strategies were performed: (pregnant OR breastfeeding OR postpartum OR pregnancy OR perinatal) AND (COVID-19 OR coronavirus OR 2019-nCoV OR SARS-CoV-2) AND (mental OR anxiety OR depression OR depressive OR insomnia OR Post-Traumatic OR sleep OR stress OR psychological OR psychology). In addition, other potentially relevant articles from reference lists and reviews were also considered. No language restrictions were applied. Endnote X9 program (Clarivate Analytics, Philadelphia, PA) was used

for management of the studies.

### 2.2. Study selection criteria

A two-step selection program was performed. First, titles and abstracts of relevant studies were screened by two independent researchers. Studies that met the following criteria were excluded in this step: (1) only recruited prenatal women as study participants; (2) did not assess psychological health symptoms during COVID-19 pandemic; (3) qualitative studies; (4) reviews, letters, comments, or study protocols. Afterwards, full texts of studies identified by the first step were reviewed in the second step. An article was excluded in this step if: (1) the data for postpartum women were not reported separately; (2) psychological health symptoms were not screened by validated scales; (3) one reported mean score for psychological health symptoms instead of prevalence. The inconsistencies of the two researchers were resolved by discussing with another researcher.

### 2.3. Data extraction

Two reviewers independently used a predesigned standardized form to extract data from each included article in accordance with the MOOSE guidelines (Stroup et al., 2000). Relevant information included first author, year of publication, country of study, study design, study periods, sample size, time after delivery, survey method, prevalence of psychological health symptoms, assessment scales, and cut-offs.

### 2.4. Quality assessment

A 11-item checklist of Agency for Healthcare Research and Quality (AHRQ) was used to assess the methodological quality of included cross-sectional and case-control studies independently by two researchers (Rostom et al., 2004). Each item would be rated as "Yes", "No" or "Unclear" and only "Yes" would be awarded 1 point in quality assessment. We considered a study scored over than 8 as a high-quality, 4 to 7

**Table 1**  
Characteristics of studies included in the meta-analysis.

First author and Year	Country	Study design	Study periods	Sample size	Time after delivery	Outcomes and assessment scales
Bo, 2021	China	Cross-sectional	2020/2/22 to 2020/3/10 (during COVID-19)	391	1 week	Depression (PHQ9 $\geq$ 5)
Ceulemans, 2021	5 countries (Ireland, Norway, Switzerland, Netherlands, and United Kingdom)	Cross-sectional	2020/6/16 to 2020/7/14 (during COVID-19)	5134	3 months	Depression (EPDS $\geq$ 13) and Anxiety (GAD7 $\geq$ 10)
Ceulemans, 2020	Belgium	Cross-sectional	After a few weeks of lockdown (during COVID-19)	3445	N.A.	Depression (EPDS $\geq$ 13) and Anxiety (GAD7 $\geq$ 10)
Guvenc, 2020	Turkey	Cross-sectional	2020/5 to 2020/7 (during COVID-19)	212	4–6 weeks	Depression (EPDS $\geq$ 13)
Liang, 2020	China	Cross-sectional	2020/3/30 to 2020/4/13 (during COVID-19)	864	6–12 weeks	Depression (EPDS $\geq$ 10)
Molgora, 2020	Italian	Cross-sectional	2020/3/1 to 2020/5/3 (during COVID-19)	186	6 months	Depression (EPDS $\geq$ 13), Anxiety (STAI $\geq$ 40) and PTSD (PPQ $\geq$ 19)
Oskovi-Kaplan, 2020	Turkey	Cross-sectional	2020/6 (during COVID-19)	223	2 days	Depression (EPDS $\geq$ 13)
Ostacoli, 2020	Italian	Cross-sectional	2020/6/15 to 2020/6/29 (during COVID-19)	163	4 months	Depression (EPDS $\geq$ 11) and PTSD (IES-R $\geq$ 24)
Spinola, 2020	Italian	Cross-sectional	2020/5/11 to 2020/6/6 (during COVID-19)	243	1 year	Depression (EPDS $\geq$ 13) and Anxiety (PSS $\geq$ 28)
Stojanov, 2020	Serbia	Cross-sectional	2020/3/29 to 2020/4/4 (during COVID-19)	108	1 year	Depression (EPDS $\geq$ 10)
Sun, 2020	China	Cross-sectional	2019/12/31 to 2020/3/22 (during COVID-19)	2092	1 week	Depression (EPDS $\geq$ 10)
Zeng, 2020	China	Cross-sectional	2020/3/25 to 2020/6/5 (during COVID-19)	109	1 week	Depression (EPDS $\geq$ 13) and Anxiety (GAD7 $\geq$ 5)
An, 2020	China	Cross-sectional	2020/5/13 to 2020/7/13 (during COVID-19)	209	N.A.	Depression (EPDS $\geq$ 10)
Basu, 2020	64 counties	Cross-sectional	2020/5/26 to 2020/6/13 (during COVID-19)	1182	6 months	Depression (PHQ4 $\geq$ 6) and PTSD (IES6 $\geq$ 1.75)
Fallon, 2021	United Kingdom	Cross-sectional	2020/4/16 to 2020/5/15 (during COVID-19)	614	1 year	Depression (EPDS $\geq$ 13) and Anxiety (STAI $\geq$ 40)
Suárez-Rico, 2021	Mexico	Cross-sectional	2020/8 to 2020/9 (during COVID-19)	293	4–12 weeks	Depression (EPDS $\geq$ 13), Anxiety (STAI $\geq$ 40) and Stress (PSS10 $\geq$ 14)
Chrzan-Dętkoś, 2021	Poland	Case-control	2020/2/20 to 2020/3/30 (during COVID-19)	78	1 year	Depression (EPDS $\geq$ 12)
			2019/10/1 to 2019/11/10 (before COVID-19)	61		
Hamami, 2020	Israel	Case-control	2020/5/1 to 2020/5/31 (during COVID-19)	79	3 days	Depression (EPDS $\geq$ 10)
			2016/10/1 to 2017/4/1 (before COVID-19)	123		
Hui, 2020	China	Case-control	2020/1/5 to 2020/4/30 (during COVID-19)	954	1 day	Depression (EPDS $\geq$ 10)
			2019/1/5 to 2020/1/4 (before COVID-19)	3577		
Mariño-Narvaez, 2021	Spain	Case-control	2020/4/1 to 2020/7/1 (during COVID-19)	75	1 month	Depression (EPDS $\geq$ 10)
			2019/9/1 to 2020/3/1 (before COVID-19)	82		
Pariente, 2020	Israel	Case-control	2020/3/18 to 2020/4/29 (during COVID-19)	223	2 days	Depression (EPDS $\geq$ 10)
			2016/11/1 to 2017/4/1 (before COVID-19)	123		
Silverman, 2020	US	Case-control	2020/3/13 to 2020/6/30 (during COVID-19)	252	N.A.	Depression (EPDS $\geq$ 9)
			2020/2/1 to 2020/3/12 (before COVID-19)	264		
Suzuki, 2020	Japan	Case-control	2020/3/11 to 2020/4/13 (during COVID-19)	148	1 month	Depression (EPDS $\geq$ 9)
			2019/3/9 to 2019/4/11 (before COVID-19)	132		
Zanardo, 2020	Italy	Case-control	2020/3/8 to 2020/5/3 (during COVID-19)	91	2 days	Depression (EPDS $\geq$ 13)
			2019/3/8 to 2019/5/3 (before COVID-19)	101		
Boekhorst, 2021	Netherlands	Case-control	2020/3/1 to 2020/5/14 (during COVID-19)	59	8–10 weeks	Depression (EPDS $\geq$ 12)
			2019/1/7 to 2020/3/1 (before COVID-19)	250		
Hiiragi, 2021	Japan	Case-control	2020/3/1 to 2020/6/1 (during COVID-19)	279	4–5 weeks	Depression (EPDS $\geq$ 9)
				339		

(continued on next page)



Table 1 (continued)

First author and Year	Country	Study design	Study periods	Sample size	Time after delivery	Outcomes and assessment scales
Lorentz, 2021	Brazil	Panel study	2019/3/1 to 2019/6/1 (before COVID-19) 2020/5/1 to 2020/9/1 (during COVID-19) 2019/11/1 to 2020/3/1 (before COVID-19)	50	6 months  0 day	Depression (EPDS $\geq 10$ )
Loret de Mola, 2021	Brazil	Panel study	2020/5/11 to 2020/7/20 (during COVID-19) 2019/1/1 to 2019/12/31 (before COVID-19)	1136	>4.5 months	Depression (EPDS $\geq 13$ ), Anxiety (GAD7 $\geq 10$ ) and Stress (IES $\geq 26$ )
Racine, 2021	Canada	Panel study	2020/5/20 to 2020/7/15 (during COVID-19) 2017/2/1 to 2019/10/1 (before COVID-19)	1333 2074	>9 years	Depression (CES-D-10 $\geq 10$ ) and Anxiety (STAI-SF $\geq 14$ )

COVID-19, coronavirus disease 2019; PTSD, post-traumatic stress disorder; PHQ9, the 9-item Patient Health Questionnaire; EPDS, the Edinburgh Postnatal Depression scale; GAD7, the 7-item Generalized Anxiety Disorder scale; STAI, the State Trait Anxiety Inventory scale; PPQ, the Perinatal PTSD Questionnaire; IES-R, the Impact of Event Scale-Revised; PSS, the Perceived Stress Scale; PHQ4, the Patient Health Questionnaire-4; IES6, the Impact of Event Scale-6; PSS10, the 10-item Perceived Stress Scale; IES, the Impact of Event scale; CES-D-10, the 10-item Center for Epidemiological Studies Depression scale; STAI-SF, the 6-item short form of the Spielberger State-Trait Anxiety Inventory.

as a medium-quality, whereas  $<3$  as a low-quality (Sun et al., 2020a). The quality of included panel studies was assessed by Newcastle-Ottawa-Scale (NOS) including 8 items (Wells et al., n.d.). We considered a panel study scored  $\geq 7$  as a high-quality study.

## 2.5. Statistical analysis

Quantitative meta-analysis was conducted for psychological health symptoms, which have relevant data reported in more than one study. The pooled prevalence with its 95 % confidence interval (CI) for each adverse psychological symptom during the COVID-19 pandemic was estimated using logit-transformed prevalence rate and its standard error (SE) in each study and presented as forest plots. Subgroup analyses were performed based on several study-level characteristics including continent, study design, assessment scale, time after delivery, survey method and study quality. The association between risk factors and postpartum psychological symptoms during the COVID-19 pandemic was summarized using study-specific odds ratio (OR) with its 95 % CI. The effects of COVID-19 pandemic on the postpartum depressive or anxiety symptoms were evaluated by the pooled OR with its 95%CI from studies provided data both before and during the COVID-19 pandemic. Subgroup analyses were also performed. The DerSimonian and Laird random effects model was selected for meta-analysis when statistical heterogeneity was detected using the  $p$ -value  $<0.05$  in Cochran Q test or the  $I^2$  statistics  $>50$  % (DerSimonian and Laird, 1986; Higgins et al., 2003). Otherwise, an inverse variance fixed effect model was adopted (Blettner et al., 1999). Publication bias was assessed using funnel plots and Egger's test if enough original studies ( $n > 10$ ) were available. R software (version 4.1.0) was used to perform all data analyses.

## 3. Results

### 3.1. Literature search

Fig. 1 presents a flowchart of the study selection process. Overall, 679 relevant references were identified in the literature search, and 634 studies were excluded through screening of titles and abstracts. This left 45 papers for full-text screening, of which 16 were excluded: data for postpartum women were not reported separately in nine studies (Li et al., 2021; Masters et al., 2021; Perzow et al., 2021; Wang et al., 2021; Liu et al., 2021; Stepowicz et al., 2020; Xue et al., 2021; Chaves et al., 2022; Farewell et al., 2020); psychological health symptoms were not screened by validated scales in three studies (Dib et al., 2020; Ollivier et al., 2021; Jafree et al., 2021), and four studies reported the mean

score for psychological health symptoms instead of prevalence (Mayopoulos et al., 2021; McFarland et al., 2021; Shayganfard et al., 2020; Fernandes et al., 2021). Finally, 29 articles were included in the meta-analysis (Loret de Mola et al., 2021; Pariente et al., 2020; Racine et al., 2021; Silverman et al., 2020; An et al., 2021; Basu et al., 2021; Bo et al., 2020; Boekhorst et al., 2021; Ceulemans et al., 2021; Ceulemans et al., 2020; Chrzan-Dętkoś et al., 2021; Fallon et al., 2021; Guvenc et al., 2021; Hamami et al., 2020; Hiiragi et al., 2021; Hui et al., 2021; Liang et al., 2020; Lorentz et al., 2020; Mariño-Narvaez et al., 2021; Molgora and Accordini, 2020; Oskovi-Kaplan et al., 2021; Ostacoli et al., 2020; Spinola et al., 2020; Stojanov et al., 2021; Suárez-Rico et al., 2021; Sun et al., 2020b; Suzuki, 2022; Zanardo et al., 2020; Zeng et al., 2020).

### 3.2. Study characteristics

Details of the 29 included studies are shown in Table 1. These 29 studies involved 20,225 postpartum women during the COVID-19 pandemic and 8312 postpartum women before the COVID-19 pandemic. There were two multinational studies that recruited participants from five and 64 countries, respectively (Basu et al., 2021; Ceulemans et al., 2021). The remaining 27 studies were conducted in 16 different countries over four continents (Loret de Mola et al., 2021; Pariente et al., 2020; Racine et al., 2021; Silverman et al., 2020; An et al., 2021; Bo et al., 2020; Boekhorst et al., 2021; Ceulemans et al., 2020; Chrzan-Dętkoś et al., 2021; Fallon et al., 2021; Guvenc et al., 2021; Hamami et al., 2020; Hiiragi et al., 2021; Hui et al., 2021; Liang et al., 2020; Lorentz et al., 2020; Mariño-Narvaez et al., 2021; Molgora and Accordini, 2020; Oskovi-Kaplan et al., 2021; Ostacoli et al., 2020; Spinola et al., 2020; Stojanov et al., 2021; Suárez-Rico et al., 2021; Sun et al., 2020b; Suzuki, 2022; Zanardo et al., 2020; Zeng et al., 2020). There were 16 cross-sectional studies that reported prevalence rates of psychological health symptoms during the COVID-19 pandemic (An et al., 2021; Basu et al., 2021; Bo et al., 2020; Ceulemans et al., 2021; Ceulemans et al., 2020; Fallon et al., 2021; Guvenc et al., 2021; Liang et al., 2020; Molgora and Accordini, 2020; Oskovi-Kaplan et al., 2021; Ostacoli et al., 2020; Spinola et al., 2020; Stojanov et al., 2021; Suárez-Rico et al., 2021; Sun et al., 2020b; Zeng et al., 2020). The remaining 10 case-control studies (Pariente et al., 2020; Silverman et al., 2020; Boekhorst et al., 2021; Chrzan-Dętkoś et al., 2021; Hamami et al., 2020; Hiiragi et al., 2021; Hui et al., 2021; Mariño-Narvaez et al., 2021; Suzuki, 2022; Zanardo et al., 2020) and three panel studies (Loret de Mola et al., 2021; Racine et al., 2021; Lorentz et al., 2020) compared the differences in the risk for psychological health symptoms before and during the COVID-19 pandemic. The total sample size ranged from 50 to

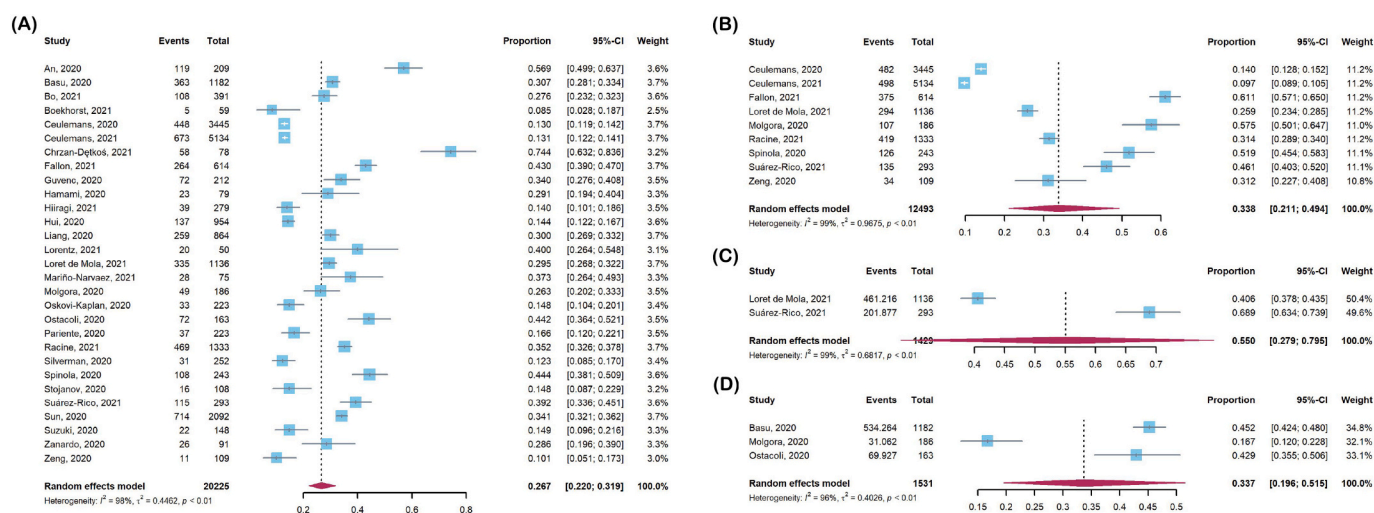
**Table 2**

The methodological quality of the included studies.

Author, year	Source of information	Inclusion/exclusion criteria	Time period for identity	Subjects consecutive	Evaluators masked	Quality assurance assessments	Patient exclusions	Confounding assessed/controlled	Missing data	Response rates	Follow-up	Total
Cross-sectional and case-control studies												
Bo, 2021	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	No	No	6
Ceulemans, 2021	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes	No	7
Ceulemans, 2020	Yes	No	No	No	No	Yes	No	No	No	No	No	2
Guvenc, 2020	Yes	Yes	Yes	No	No	Yes	Yes	No	No	Yes	No	6
Liang, 2020	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	9
Molgora, 2020	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	No	No	7
Oskovi-Kaplan, 2020	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	Yes	No	7
Ostacoli, 2020	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	9
Spinola, 2020	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No	No	No	6
Stojanov, 2020	Yes	Yes	Yes	No	No	Yes	Yes	No	No	No	No	5
Sun, 2020	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	No	No	6
Zeng, 2020	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	No	8
An, 2020	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	9
Basu, 2020	Yes	Yes	Yes	No	No	Yes	Unclear	Yes	Yes	No	No	6
Fallon, 2021	Yes	Yes	Yes	No	No	Yes	No	Yes	No	Yes	No	6
Suárez-Rico, 2021	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	Yes	No	7
Chrzan-Dętkoś, 2021	Yes	Yes	Yes	No	No	Yes	No	No	Yes	No	No	5
Hamami, 2020	Yes	Yes	Yes	Unclear	No	Yes	Yes	Yes	No	Yes	No	7
Hui, 2020	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No	Yes	Yes	8
Mariño-Narvaez, 2021	Yes	Yes	Yes	No	No	Yes	Yes	No	No	No	No	5
Pariente, 2020	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	No	No	6
Silverman, 2020	Yes	Yes	Yes	Yes	No	Yes	No	No	No	No	No	5
Suzuki, 2020	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No	Yes	No	7
Zanardo, 2020	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	9
Boekhorst, 2021	Yes	Yes	Yes	Unclear	No	Yes	Yes	Yes	Yes	Yes	No	8
Hiiragi, 2021	Yes	Yes	Yes	Unclear	No	Yes	Yes	Yes	Yes	Yes	No	8
Panel studies												
Lorentz, 2021	–		1	1	1		2	–	1	1		7
Loret de Mola, 2021	–		1	1	1		2	–	1	1		7
Racine, 2021	1		1	1	1		2	–	1	1		8

5134 postpartum women from 0 days to >9 years after delivery. All 29 studies reported rates of postpartum depressive symptoms, with the Edinburgh Postnatal Depression scale (EPDS) (cut-off points from 9 to 13) used in 25 studies (Loret de Mola et al., 2021; Pariente et al., 2020; Silverman et al., 2020; An et al., 2021; Boekhorst et al., 2021; Ceulemans

et al., 2021; Ceulemans et al., 2020; Chrzan-Dętkoś et al., 2021; Fallon et al., 2021; Guvenc et al., 2021; Hamami et al., 2020; Hiiragi et al., 2021; Hui et al., 2021; Liang et al., 2020; Lorentz et al., 2020; Mariño-Narvaez et al., 2021; Molgora and Accordini, 2020; Oskovi-Kaplan et al., 2021; Ostacoli et al., 2020; Spinola et al., 2020; Stojanov et al., 2021;



**Fig. 2.** The pooled prevalence of postpartum psychological symptoms during the COVID-19 pandemic. (A) postpartum depressive symptoms. (B) postpartum anxiety symptoms. (C) postpartum stress symptoms. (D) postpartum post-traumatic stress disorder symptoms.

Suárez-Rico et al., 2021; Sun et al., 2020b; Suzuki, 2022; Zanardo et al., 2020; Zeng et al., 2020). The other three studies used the 9-item Patient Health Questionnaire (PHQ9), the Patient Health Questionnaire-4 (PHQ4), and the 10-item Center for Epidemiological Studies Depression scale (CES-D-10) with cut-off points of 5, 6, and 10, respectively (Racine et al., 2021; Basu et al., 2021; Bo et al., 2020). Nine studies reported the prevalence of postpartum anxiety using the 7-item Generalized Anxiety Disorder scale (GAD7), the Perceived Stress Scale (PSS), the State Trait Anxiety Inventory scale (STAI), or the 6-item short form of the Spielberger State-Trait Anxiety Inventory (STAI-SF) (Loret de Mola et al., 2021; Racine et al., 2021; Ceulemans et al., 2021; Ceulemans et al., 2020; Fallon et al., 2021; Molgora and Accordini, 2020; Spinola et al., 2020; Suárez-Rico et al., 2021; Zeng et al., 2020). In addition, the prevalence of postpartum stress and post-traumatic stress disorder (PTSD) symptoms were reported by two (Loret de Mola et al., 2021; Suárez-Rico et al., 2021) and three studies (Basu et al., 2021; Molgora and Accordini, 2020; Ostacoli et al., 2020), respectively. The methodological quality scores for the included studies are shown in Table 2, and 11 were high-quality studies (Loret de Mola et al., 2021; Racine et al., 2021; An et al., 2021; Boekhorst et al., 2021; Hiiragi et al., 2021; Hui et al., 2021; Liang et al., 2020; Lorentz et al., 2020; Ostacoli et al., 2020; Zanardo et al., 2020; Zeng et al., 2020).

### 3.3. Postpartum psychological health during the COVID-19 pandemic

#### 3.3.1. Postpartum depressive symptoms

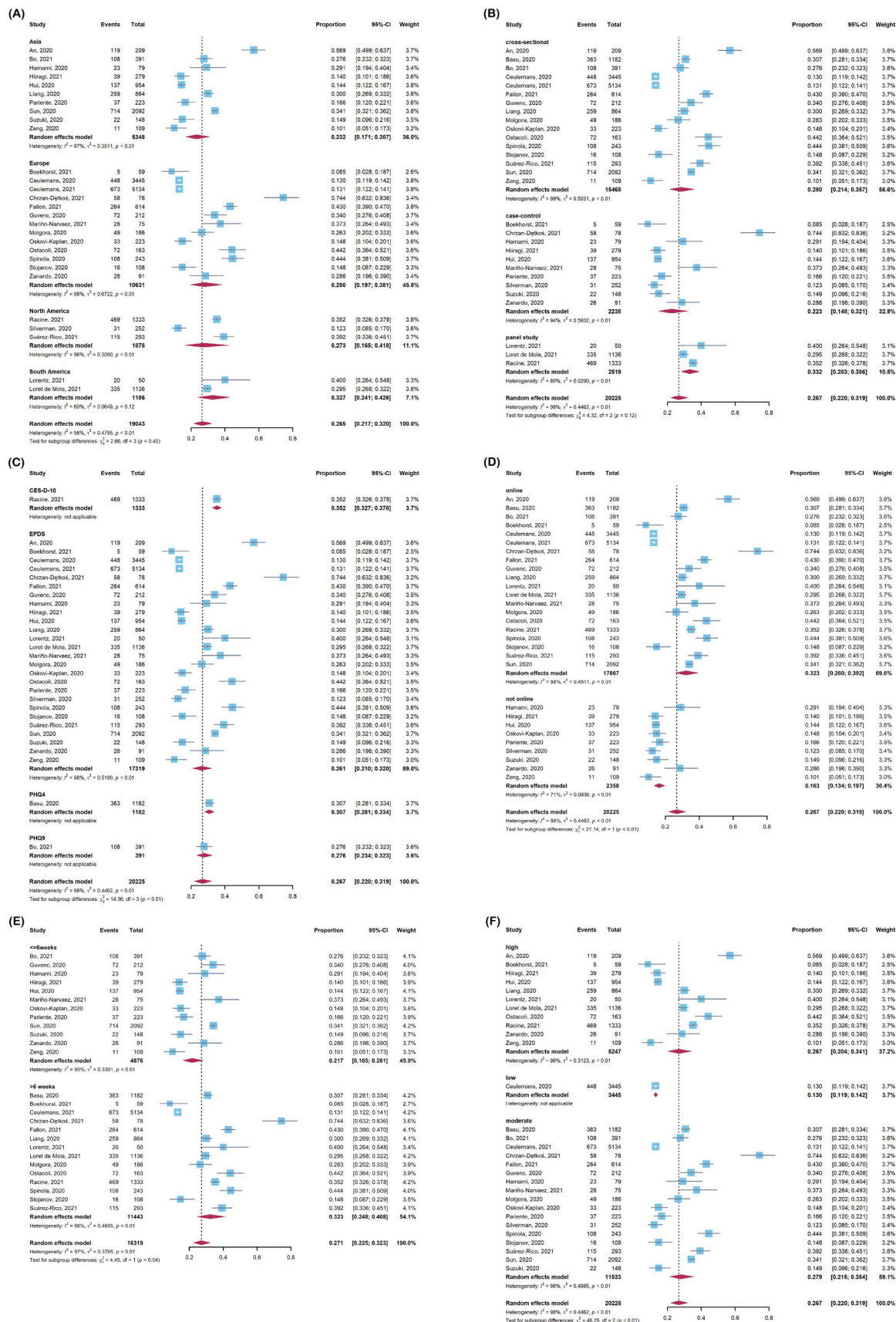
The rate of postpartum depressive symptoms during the COVID-19 pandemic was evaluated in 29 studies and ranged from 8.5 % to 74.4 %. The pooled prevalence of postpartum depressive symptoms was 26.7 % (95 % CI: 22.0 %–31.9 %), as shown in Fig. 2A. Results from subgroup analyses are shown in Fig. 3. Ten studies were performed in Asia and the pooled prevalence of depressive symptoms in these studies was 23.2 % (95%CI: 17.1 %–30.7 %). Thirteen studies provided data from Europe with a pooled prevalence of depressive symptoms of 28.0 % (95%CI: 19.7 %–38.1 %). The three studies conducted in North America and two studies conducted in South America reported pooled prevalence rates of 27.3 % (95%CI: 16.5 %–41.8 %) and 32.7 % (95%CI: 24.1 %–42.6 %), respectively (Fig. 3A). The pooled prevalence rates of depressive symptoms in cross-sectional, case-control, and panel studies were 28.0 % (95%CI: 21.4 %–35.7 %), 22.3 % (95%CI: 14.8 %–32.1 %), and 33.2 % (95%CI: 28.3 %–38.6 %), respectively (Fig. 3B). Twenty-six studies used the EPDS to assess postpartum depression, and the pooled prevalence was 26.1 % (95%CI: 21.0 %–32.0 %). The studies that used the CES-D-10, PHQ4, and PHQ9 reported postpartum depression rates of

35.2 % (95%CI: 32.7 %–37.8 %), 30.7 % (95%CI: 28.1 %–33.4 %), and 27.6 % (95%CI: 23.4 %–31.9 %), respectively (Fig. 3C). The prevalence of postpartum depressive symptoms in studies that used an online survey was 32.3 % (95%CI: 26.0 %–39.2 %), which was higher than the prevalence in non-online survey studies (16.3 %, 95%CI: 13.4 %–19.7 %) (Fig. 3D). Data for time after delivery were available for 26 studies. The pooled prevalence rate of depressive symptoms in women whose postpartum duration was  $\leq 6$  weeks was 21.7 % (95%CI: 16.5 %–28.1 %) and that in women  $> 6$  weeks after delivery was 32.3 % (95%CI: 24.8 %–40.8 %) (Fig. 3E). Among the 11 high-quality studies, the pooled postpartum depressive symptom rate was 26.7 % (95%CI: 20.4 %–34.1 %), which was similar to that among moderate-quality studies (27.9 %, 95%CI: 21.6 %–35.4 %). Only one low-quality study reported the prevalence rate of postpartum depression (13.0 %, 95%CI: 11.9 %–14.2 %) (Fig. 3F). Summary risk estimates of associations between risk factors and postpartum depression during the COVID-19 pandemic are shown in Table 3. Both lower income (OR = 1.28, 95%CI: 1.06–1.54) and formula feeding (OR = 1.58, 95%CI: 1.21–2.07) significantly increased the risk for postpartum depression. Similar but borderline significant associations were found for maternal age  $< 35$  years (OR = 1.18, 95%CI: 0.93–1.50) and an education below a high school degree (OR = 1.13, 95%CI: 0.92–1.39). Employment, first pregnancy (OR = 1.22, 95%CI: 0.74–2.01), and cesarean delivery (OR = 0.96, 95%CI: 0.76–1.21) did not show any association with postpartum depression.

#### 3.3.2. Postpartum anxiety symptoms

The prevalence of postpartum anxiety symptoms was reported in nine studies. As shown in Fig. 2B, the pooled rate of anxiety symptoms was 33.8 % (95%CI: 21.1 %–49.4 %). Subgroup analyses are shown in Fig. 4. Pooled analyses by continent revealed that the prevalence of postpartum anxiety symptoms was similar in Europe (34.3 %, 95%CI: 15.1 %–60.5 %) and North America (38.3 %, 95%CI: 25.2 %–53.3 %). Only one study was conducted in Asia and one in South America, and these studies reported lower postpartum anxiety rates (31.2 %, 95%CI: 23.2 %–40.5 % and 25.9 %, 95%CI: 23.4 %–28.5 %, respectively) (Fig. 4A). The pooled prevalence rate of anxiety symptoms was 35.5 % (95%CI: 18.4 %–57.3 %) in cross-sectional studies, which was higher than that in panel studies (28.6 %, 95%CI: 23.5 %–34.4 %) (Fig. 4B). The prevalence of anxiety symptoms assessed by the STAI (55.0 %, 95%CI: 45.4 %–64.3 %) and PSS (51.9 %, 95%CI: 45.4 %–58.3 %) was higher than that assessed by the GAD7 (18.3 %, 95%CI: 11.4 %–28.2 %) and STAI-SF (31.4 %, 95%CI: 29.0 %–34.0 %) (Fig. 4C). Most studies adopted an online survey method, which yielded a pooled prevalence for anxiety symptoms of 34.2 % (95%CI: 20.6 %–50.9 %). Only one study





**Table 3**

Summary risk estimates of association between risk factors and postpartum depression during the COVID-19 pandemic.

Risk factors	Studies, N	Summary OR (95% CI)	Heterogeneity	
			I <sup>2</sup> , %	p-value
Maternal age < 35 years	3	1.18 (0.93–1.50)	0	0.504
Employment	4	1.20 (0.71–2.02)	81.9	<0.05
Under high school degree	5	1.13 (0.92–1.39)	0	0.779
Lower income level	4	1.28 (1.06–1.54)	0	0.811
First pregnancy	2	1.22 (0.74–2.01)	56.1	0.131
Cesarean section	4	0.96 (0.76–1.21)	0	0.763
Formula feeding	2	1.58 (1.21–2.07)	41.8	0.190

N, number; OR, odds ratio; CI, confidence interval.

did not use online survey and reported a prevalence of anxiety symptoms of 31.2 % (95%CI: 23.2 %–40.5 %) (Fig. 3D). Seven studies included women >6 weeks after delivery. The pooled prevalence for anxiety symptoms of these seven studies was 38.0 % (95%CI: 21.4 %–58.0 %), which was higher than that in women <6 weeks after delivery reported in one study (31.2 %, 95%CI: 23.2 %–40.5 %) (Fig. 3E). Among the three high-quality studies, the pooled rate of anxiety symptoms was 29.1 % (95%CI: 24.8 %–33.8 %), which was lower than that among the five moderate-quality studies (42.2 %, 95%CI: 15.6 %–74.3 %) (Fig. 3F). Risk factor analyses were not performed because of the limited number of original studies.

### 3.3.3. Prevalence of postpartum stress and PTSD

The pooled prevalence of postpartum stress was 55.0 % (95%CI: 27.9 %–79.5 %) and that of PTSD was 33.7 % (95%CI: 19.6 %–51.5 %), as reported in two and three studies, respectively (Fig. 2C and D). Subgroup and risk factor analyses were not performed for stress and PTSD in postpartum women because of the limited number of original studies.

## 3.4. Effects of COVID-19 pandemic on postpartum depressive and anxiety symptoms

### 3.4.1. postpartum depressive symptom

Thirteen studies reported the difference in postpartum depression prevalence rates before and during the COVID-19 pandemic. As shown in Fig. 5A, the pooled OR for postpartum depression during the COVID-19 pandemic was 1.54 (95 % CI: 1.00–2.36). Subgroup analyses are shown in Fig. 6. Pooled analyses by continents revealed that the risk for postpartum depression during the COVID-19 pandemic was significantly increased in Europe (OR = 1.95, 95%CI: 1.32–2.87) and South America (OR = 4.32, 95%CI: 1.21–15.41) compared with Asia (OR = 0.94, 95% CI: 0.63–1.41) and North America (OR = 1.41, 95%CI: 0.50–3.94) (Fig. 6A). The pooled OR during the COVID-19 pandemic in case-control studies was 1.15 (95 % CI: 0.85–1.56), which was lower than that in panel studies (OR = 3.47, 95 % CI: 1.34–8.95) (Fig. 6B). Nearly all studies (12 of 13) adopted the EPDS to assess postpartum depression, and the pooled OR during COVID-19 pandemic in these 12 studies was 1.47 (95%CI: 0.86–2.53). Only one study used the CES-D-10 to identify postpartum depressive symptoms, and that study reported a higher OR during the COVID-19 pandemic (OR = 2.31, 95%CI: 1.98–2.71) (Fig. 6C). The pooled OR during the COVID-19 pandemic was 1.40 (95 % CI: 0.77–2.55) in the two studies that used online surveys in both the pre- and post-pandemic periods, which was higher than the OR in the other seven non-online survey studies (OR = 1.04, 95%CI: 0.73–1.50). Four studies used offline and online surveys before and during COVID-19, respectively, which yielded the highest pooled OR during the pandemic (OR = 3.10, 95%CI: 1.42–6.78) (Fig. 6D). Compared with women ≤6 weeks after delivery (OR = 1.18, 95%CI: 0.80–1.75), the pooled OR for depressive symptom during the COVID-19 pandemic was higher in those >6 weeks after delivery (OR = 2.49, 95%CI: 1.20–5.17)

(Fig. 6E). Among the seven high-quality studies, the risk for postpartum depression during the COVID-19 pandemic was significantly increased (OR = 2.26, 95 % CI: 1.30–3.91), but this association was not found in the six moderate-quality studies (OR = 0.95, 95%CI: 0.62–1.48) (Fig. 6F).

### 3.4.2. Postpartum anxiety symptoms

Only two studies reported the difference in postpartum anxiety symptoms before and during the COVID-19 pandemic, and the pooled OR during the COVID-19 pandemic was 2.56 (95%CI: 1.62–4.04) (Fig. 5B). A subgroup analysis was not conducted because of the limited number of studies.

## 3.5. Publication bias

The funnel plot and Egger's test revealed there was no significant publication bias in the prevalence of postpartum depressive symptoms (Fig. 7).

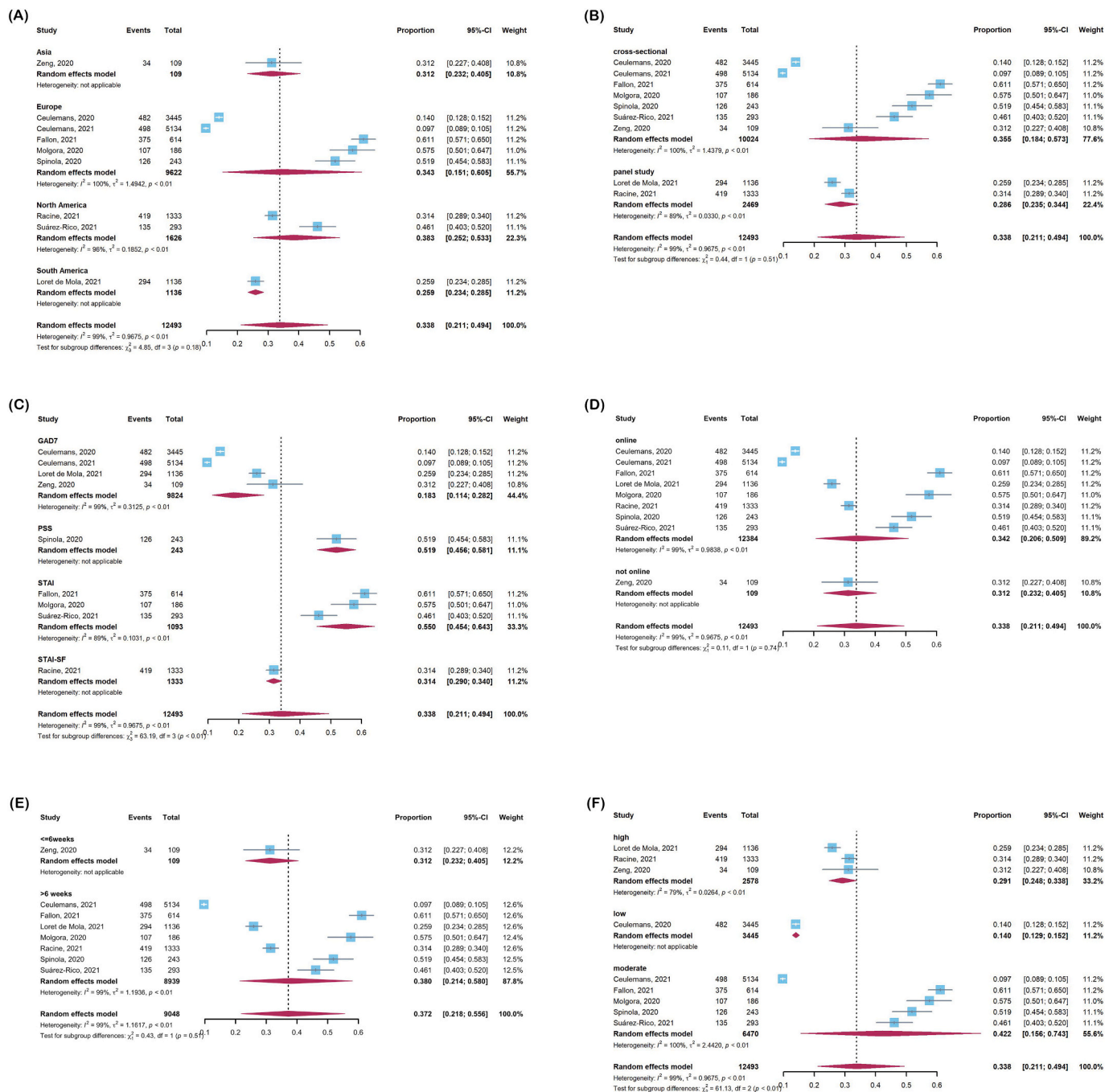
## 4. Discussion

To our knowledge, this systematic review and meta-analysis of 29 studies is the first to identify an association between COVID-19 pandemic and psychological health symptoms in postpartum women. The results of our analyses revealed that a high proportion of postpartum women suffered from psychological symptoms during the COVID-19 pandemic, with this prevalence significantly higher than before the COVID-19 pandemic. Women >6 weeks after delivery, younger than 35 years, with a low income, with less education, and that used formula feeding had a higher risk for psychological disorders after delivery.

In our systematic review and meta-analysis, we found that the prevalence of postpartum depressive, anxiety, stress, and PTSD symptoms during the COVID-19 pandemic was 26.7 %, 33.8 %, 55.0 %, and 33.7 %, respectively, which were similar to ai previous meta-analyses of mental health among perinatal women during the COVID-19 pandemic (Shorey et al., 2021; Yan et al., 2020). In addition, the results of the present study showed that compared with the general population, postpartum women faced a higher risk for psychological disorders during the COVID-19 pandemic (Krishnamoorthy et al., 2020). These findings were consistent with a previous study involving perinatal women (Basu et al., 2021), which suggested that new mothers faced tremendous social, biological, and psychological changes, making them more susceptible to negative emotions than the general population (Kolakowsky-Hayner et al., 2021; Vesga-Lopez et al., 2008).

Several socio-demographic risk factors for postpartum psychological disorders during the COVID-19 pandemic were identified in the present study. First, we found that the prevalence of postpartum depressive and anxiety symptoms was higher in women >6 weeks after delivery, whereas the prevalence was lower in the first 6 weeks of the postpartum period. The results of previous literature on the peak period for postpartum mental disorders are inconsistent. Some studies indicated that the prevalence of postpartum depression was higher during the first 3 months after delivery (Cooper et al., 1988). However, longitudinal research showed that depressive symptoms persisted for >1 year after delivery (Woolhouse et al., 2015). Evidence from a randomized controlled trial also revealed that the risk for postpartum depression increased 6 weeks after delivery and lasted to 3 months after delivery (Sangsawang et al., 2022). It is important to note that new mothers faced a more challenging and complex environment during the COVID-19 pandemic compared with before the pandemic. With increasing time after delivery, more mothers and babies need activities outside the home. The conflict between outdoor needs and quarantine measures may contribute to the increased prevalence of postpartum psychological disorders during the COVID-19 pandemic (Zanardo et al., 2020).

Second, we found a higher risk for postpartum depression in mothers who were younger than 35 years compared with older mothers. Similar



**Fig. 4.** Subgroup analysis of the prevalence of postpartum anxiety symptoms during the COVID-19 pandemic by (A) continent, (B) study design, (C) assessment scale, (D) time after delivery, (E) survey method, (F) study quality. Abbreviations: GAD7, the 7-item Generalized Anxiety Disorder scale; PSS, the Perceived Stress Scale; STAI, the State Trait Anxiety Inventory scale; STAI-SF, the 6-item short form of the Spielberger State-Trait Anxiety Inventory.

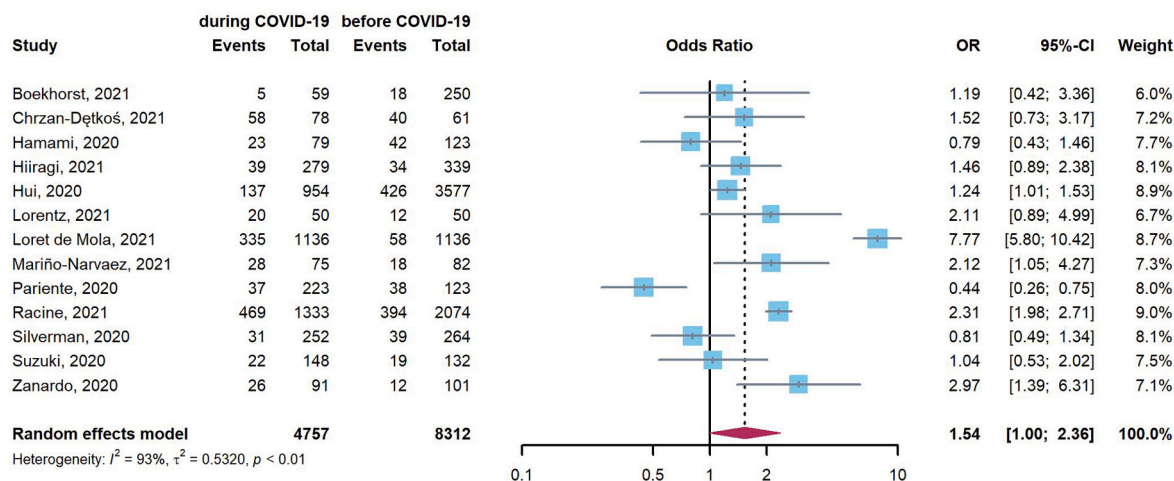
results were also found in other studies that showed older postpartum or pregnant women were less likely to experience anxiety and depression regardless of timing (i.e., before or during the COVID-19 pandemic) (Fan et al., 2021; Alshikh Ahmad et al., 2021). A previous study suggested that the median age-of-onset for mental disorders ranged from late teens through the early 20s before the COVID-19 pandemic (Kessler et al., 2007). In addition, the high risk for postpartum psychological disorders in younger mothers may be attributable to the lack of experience in caring new babies and relieving negative emotion.

Third, lower income or education level, rather than unemployment, was significantly associated with a higher prevalence of postpartum depression. The evidence before the COVID-19 pandemic revealed that

lower income level was a risk factor for postpartum psychological disorders (Alshikh Ahmad et al., 2021; Zhao and Zhang, 2020). Furthermore, a previous study showed that around half of families experienced joblessness or income disruption during the COVID-19 pandemic (Racine et al., 2021). Therefore, financial pressure from raising newborns may be more severe, resulting in a higher prevalence of postpartum psychological disorders during the COVID-19 pandemic (Li et al., 2020a). Furthermore, people with a lower education level may have less capabilities to obtain, interpret, and update information about the disease than people with a higher education level, which may increase postpartum women's worries about the pandemic, and therefore affect postpartum mental health (Alshikh Ahmad et al., 2021). Interestingly,



(A)



(B)

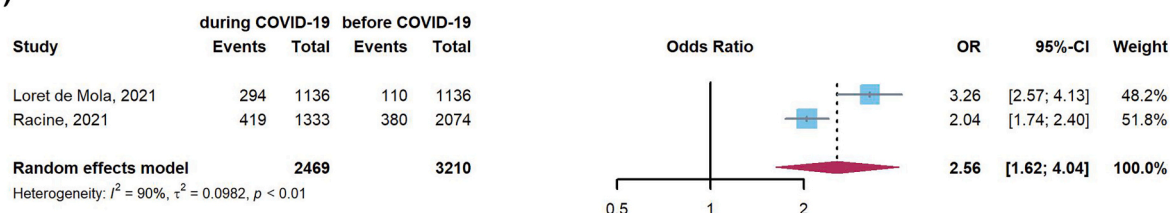


Fig. 5. The pooled odds ratio of COVID-19 pandemic on (A) postpartum depressive symptoms, and (B) postpartum anxiety symptoms.

employment did not significantly decrease postpartum depressive symptoms in our meta-analysis. Having to give up growth opportunities such as attending meetings or travelling for work, as well as making special leave arrangements may increase job uncertainty, which could lead to negative emotions among employees during infectious disease outbreaks (Brooks et al., 2020). This may counteract the benefits from employment, such as increases in income or social interactions, and explain the insignificant association between employment and postpartum psychological disorders during the COVID-19 pandemic (Guin-tivano et al., 2018).

Fourth, mothers that used formula feeding had an increased risk for postpartum depression during the COVID-19 pandemic. This finding was consistent with most previous studies both before and during the COVID-19 pandemic (Ceulemans et al., 2021; Haga et al., 2012). Formula feeding may decrease the protective effects of a satisfactory mother-infant relationship and increase economic pressure, thereby raising the risk for postpartum psychological disorders during the COVID-19 pandemic.

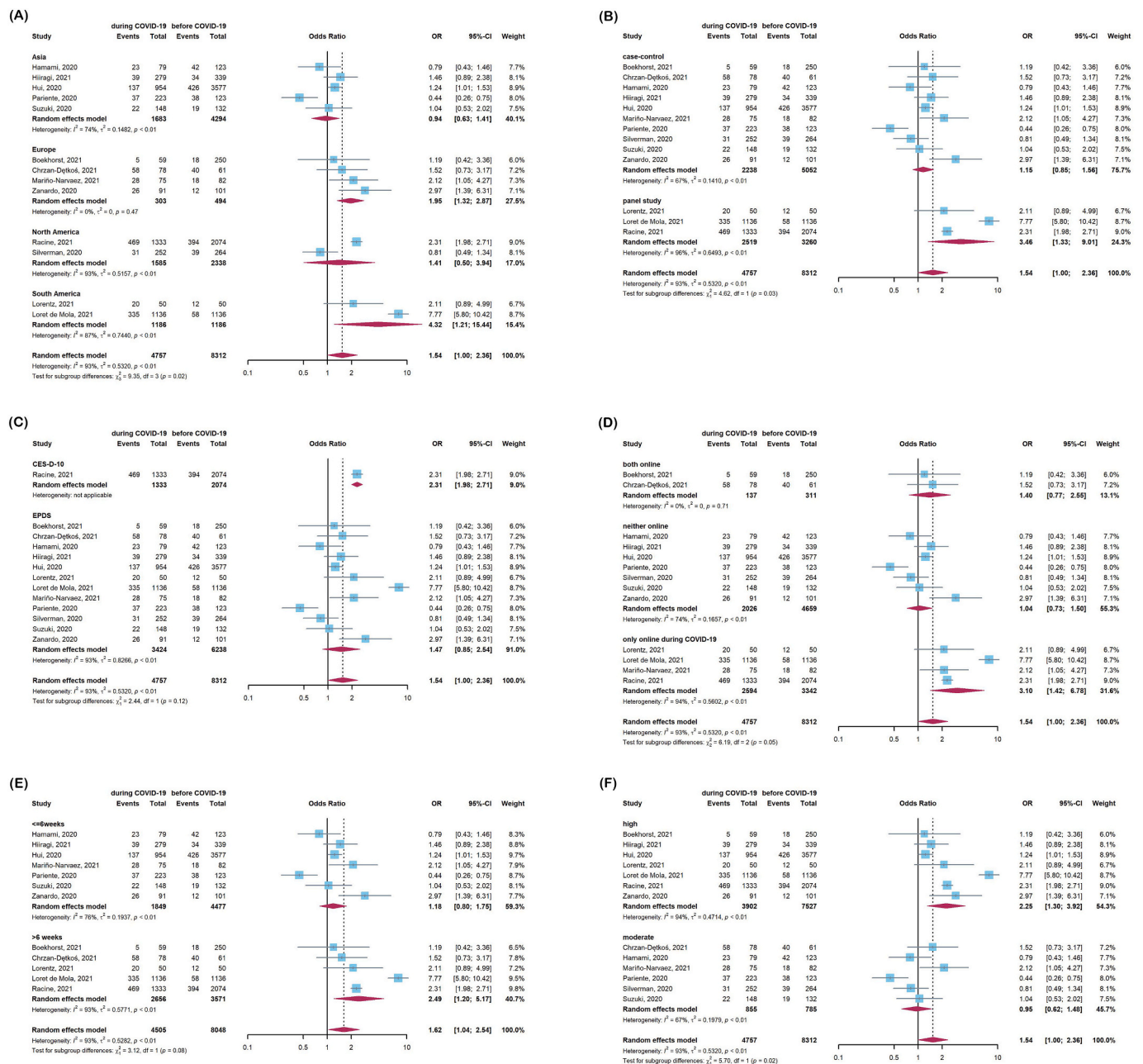
Before the COVID-19 pandemic, nearly 20 % of postpartum women suffered from depression or anxiety (Howard et al., 2014; Dennis et al., 2017), which was significantly lower than the prevalence during the COVID-19 pandemic. Evidence from pregnant women and the general population also revealed that the COVID-19 outbreak significantly increased the risk for negative emotions or psychological symptoms, which was consistent with our finding among postpartum women (Yan et al., 2020; Ayaz et al., 2020; Yuan et al., 2020; Li et al., 2020b). We found that the COVID-19 pandemic significantly increased the risk for postpartum psychological disorders: the pooled ORs during the COVID-19 pandemic for postpartum depressive and anxiety symptoms were 1.54 (95 % CI: 1.00–2.36) and 2.56 (95%CI: 1.62–4.04), respectively, and women with >6 weeks after delivery were more sensitive to the negative effects of the COVID-19 pandemic. Numerous risk factors increased during the COVID-19 pandemic, such as medical inconvenience, fear of being infected by the COVID-19, lack of social support,

financial stress, and prenatal psychological disorders, which may explain its negative effects on postpartum psychological health (Payne and Maguire, 2019).

Subgroup analyses in the present study showed that women from Asian countries had a lower risk for psychological disorders after delivery compared with women from other countries. This was consistent with the results of a previous meta-analysis among pregnant women in which Europe had the highest prevalence of anxiety or depressive symptoms, followed by Asia and North America (Shorey et al., 2021). An international cross-sectional study among perinatal women revealed that after adjusting for various risk factors, the prevalence of anxiety, depression, and PTSD in other regions were 1.5 to 3 times significantly higher than that in Asia during the COVID-19 pandemic (Basu et al., 2021). A meta-analysis involving people at high risk for COVID-19 infection, namely medical workers, also showed that participants in Asian countries had a low prevalence of adverse psychological symptoms during the pandemic (Olaya et al., 2021). Given that the severity of the COVID-19 pandemic and control measures differed among countries, more international studies are needed to examine region-specific effects of the COVID-19 pandemic on postpartum psychological health. Our subgroup analyses showed that the pooled prevalence of postpartum psychological symptoms was higher in studies that used online surveys, which indicated that the survey method may influence the performance on self-reported scales of psychological health.

To our knowledge, this study is the first to pool the prevalence of postpartum depressive, anxiety, stress, and PTSD symptoms during the COVID-19 pandemic and estimate the effects of the pandemic on the psychological health of postpartum women. In addition, postpartum women that were >6 weeks after delivery, younger than 35 years, with a low income, with less education, and that used formula feeding were more susceptible to the effects of the COVID-19 pandemic on psychological health. These findings could provide comprehensive new evidence to prevent postpartum psychological disorders during the COVID-19 pandemic. Our study had some limitations. First, significant but





effect of the COVID-19 pandemic on postpartum psychological health. Third, the prevalence of postpartum insomnia during the COVID-19 pandemic was unable to be pooled because it was reported by only one study. More studies could focus on postpartum sleep disorders during the COVID-19 pandemic to clarify this point. Fourth, most online-survey-based studies were performed among women >6 weeks after delivery who experienced higher risk for postpartum psychological symptoms during the COVID-19 pandemic, indicating that potential selection bias may exist in the original studies.

In conclusion, our study found that a significantly higher proportion of postpartum women suffered from symptoms of psychological disorders during the COVID-19 pandemic compared with before the pandemic. More attention and preventive measures should be adopted to improve psychological health in postpartum women, particularly for those >6 weeks after delivery, younger than 35 years, with a low income, with less education, and that use formula feeding.

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## CRediT authorship contribution statement

Wentao Yue and Chenghong Yin initiated and designed the research. Shen Gao, Shaofei Su and Enjie Zhang searched and identified literatures. Enjie Zhang, Ruixia Liu, Yue Zhang and Chengrong Wang performed data extraction. Jianhui Liu and Shuanghua Xie assessed the quality of included studies. Shen Gao and Shaofei Su performed meta-analyses. Shen Gao and Shaofei Su wrote the first draft of the manuscript. Wentao Yue and Chenghong Yin contributed to manuscript revision and supervision. All authors contributed to manuscript final version approval.

## Conflict of Interest

All the authors declared no potential competing interests with respect to the research, authorship, and/or publication in this paper.

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No.

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