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Psychosocial and peripartum determinants of postpartum depression: Findings from a prospective population-based cohort. The ABCD study

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ABSTRACT

Background: Postpartum depression is prevalent and concerns a serious health problem for women and their families. The current large-scale birth cohort study investigated: (1) the associations of various potential determinants of postpartum depression using a multidimensional approach, and (2) the individual contribution of obstetric and perinatal determinants and pregnancy-specific anxiety to the risk of postpartum depression.
Methods: This study was based on a large-scale birth cohort study in Amsterdam, the Netherlands (ABCD-study). In 5109 women depressive symptoms were assessed using the Center for Epidemiologic Studies Depression Scale (cut-off ≥16 indicating high risk of postpartum depression). Determinants were assessed using self-report or perinatal registries.
Results: In the final multivariable model, other-Western and non-Western ethnic background, increased antepartum depressive symptoms, increased antepartum anxiety, increased pregnancy-specific anxiety, being unemployed, poor sleep quality, unwanted pregnancy, abuse, multiparity, and congenital abnormality were all independently related to an increased risk of postpartum depression. The strongest risk factors for postpartum depression were antepartum depressive symptoms (adjusted odds ratio (AOR) = 3.86, 95% confidence interval (CI) 3.02–4.92), having a baby with a congenital abnormality (AOR = 2.33, 95% CI 1.46–3.73), and abuse (AOR = 1.95, 95% CI 1.02–3.73). The final model accounted for 24.5% of the variance.
Limitations: Our dataset did not provide information on social support or maternal and family history of depression. Next to these determinants, future research should include biological factors.
Conclusions: The determinants identified provide opportunities for the development of multidimensional early screening and early intervention strategies for women with an increased risk of postpartum depression.

1. Introduction

Postpartum depression is prevalent and concerns a serious health problem for women and their families. In the last decennia, the prevalence of postpartum depression has increased [1] and varies from 8.9% to 13% as indicated by large-scale population-based studies and previous reviews [2–5]. In clinical practice and research, depression with an onset up to 6 months after childbirth is considered as postpartum depression [6,7]. Postpartum depressive symptoms are related to high personal suffering of mothers, diminished quality of life, and a high risk for relapse and chronicity [8–11]. Furthermore, postpartum depression can lead to poor family functioning, child behavioral and cognitive problems, and offspring psychopathology in adulthood [7,12–14]. This stresses the need for early detection of pregnant women at risk for postpartum depression and its risk factors, in order to make use of the window of opportunity for timely prevention and intervention. To optimize the detection of women at risk, a multidimensional approach has been recommended [15]. Nevertheless, for the development and improvement of targeted screening and intervention strategies, further understanding of the multidimensionality of risk factors of postpartum depression is crucial. However, large-scale birth cohort studies investigating in what way various antepartum psychosocial, sociodemographic, lifestyle, and obstetric and perinatal factors simultaneously

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contribute to the risk of postpartum depression, are scarce. Gaining such insights is highly needed as currently multidimensional screening instruments to detect women at risk of ante- and postpartum depression are lacking, as recently indicated by the US Preventive Services Task Force [16].

In the context of cognitive behavioral theories and a stress-vulnerability model of depression assuming a reciprocal interaction between environmental stressors and (neuro)biological vulnerabilities [7,17,18], several risk factors for postpartum depression have been found by previous studies. These include sociodemographic characteristics such as low educational level and socioeconomic status [19–22], and psychosocial factors such as antepartum depression and anxiety, neuroticism, poor social support, abuse, stressful life events during pregnancy and psychological stressors like sleeping problems or unwanted pregnancy [1,20,23–25]. A personal and family history of depression also concern significant risk factors of postpartum depression [26]. Concerning these psychological factors, the contribution of pregnancy-specific anxiety, however, has thus far been understudied with regard to the risk of postpartum depression [27]. Pregnancy-specific anxiety reflects pregnancy-related fears, such as fear of giving birth, and has been suggested to represent a unique type of psychological distress in pregnancy, distinct from general anxiety [28]. The role of obstetric and perinatal risk factors in relation to postpartum depression has been inconclusive [3,29–31], although meta-analyses concluded that, overall, obstetric and perinatal factors contribute weakly but significantly to the prediction of postpartum depression [3,24]. Recent prospective cohort studies correspondingly showed that pregnancy complications (e.g., pre-eclampsia), childbirth- and perinatal complications (e.g., caesarean section, neonatal unit admission) as well as postpartum complications (e.g., breastfeeding difficulties) are related to an increased risk of postpartum depression [2,23,32,33]. However, these cohort studies often controlled only, if at all, for a limited number of psychosocial factors (e.g. [2,23]). Also, the findings of the previous meta-analyses [3] were based on composite measures of perinatal and obstetric factors, although the individual factors examined varied between studies (e.g. [2,29,30,32]). Thus, so far, previous studies were not able to provide a decisive answer which obstetric and perinatal factors consistently predict postpartum depression.

The overarching aim of the current study is to examine the associations of various potential determinants of postpartum depression using a multidimensional approach in a large-scale population-based prospective birth cohort in the Netherlands. We will particularly investigate the unique contribution of obstetric and perinatal factors and pregnancy-specific anxiety to the risk of developing postpartum depression, while simultaneously examining the influence of sociodemographic, lifestyle and health-related, and psychosocial factors.

2. Methods

2.1. Participants and design

The current study sample was embedded in the Amsterdam Born Children and their Development (ABCD) study. For this ongoing population-based prospective birth cohort study, all pregnant women living in Amsterdam ($n = 12{,}373$) were approached for participation during their first obstetric care visit in the period from January 2003 to March 2004 [34]. Of these, up to 8130 women provided information about psychosocial factors (including antepartum depressive symptoms) as part of the pregnancy questionnaire at 16 weeks' gestation on average (Median with inter-quartile range (IQR) = 14–18 weeks). A total of 5218 women (64.2% of the 8130 eligible women) completed the postpartum questionnaire on average 13 weeks after childbirth (IQR = 12–13 weeks), of which 5109 (62.8% of 8130 women) were included in the present study based on available data of the outcome measure (i.e., postpartum depression). Detailed information regarding the study design has been published in the cohort profile [34]. Furthermore, the design and measures used for the current study have previously been described in publications of the ABCD study addressing research questions related to maternal psychosocial and obstetric health different from the current aim [35–55]. Preliminary results addressing the main research question of the current study have been published in a conference abstract [56].

2.2. Ethical issues

The Central Committee on Research Involving Human Subjects in The Netherlands and the medical ethics research committee of the Amsterdam Medical Center, The Netherlands (MEC 02/039, March 2002) have approved the study protocol [34]. Written informed consent was obtained from all women before participation [34].

2.3. Outcome measure

The primary outcome was the presence of depressive symptoms at 3 months postpartum. Depressive symptoms were assessed with the Center for Epidemiologic Studies Depression Scale (CES–D) [57,58]. The CES-D comprises 20 items, rated on a 4-point Likert scale ranging from 0 (rarely or none of the time) to 3 (most or almost all the time). It provides a total score on depressive symptomatology (0–60) [41,57,58]. Higher scores indicate more depressive symptoms, while a score of ≥16 is indicative of being at risk of clinical depression [58]. As this cut-off has been demonstrated to correspond well with diagnostic measures, it was applied in this study to differentiate between a low versus high risk of having postpartum depression [59,60]. To improve readability, we will refer to being at high risk of postpartum depression as postpartum depression. While the CES-D was not specifically designed for the assessment of peripartum depression, it has been shown to be a reliable and valid instrument, that is strongly correlated with the well-known Edinburgh Postnatal Depression Scale (EPDS) [61,62]. Moreover, the CES-D has been reported to detect clinically diagnosed depression in pregnant as well as postpartum women, with moderate to very high levels of sensitivity and specificity and good diagnostic accuracy as shown by ROC curve analyses [6,63,64]. In our study, Cronbach's alpha was 0.90 for the postpartum assessment.

2.4. Potential determinants

2.4.1. Socio-demographic factors

Sociodemographic characteristics were obtained via the pregnancy questionnaire at 16 weeks' gestation assessing information on maternal age (<26/26–30/31–35/≥36 years), ethnic background (Dutch/other-Western/non-Western; classified using country of birth of the participant's mother), educational level (low/medium/high; classified according to years of education after primary education) and living with a partner (living together/not living together/single).

2.4.2. Psychosocial factors

Antepartum depressive symptoms were assessed at 16 weeks' gestation by self-report using the CES-D [57,58]. In our sample, Cronbach's alpha for the antepartum assessment was 0.90.

Antepartum general anxiety was assessed with the State-Trait Anxiety Inventory (STAI) [65,66]. The state anxiety subscale comprises 20 items. Items were rated on a 4-point Likert scale ranging from 0 (rarely or none of the time) to 3 (most or all the time) [43–45]. It measures temporarily experienced anxiety and has good psychometric properties [65]. The total score (range 20–80) of the state anxiety subscale was dichotomized into high versus low/moderate anxiety with a cut-off by the 85th percentile in line with previous studies [67,68]. In the current sample, Cronbach's alpha was 0.94.

Pregnancy-specific anxiety was assessed with the Pregnancy Related Anxiety Questionnaire-Revised (PRAQ-R) [28,43]. The PRAQ-R comprises 10 items, rated on a 5-point Likert scale ranging from 1 (definitely

not true) to 5 (definitely true) and has been shown to measure a distinctive type of anxiety as compared to general anxiety [28,43]. As cut-off scores were not available for dichotomization of the PRAQ-R scores, we used the 85th percentile of the total score (range 10–50) to detect women with an elevated level of pregnancy-specific anxiety, in line with previous studies [69,70]. In the current sample, Cronbach's alpha was 0.81.

Work-related stress during pregnancy was assessed with the Dutch version of the Job Content Questionnaire (JCQ) [71,72]. The JCQ measures experienced job demand with 25 items and experienced job control with 11 items, on a 4-point Likert scale [72]. A higher score on the demand scale indicates higher job demand, a higher score on the control scale indicates less perceived job control. The job demand score was categorized into low (below the 50th percentile), moderate (50th–90th percentile) and high (above the 90th percentile). The job control score was categorized into high (above the 50th percentile), moderate (10th–50th percentile), and low (below the 10th percentile) [46,51]. According to the JCQ guidelines, the variable work-related stress was subsequently determined using four categories, as follows [46]. The category of 'high job strain' comprised women who fell in the categories of high job demand with low or moderate job control. 'Low job strain', contains the categories of low job demand with moderate or high job control. 'Moderate job strain' comprised all women with the remaining category combinations, while the fourth category comprised unemployed women [46,51,72]. In the current sample, Cronbach's alpha of the overall scale was 0.79.

Sleep quality was assessed based on three items in the pregnancy questionnaire ('Difficulty falling asleep,' 'Woke up too early' and 'Had a restless/disturbed sleep'). The items could be scored on a 4-point Likert scale ranging from 1 ((almost) never) to 4 (very frequently). The 85th percentile of the resulting total score (range 3–12) was used as a cut-off to indicate having a poor sleep quality.

Unwanted pregnancy was assessed by the following three items in the pregnancy questionnaire: 'Happy to be pregnant', 'Pregnancy was (really) wanted' and 'Did not want to be pregnant (anymore)'. The items could be rated on a 4-point Likert scale ranging from 1 (definitely true) to 4 (definitely not true), resulting in a total score from 3 to 12. The total score of the items was used and a cut-off by the 85th percentile as a cut-off to indicate high unwanted pregnancy.

Physical and sexual abuse was assessed by two questions about the experience of physical abuse or sexual abuse during pregnancy and due to the low prevalence in the present sample combined into one variable (abuse combined, yes/no) for the analysis.

2.4.3. Lifestyle and health-related factors

Lifestyle and health determinants were obtained via the postpartum questionnaire filled out by mothers at 3 months postpartum and included questions about tobacco consumption during the last month of pregnancy (yes/no), alcohol consumption during the last month of pregnancy (yes/no) and drug consumption during pregnancy (yes/no). Pre-pregnancy body mass index (BMI) was obtained via the pregnancy questionnaire (underweight/normal/overweight/obese, as defined by the World Health Organization (WHO) [73]. Previous research has shown high levels of concordance between self-report and researcher assessed data on pre-pregnancy BMI [74–76].

2.4.4. Obstetric and perinatal factors

Obstetric and perinatal determinants were assessed by a combination of data of medical registries routinely recorded by midwives and obstetricians (Dutch Perinatal Registration (Perined)) [77] and the self-report questionnaires filled out by mothers [43,79]. Maternal report of the respective obstetric and perinatal characteristics has been demonstrated to be a valid assessment method [80,81]. Obstetric factors regarding pregnancy variables and complications included history of spontaneous abortion (yes/no), history of induced abortion (yes/no), parity (primi/multi), pregnancy-induced hypertension (yes/no), pre-eclampsia (yes/no), and gestational diabetes (yes/no, self-report). Pregnancy-induced hypertension and pre-eclampsia were classified following the recommendations of the International Society for the Study of Hypertension in Pregnancy (ISSHP) [52,82].

Obstetric variables regarding delivery complications included caesarean section (yes/no), induced labor (yes/no, self-report), postpartum hemorrhage (≥1000 ml, yes/no), episiotomy (yes/no), caregiver (midwife-led care/referral/obstetrician-led care).

Perinatal variables included infant's sex (male/female), prematurity (gestational age <37 weeks) (yes/no), small-for-gestational age (birthweight <10th percentile, standardized for parity, sex of the child and gestational age using population based reference values from Perined) (yes/no), APGAR score <7 at 5 min after birth (yes/no), hospital admission of the baby (yes/no, self-report), hospital admission of the baby longer than 24 h (yes/no, self-report), congenital abnormality (yes/no), and breastfeeding duration (no breastfeeding/<3 months/3–6 months/≥ 6 months, self-report).

2.5. Statistical analysis

First, using independent *t*-tests for continuous variables and Chi-square tests for categorical variables, we compared sociodemographic, psychosocial, lifestyle and health-related, and obstetric and perinatal factors of women with a low risk of having postpartum depression to those women with a high risk. To examine whether non-response was selective, we compared women with missing data on the CES-D postpartum to those women who completed the CES-D postpartum.

Second, to deal with missing values in some of the determinants, ranging from 0.1% missing values for 'abuse' and 'infant's sex' to 19.0% for the variable 'episiotomy' and an average number of missing data of 3.37% (see also Table 1), we conducted multiple imputation. 'Hospital admission of the baby' was excluded due to more than 30% missing values. Little's MCAR test showed that data were not missing completely at random ($p = 0.004$). Information was missing due to drop-out or because perinatal registry data could only be partly linked to the participants. In line with the guideline by van Buuren [83] recommending to consider the average number of missing data as an approximation of the number of imputed sets needed and to address imputation variability, ten imputed sets were used for multiple imputation. Multiple imputation including all variables was conducted using the default settings of the multiple imputation procedure using the Statistical Package for Social Sciences (SPSS). Missing values were replaced by imputed values which were generated from their predictive distribution, based on the relations between all determinants included in the current study [84].

Third, to examine the associations between determinants and postpartum depression and to calculate crude odds ratios (OR) and their 95% confidence intervals (CI), we conducted univariable logistic regression analyses.

Fourth, we conducted a multivariable hierarchical logistic regression analysis based on a conceptual hierarchical framework, following the approach of Victora et al. [85]. To be able to correctly assess risk factors of a disorder, they propose to account for the often intricate hierarchical relationships between determinants by constructing a multivariable model based on a framework of the variables for which one plans to adjust [85]. According to our framework, sociodemographic determinants were entered at the first step, assuming that these factors may directly or indirectly influence all the other factors under study. At the second hierarchical step, all psychosocial determinants were entered, as these may be the most conclusive and robust determinants of postpartum depression, based on the existing literature [1,24]. The third step included lifestyle and health-related factors, followed by the fourth step, comprising obstetric and perinatal factors. We considered determinants of postpartum depression to be those variables that demonstrated a statistically significant association ($p < 0.05$) with postpartum depression in each respective level of our predefined hierarchical model. At each step,

Table 1
Participant characteristics by risk of postpartum depression.

	Postpartum depressive symptoms (CES-D)			*p*-Value
	Total study population	% Low/moderate	% High	
	N = 5109 (%)[a]	*n* = 4287 (83.9%)	*n* = 822 (16.1%)	
Sociodemographic factors				
Maternal age				<0.001
< 26 years	620 (12.1)	470 (11.0)	150 (18.2)	
26–30 years	1266 (24.8)	1071 (25.0)	195 (23.7)	
31–35 years	2254 (44.1)	1933 (45.1)	321 (39.1)	
≥ 36 years	969 (19.0)	813 (19.0)	126 (19.0)	
Ethnicity				<0.001
Dutch	3265 (63.9)	2895 (67.5)	370 (45.0)	
Other-Western	733 (14.3)	596 (13.9)	137 (16.7)	
Non-Western	1109 (21.7)	794 (18.5)	315 (38.3)	
Missing	2 (< 0.1)	2 (<0.1)	0	
Education				<0.001
High	2402 (47.0)	2117 (49.4)	285 (34.7)	
Medium	1591 (31.1)	1321 (30.8)	270 (32.8)	
Low	1088 (21.3)	826 (19.3)	262 (31.9)	
Missing	28 (0.5)	23 (0.5)	5 (0.6)	
Marital status				<0.001
Living together with spouse/partner	4559 (89.2)	3862 (90.1)	697 (84.8)	
Not living together	432 (8.5)	339 (7.9)	93 (11.3)	
Single	110 (2.2)	81 (1.9)	29 (3.5)	
Missing	8 (0.2)	5 (0.1)	3 (0.1)	
Psychosocial factors				
Antepartum depressive symptoms (CES-D)	1324 (25.9)	805 (18.8)	519 (63.1)	<0.001
Missing	24 (0.5)	18 (0.4)	6 (0.7)	
State anxiety (STAI)	693 (13.6)	373 (8.7)	320 (38.9)	<0.001
Missing	231 (4.5)	184 (4.3)	47 (5.7)	
Pregnancy-specific anxiety (PRAQ)	632 (12.4)	444 (10.4)	188 (22.9)	<0.001
Missing	293 (5.7)	225 (5.2)	68 (8.3)	
Work-related stress (JCQ)				<0.001
Low job strain	1633 (32.0)	1472 (34.3)	161 (19.6)	
Moderate job strain	1745 (34.2)	1523 (35.5)	222 (27.0)	
High job strain	217 (4.2)	168 (3.9)	49 (6.0)	
No job	1060 (20.7)	764 (17.8)	296 (36.0)	
Missing	454 (8.9)	360 (8.4)	94 (11.4)	
Poor sleep quality (% High)	609 (11.9)	414 (9.7)	195 (23.7)	<0.001
Missing	365 (7.1)	269 (6.3)	96 (11.7)	
Unwanted pregnancy (% High)	667 (13.1)	476 (11.1)	191 (23.2)	<0.001
Missing	52 (1.0)	41 (1.0)	11 (1.3)	
Abuse (sexual/physical, % Yes)	75 (1.5%)	42 (1.0)	33 (4.0)	<0.001
Missing	6 (0.1)	3 (0.1)	3 (0.4)	
Lifestyle and health-related factors				
Tobacco use (% Yes)	474 (9.3)	369 (8.6)	105 (12.8)	<0.001
Alcohol use (% Yes)	1544 (30.2)	1355 (31.6)	189 (23.0)	<0.001
Drug use (% Yes)	72 (1.4)	54 (1.3)	18 (2.2)	0.038
Missing	1 (< 0.1)	1 (< 0.1)	0	
BMI				<0.001
Normal	3758 (73.6)	3201 (74.7)	557 (67.8)	
Underweight	235 (4.6)	201 (4.7)	34 (4.1)	
Overweight	774 (15.1)	622 (14.5)	152 (18.5)	
Obese	299 (5.9)	229 (5.3)	70 (8.5)	
Missing	43 (0.8)	34 (0.8)	9 (1.1)	
Obstetric and perinatal factors				
History of spontaneous abortion (% Yes)	1014 (19.8)	842 (19.6)	172 (20.9)	0.398
History of induced abortion (% Yes)	841 (16.5)	674 (15.7)	167 (20.3)	0.001
Multiparity (% Yes)	2146 (42.0)	1718 (40.1)	428 (52.1)	<0.001
Gestational hypertensive disorders				0.050
Pregnancy-induced hypertension (% Yes)	544 (10.6)	474 (11.1)	70 (8.5)	
Pre-eclampsia (% Yes)	217 (4.2)	175 (4.1)	42 (5.1)	
Missing	304 (6.0)	252 (5.9)	52 (6.3)	
Gestational diabetes (% Yes)	65 (1.3)	51 (1.2)	14 (1.7)	0.229
Caesarean section (% Yes)	686 (13.4)	561 (13.1)	125 (15.2)	0.086
Missing	308 (6.0)	254 (5.9)	54 (6.6)	
Induced labor (% Yes)	797 (15.6)	666 (15.5)	131 (15.9)	0.576
Missing	629 (12.3)	514 (12.0)	115 (14.0)	
Postpartum hemorrhage (% Yes)	199 (3.9)	170 (4.0)	29 (3.5)	0.557
Missing	777 (15.2)	651 (15.2)	126 (15.3)	
Episiotomy (% Yes)	469 (9.2)	423 (9.9)	46 (5.6)	<0.001
Missing	971 (19.0)	825 (19.2)	146 (17.8)	
Caregiver				0.782
Midwife-led care	2067 (40.5)	1739 (40.6)	328 (39.9)	
Midwife-to obstetrician-led care during pregnancy	836 (16.4)	696 (16.2)	140 (17.0)	

Table 1 (*continued*)

	Postpartum depressive symptoms (CES-D)			*p*-Value
	Total study population	% Low/moderate	% High	
	$N = 5109$ (%)[a]	$n = 4287$ (83.9%)	$n = 822$ (16.1%)	
Midwife-to obstetrician-led care during labor	1079 (21.1)	909 (21.2)	170 (20.7)	
Obstetrician-led care	205 (4.0)	166 (3.9)	39 (4.7)	
Midwife-to obstetrician-led care, timing unknown	356 (7.0)	297 (6.9)	59 (7.2)	
Missing	566 (11.1)	480 (11.2)	86 (10.5)	
Infant's sex (% male)	2558 (50.1)	2136 (49.8)	422 (51.3)	0.397
Missing	4 (0.1)	2 (<0.1)	2 (0.2)	
Prematurity (% Yes)	240 (4.7)	190 (4.4)	50 (6.1)	0.038
Missing	11 (0.2)	6 (0.1)	5 (0.6)	
Small for gestational age < P10 (% Yes)	423 (8.3)	347 (8.1)	76 (9.2)	0.257
Missing	31 (0.6)	23 (0.5)	8 (1.0)	
APGAR <7 at 5 min (% Yes)	58 (1.1)	50 (1.2)	8 (1.0)	0.629
Missing	379 (7.4)	319 (7.4)	60 (7.3)	
Hospital admission baby >24 h (% Yes)	1286 (25.2)	1057 (24.7)	229 (27.9)	0.051
Missing	27 (0.5)	22 (0.5)	5 (0.6)	
Congenital abnormality (% Yes)	145 (2.8)	106 (2.5)	39 (4.7)	<0.001
Missing	10 (0.2)	7 (0.2)	3 (0.4)	
Breastfeeding duration				0.026
Did not	875 (17.1)	714 (16.7)	161 (19.6)	
< 2.9 months	1144 (22.4)	944 (22.0)	200 (24.3)	
3–5.9 months	1558 (30.5)	1334 (31.1)	224 (27.3)	
≥ 6 months	1520 (29.8)	1288 (30.0)	232 (28.2)	
Missing	12 (0.2)	7 (0.2)	5 (0.6)	

Note. CES-D (*Center for Epidemiologic Studies Depression*), STAI (*State And Trait Anxiety*), PRAQ (*Pregnancy Related Anxiety Questionnaire*), JCQ (*Job Content Questionnaire*), BMI = Body Mass Index, APGAR = appearance, pulse, grimace, activity and respiration, SD = standard deviation.

[a] Some data were missing. If applicable, missing values per factor and group are presented.

the respective variables were entered simultaneously, and only those determinants that showed a significant association with postpartum depression at that step were kept during the subsequent steps. The reported pooled adjusted ORs (AORs) are those corresponding to the final risk model. Based on the hierarchical regression analyses, we also calculated the explained proportion of variance of the models using Nagelkerke's R^2, goodness-of-fit statistics using the Hosmer & Lemeshow test as well as the receiver operating characteristic (ROC) curve providing the Area Under the Curve (AUC) indicating predictive accuracy of the final model. Finally, as previous research suggests ethnic differences in mental health outcomes [86,87], we tested whether ethnicity influenced our results by conducting a sensitivity analysis by rerunning the hierarchical logistic regression analyses among the included Dutch women only. This sensitivity analysis was based on the same imputed dataset used for our main analyses.

All analyses were conducted using SPSS, version 25.0 for Windows (SPSS Inc. Chicago, IL, USA). *p*-Values < 0.05 were considered statistically significant.

2.6. Non-response analysis

For the non-response analysis, we compared non-responders (women reporting data on antepartum psychosocial data including CES-D antepartum but not postpartum) with women who also completed the CES-D postpartum. Compared to responders, non-responders ($n = 3021$) were more likely to be of other-Western ethnicity (53.7% v. 21.4%, $\chi^2(2) = 937$, $p < 0.001$), low educated (43.8% v. 21.2%, $\chi^2(2) = 574$, $p < 0.001$), to have more antepartum anxiety symptoms (STAI m = 40.8 SD 10.4 v. m = 37.0 SD 9.96, $t(8,102) = 16.2$, $p < 0.001$), and more antepartum depressive symptoms (CES-D m = 14.3 SD 9.11 v. m = 11.8 SD 8.18, $t(8,128) = 13.3$, $p < 0.001$). Non-responders were also more likely to be multiparous (47.9% v. 41.9%, $\chi^2(1) = 28.2$, $p < 0.001$), and to have given birth to a small-for-gestational age neonate (12.6% v. 8.3%, $\chi^2(1) = 36.5$, $p < 0.001$), while being less likely to have undergone a caesarean section (11.9% v. 14.3%, $\chi^2(1) = 7.01$, $p = 0.008$) than responders.

3. Results

3.1. Participant characteristics

Participant characteristics are described in Table 1. Of the 5109 participating women included in this study, the mean age was 31.5 (SD 4.1) years, and the majority of women (58%) was primiparous. Most women (63.9%) were of Dutch ethnicity, 14.3% of other-Western and 21.7% of non-Western ethnicity. Of all women, 47.0% were high educated, 31.1% had a medium level of education, and 21.7% were low educated. At 3 months after birth, the prevalence of postpartum depression was 16.1% ($n = 822$).

3.2. Univariable associations with postpartum depression

Table 2 shows the results of the univariable analyses examining the association of sociodemographic, psychosocial, lifestyle and health-related, and perinatal and obstetric factors with postpartum depression (ORs and respective 95% CIs). Women with postpartum depression were more often younger than 26 years, of other-Western and non-Western ethnicity, low educated, and not living with a partner or single than women with low levels of postpartum depressive symptoms. In the univariable analyses, all psychosocial factors and lifestyle and health-related factors were associated with a higher risk of postpartum depression. Reported antepartum depressive symptoms, pregnancy-specific anxiety, state anxiety, high work-related stress, poor sleep quality, unwanted pregnancy, and abuse during pregnancy were associated with a higher likelihood of postpartum depression, as were antepartum tobacco use, drug use, and high pre-pregnancy BMI. Alcohol use during pregnancy was related to a lower risk of postpartum depression. Regarding obstetric and perinatal factors, women with postpartum depression were more likely to have an induced abortion in history, to have given birth prematurely, to have a child with a congenital abnormality and less likely to breastfeed their children. Episiotomy during birth was associated with a lower likelihood of postpartum depression.

Table 2
Univariable regression results and final hierarchical logistic regression model of risk factors independently associated with postpartum depression.

	Crude odds ratio[a] (95% CI)	*p*-Value	Adjusted odds ratio[b] (95% CI) in final model	*p*-Value
Sociodemographic factors				
Maternal age				
< 26 years	1.92 (1.55–2.39)	**<0.001**		
26–30 years	1.10 (0.90–1.33)	0.350		
31–35 years	Reference			
≥ 36 years	1.16 (0.94–1.42)	0.173		
Ethnicity				
Dutch	Reference		Reference	
Other-Western	1.80 (1.45–2.23)	**<0.001**	1.62 (1.23–2.12)	**0.001**
Non-Western	3.10 (2.62–3.67)	**<0.001**	1.49 (1.14–1.94)	**0.004**
Education				
High	Reference		Reference	
Medium	1.52 (1.27–1.82)	**<0.001**	1.06 (0.84–1.34)	0.623
Low	2.33 (1.94–2.81)	**<0.001**	0.88 (0.66–1.17)	0.367
Marital status				
Living together with spouse/partner	Reference			
Not living together	1.53 (1.20–1.95)	**0.001**		
Single	1.98 (1.29–3.06)	**0.002**		
Psychosocial factors				
Antepartum depressive symptoms (CES-D)	7.47 (6.36–8.79)	**<0.001**	3.86 (3.02–4.92)	**<0.001**
State anxiety (STAI)	6.46 (5.41–7.72)	**<0.001**	1.73 (1.32–2.26)	**<0.001**
Pregnancy-specific anxiety (PRAQ)	2.62 (2.16–3.19)	**<0.001**	1.76 (1.35–2.29)	**<0.001**
Work-related stress (JCQ)				
Low job strain	Reference		Reference	
Moderate job strain	1.32 (1.07–1.62)	**0.010**	1.18 (0.91–1.53)	0.222
High job strain	2.53 (1.76–3.62)	**<0.001**	1.81 (0.98–2.49)	0.061
No job	3.43 (2.77–4.24)	**<0.001**	1.55 (1.32–2.47)	**<0.001**
Poor sleep quality	3.05 (2.48–3.75)	**<0.001**	1.49 (1.15–1.93)	**0.003**
Unwanted pregnancy	2.45 (2.02–2.97)	**<0.001**	1.42 (1.09–1.85)	**0.009**
Abuse (sexual/physical)	4.24 (2.67–6.73)	**<0.001**	1.95 (1.02–3.73)	**0.043**
Lifestyle and health-related factors				
Tobacco use	1.56 (1.24–1.98)	**<0.001**		
Alcohol use	0.71 (0.59–0.86)	**<0.001**		
Drug use	1.76 (1.02–3.01)	**0.041**		
BMI				
Normal	Reference			
Underweight	0.98 (0.67–1.43)	0.913		
Overweight	1.41 (1.16–1.71)	**0.001**		
Obese	1.75 (1.32–2.33)	**<0.001**		
Obstetric and perinatal factors				
History of spontaneous abortion	1.08 (0.90–1.30)	0.398		
History of induced abortion	1.37 (1.13–1.65)	0**.001**		
Multiparity	1.62 (1.40–1.89)	**<0.001**	1.58 (1.27–1.97)	**<0.001**
Gestational hypertensive disorders				
Pregnancy-induced hypertension	0.78 (0.61–1.01)	0.060		
Pre-eclampsia	1.24 (0.89–1.75)	0.210		
Gestational diabetes	1.44 (0.79–2.61)	**0**.231		
Induced labor	1.00 (0.82–1.22)	0.989		
Caesarean section	0.83 (0.67–1.03)	0.092		
Postpartum hemorrhage	0.94 (0.63–1.40)	0.754		
Episiotomy	0.62 (0.46–0.82)	**0.001**		
Caregiver				
Midwife-led care	Reference			
Midwife-to obstetrician-led care during pregnancy	1.04 (0.84–1.29)	0.700		
Midwife-to obstetrician-led care during labor	0.99 (0.81–1.21)	0.953		
Obstetrician-led care	1.24 (0.84–1.83)	0.283		
Midwife-to obstetrician-led care, timing unknown	1.07 (0.80–1.45)	0.644		
Infant's sex (male)	0.94 (0.81–1.09)	0.407		
Prematurity	1.42 (1.03–1.95)	0**.033**		
Small for gestational age < P10	1.17 (0.90–1.51)	0.251		
APGAR <7 at 5 min	0.96 (0.46–2.00)	0.905		
Hospital admission baby >24 h	1.18 (0.99–1.39)	0.058		
Congenital abnormality	1.96 (1.35–2.85)	**<0.001**	2.33 (1.46–3.73)	**<0.001**
Breastfeeding duration				
Did not	1.26 (1.01–1.57)	0**.039**		
< 3 months	1.18 (0.96–1.45)	0.123		
3–6 months	0.93 (0.76–1.14)	0.484		
≥ 6 months	Reference			

Note. Values are odds ratios and estimate the risk of having postpartum depression for the factors indicated in the first column.
Bold text indicates statistically significant associations (p > 0.05).
[a] Univariable analyses.
[b] Adjusted for all variables included in the final model.

3.3. Independent risk factors of postpartum depression

Results of the final multivariable hierarchical regression model are presented in Table 2. Other-Western (AOR 1.62, 95% CI 1.23–2.12) and non-Western (AOR 1.49, 95% CI 1.14–1.94) ethnicity were the only sociodemographic factors that remained significantly associated with postpartum depression in the final model, explaining 5.2% of the variance (Nagelkerke R^2). The psychosocial risk factors entered in the second step that remained significant included antepartum depressive symptoms (AOR 3.86, CI 95% 3.02–4.92), pregnancy-specific anxiety (AOR 1.76, CI 95% 1.35–2.29), state anxiety (AOR 1.73, CI 95% 1.32–2.26), unemployment (AOR 1.73, CI 95% 1.32–2.47), poor sleep quality (AOR 1.49, CI 95% 1.15–1.93), unwanted pregnancy (AOR 1.42, CI 95% 1.09–1.85), and abuse during pregnancy (AOR 1.95, CI 95% 1.02–3.73), whereas moderate or high job strain did not contribute significantly to the final model. Adjusted for the sociodemographic factors, psychosocial risk factors explained an additional 17.7% of the variance (changed Nagelkerke R^2). None of the lifestyle and health-related factors entered at the third step were significantly associated with postpartum depression and did not add a significant amount of unique variance. Multiparity (AOR 1.58, 95% CI 1.27–1.97) and having a child with a congenital abnormality (AOR 2.33, 95% CI 1.46–3.73) were the only obstetric and perinatal risk factors that remained significant in the final model. Obstetric and perinatal risk factors explained an additional 1.6% of the variance (changed Nagelkerke R^2). According to the benchmarks by Cohen [88], the final model explained a moderate amount of total variance of 24.5% (Nagelkerke R^2). The Hosmer & Lemeshow test showed a good fit of the final model ($\chi 2(8) = 28.2$, $p = 0.741$). The receiver operating characteristic (ROC) curve using all factors of the final model to predict postpartum depression had an area under the curve of 0.78 (95% CI 0.76–0.80, $p < 0.001$), indicating fair accuracy. See Fig. 1 for the ROC curve.

3.4. Sensitivity analysis

When the hierarchical regression analysis was rerun including Dutch women only, a similar overall pattern of results was obtained, with the exception of antepartum state anxiety, unwanted pregnancy and abuse no longer being associated with a higher risk of postpartum depression, while preterm birth (OR 1.90, CI 95% 1.06–3.41) contributed significantly to the final model. In the Dutch subgroup, the final model explained 19.3% (Nagelkerke R^2) of the variance and the ROC curve had an AUC of 0.76 (95% CI 0.73–0.79, $p < 0.001$), again indicating fair accuracy.

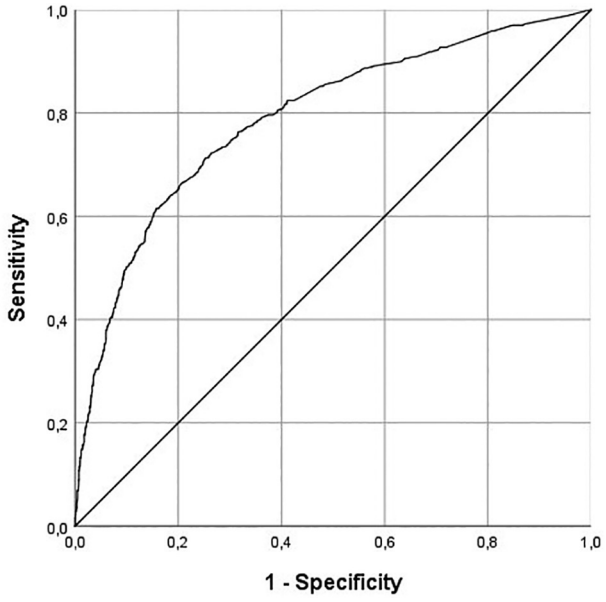

Fig. 1. ROC curve for sociodemographic, antepartum psychosocial, and obstetric and perinatal determinants of postpartum depression (the area under the curve was 0.78 (95% CI 0.76–0.80, $p < 0.001$).

4. Discussion

The present large-scale multi-ethnic population-based prospective cohort study demonstrated that other-Western and non-Western ethnic background, increased antepartum depressive symptoms, state anxiety as well as pregnancy-specific anxiety, poor sleep, unwanted pregnancy, experiencing abuse during pregnancy, multiparity, and being a mother of a child with a congenital abnormality were independent risk factors of postpartum depression. The strongest determinants were high antepartum depressive symptoms, abuse during pregnancy and being a mother of a child with a congenital abnormality. The final multifactorial risk model accounted for a moderate amount of the variance in postpartum depression.

Our study is one of the few studies taking into account a large number of risk factors for postpartum depression from various categories, including obstetric and perinatal risk factors. In contrast to the results of previous population-based studies [2,23,33], which identified several obstetric and perinatal complications as independent determinants of postpartum depression, we observed that only multiparity and being a mother of a child with a congenital abnormality were independent risk factors for postpartum depression. Our results concur with previous meta-analyses demonstrating that, overall, obstetric and perinatal complications contribute significantly but only weakly to the risk of postpartum depression [3,24]. However, findings regarding the contribution of specific obstetric and perinatal risk factors are inconclusive. Also, prior studies investigating the link between obstetric and perinatal risk factors and postpartum depression considered, in contrast to the present study, only a limited number of psychosocial risk factors, even though these factors are known to contribute largely to the risk of developing postpartum depression (e.g., [2,23,33].

Interestingly, although all sociodemographic factors were univariably associated with postpartum depression, only ethnicity remained in the final model. In line with a previous Dutch cohort study, other-Western and non-Western ethnicity independently predicted postpartum depression [2]. Sociodemographic factors are known to elicit inequalities in both antepartum mental health as well as in perinatal health [87,89–91]. Our findings suggest that, with the exception of ethnicity, most of the relations between sociodemographic factors and the risk of postpartum depression are explained by the included antepartum mental and perinatal factors. Antepartum mental and perinatal factors may explain these associations via two processes. The stress theory postulates that individuals with higher socio-economic levels are better equipped with personal resources, e.g., adaptive coping or resilience, which protect against developing depression [92,93]. Moreover, non-Western ethnicity is particularly associated with postpartum depression possibly due to ethnicity-related inequalities in healthcare utilization as suggested by previous research in the Netherlands [86,94]. Relatedly, our analyses among the subsample of women with Dutch ethnicity generally revealed a similar pattern of risk factors with preterm birth independently contributing to the final model, while mental health factors, including antepartum state anxiety, unwanted pregnancy, and abuse, were no longer associated with postpartum depression.

It is striking that all antepartum psychosocial factors except work-related stress were shown to be independently related to postpartum depression in the complete sample, albeit measured early in pregnancy. Increased antepartum depressive symptoms were the strongest risk factor, increasing the risk of postpartum depression nearly four times. The experience of sexual and/or physical abuse during pregnancy was the third strongest risk factor and almost doubled the risk of postpartum

depression. These findings are in line with prior research, demonstrating that antepartum depression and abuse strongly predict postpartum depression [1,20,24]. Next to antepartum general anxiety, pregnancy-specific anxiety was also independently associated with postpartum depression, supporting the notion of the distinctiveness of pregnancy-specific anxiety, as previously depicted by Huizink, Mulder [28]. To the best of our knowledge, to date only the small-scale study (n ⟨300⟩ by Hain, Oddo-Sommerfeld [27] has investigated the specific contribution of pregnancy-specific anxiety to postpartum depression, indicating that, in agreement with the findings based on our large-scale population-based study, it is indeed an independent risk factor.

Further, in line with evidence from previous studies, lifestyle and health-related factors were univariably associated with a higher risk of postpartum depression, with the exception of alcohol use [95,96]. Alcohol use during pregnancy was associated with a lower risk of postpartum depression. This finding has been reported in a previous study [97] and it might be explained by the effect of sociodemographic factors, as earlier research has shown that higher educated, employed pregnant women are more likely to consume alcohol and to reduce rather than quit alcohol consumption during pregnancy [98,99]. Accordingly, we found in additional analyses that high educated women reported more prenatal alcohol use compared to medium or low educated women. However, in our final model none of the lifestyle and health-related factors were found to be independent determinants of postpartum depression. A possible explanation for this might be that poor health behaviors are correlates of psychological distress by means of inadequate coping behaviors and thus are overshadowed in the final model by the psychosocial risk factors [100].

Regarding the studied obstetric and perinatal factors, only multiparity and being the mother of a child with a congenital abnormality were independent risk factors of postpartum depression. It has previously been hypothesized that the impact of obstetric and perinatal complications on maternal mood might act via neuroimmunological mechanisms along with hormonal alterations (e.g., gestational diabetes or hypertension) [33,101–103] as well as via psychological stress eliciting effects (e.g., caesarean section) [7]. Being a mother of a child with a congenital abnormality was the second strongest risk factor increasing the risk of postpartum depression two and a half times. Parents of children with a congenital abnormality experience more distress, hopelessness, guilt for not giving birth to a healthy child, and a higher burden of care [104], which emphasizes that having a child with a congenital abnormality can be considered as a serious psychological stressor. The role of parity as risk factor was still unclear [1]. Our finding that multiparity independently predicted postpartum depression, might be explained by less rest and increased distress a mother possibly experiences when balancing between caring for the newborn and an older child or children [105].

We acknowledge several limitations of this study. First, we lacked information about perceived social support and the quality of the partner relationship or information about family functioning. Nevertheless, compared to previous birth cohorts [2,23], the present study measured a large number of various antepartum psychosocial factors. Further, we did not assess maternal history of depression and depression in the family, which are both strong risk factors for postpartum depression [1,20,24]. Furthermore, we assessed postpartum depression using the CES–D, a validated self-report questionnaire of general depressive symptoms, which has not specifically been designed to measure symptoms uniquely characterizing postpartum depressive symptoms, e.g., worry, like the well-known EPDS [106]. Yet, the CES-D has been shown to be strongly correlated with the EPDS [61,62] and to be a valid and reliable measure of depressive symptomatology during the antepartum and postpartum period [6,60,63]. As postpartum depressive symptoms in the present study were assessed at 3 months postpartum, women with less severe symptoms developed early during the postpartum period might have been missed. Furthermore, by using self-report questionnaires we were not able to discriminate between high risk of postpartum depression and a depressive episode as part of bipolar affective disorder, for which risk factors as well as treatment approaches might differ [107–109]. Future studies should consider using diagnostic interviews to discriminate further between postpartum depression and possible comorbid psychiatric disorders such as anxiety or bipolar affective disorder. Moreover, despite the large size of our sample, the prevalence of some obstetric and perinatal factors was rather low, which might have hampered statistical power. Finally, compared to non-responders we observed that participants were higher educated, less often had a non-Western ethnicity, were less anxious and depressed, and less often gave birth to a small-for-gestational age neonate, suggesting a better health status among the study participants. Therefore, we cannot completely rule out whether selection bias affected our results. This may have led to an underestimation of the associations between the various risk factors and postpartum depression, but not to spurious associations. A large longitudinal study on selective non-response demonstrated that the incidence and prevalence of mental disorders are indeed likely to be underestimated due to selection bias [110]. However, selective drop-out did not invalidate the prediction of the outcome [110]. Despite the large number of potential risk factors in our study, only a moderate part of the variance in postpartum depression was accounted for by the full risk model. This suggests that still some methodological and/or theoretical lacunae regarding postpartum depression prediction should be considered in the future. To yield a total picture, we recommend future research to include, next to detailed assessments of social support and history of depression, biological factors such as cortisol, oxytocin, thyroid function, and inflammatory markers [18,22].

Notwithstanding, our findings were derived from a large-scale population-based and multi-ethnic prospective birth cohort. Our aim was to identify a multidimensional set of determinants of postpartum depression as well as to investigate the unique contribution of several obstetric and perinatal factors and pregnancy-specific anxiety to the risk of developing postpartum depression. For this, we investigated a considerable amount of risk factors of different categories. Our study is one of the first to show that pregnancy-specific anxiety is a distinct risk factor for postpartum depression. Further, based on our results, we conclude that alongside ethnicity, particularly antepartum psychosocial factors, like abuse and antepartum depressive symptoms, play a significant role in determining the risk for postpartum depression while obstetric and perinatal factors only seem to weakly contribute to the risk of developing postpartum depression. One might even speculate that the two identified obstetric and perinatal factors may have a considerable psychological component, acting as additional psychological stressors.

Given the high prevalence of postpartum depression and the adverse consequences not only for the woman, but also for her child and family, we suggest the development and use of early screening tools for the timely detection of women at risk for postpartum depression. Previously, the EPDS has been advised as a screening instrument for peripartum depression [111]. However, a large Dutch population-based study found that the EPDS did not predict postpartum depression with sufficient accuracy when administered antepartum [112]. Hence, it might be more beneficial to screen in a multidimensional manner [15], as recently recommend by the US Preventive Services Task Force [16]. Due to the moderate amount of variance explained by the final model, future research should focus on integrating the risk factors identified in the current study with other established risk factors (e.g. (family) history of depression) to optimize the development and predictive accuracy of future early multidimensional screening tools. One should also explore whether the predictive accuracy of such tools might benefit from the addition of peripartum neurobiological and neuroendocrine factors [18]. Early and accurate identification is crucial to be able to subsequently offer preventative interventions to decrease the impact of risk factors and increase maternal resilience and psychological wellbeing.

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Declaration of competing interest

None declared.

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