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Investigating the association between neuroticism and adverse obstetric and neonatal outcomes

Cathrine Axfors[1,3], Patricia Eckerdal[2,3*], Helena Volgsten[2], Anna-Karin Wikström[2], Lisa Ekselius[1], Mia Ramklint[1], Inger Sundström Poromaa[2] & Alkistis Skalkidou[2]

Neuroticism is not only associated with affective disorders but also with certain somatic health problems. However, studies assessing whether neuroticism is associated with adverse obstetric or neonatal outcomes are scarce. This observational study comprises first-time mothers (n = 1969) with singleton pregnancies from several cohorts based in Uppsala, Sweden. To assess neuroticism-related personality, the Swedish universities Scales of Personality was used. Swedish national health registers were used to extract outcomes and confounders. In logistic regression models, odds ratios (ORs) with 95% confidence intervals (CIs) were calculated for the outcomes by an increase of 63 units of neuroticism (equalling the interquartile range). Analyses were adjusted for maternal age, educational level, height, body mass index, year of delivery, smoking during pregnancy, involuntary childlessness, and psychiatric morbidity. Main outcomes were mode of delivery, gestational diabetes mellitus, gestational hypertension, preeclampsia, induction of delivery, prolonged delivery, severe lacerations, placental retention, postpartum haemorrhage, premature birth, infant born small or large for gestational age, and Apgar score. Neuroticism was not independently associated with adverse obstetric or neonatal outcomes besides gestational diabetes. For future studies, models examining sub-components of neuroticism or pregnancy-specific anxiety are encouraged.

One of the most studied personality domains is neuroticism, and high levels are more common in women than in men[1]. Individuals with high scores of neuroticism typically describe themselves as anxious, vulnerable to stress, lacking self-confidence, and easily frustrated[2]. Neuroticism is associated with negative wellbeing[3] and greater perceived need for health care[4]. Furthermore, neuroticism predisposes for major depression and anxiety disorders[5–8]. Studies report that individuals with high neuroticism experience more stressful life events than those with low neuroticism[9] and are more sensitive to the depressogenic effects of adversity[10]. In addition to the well-studied relationship with mental disorders, neuroticism has been associated with certain somatic health problems and mortality[11–17]. Patients high in neuroticism more often express somatic complaints without medical explanation[18,19] and report lower quality of life[20].

During pregnancy and after childbirth, women with high neuroticism report higher pregnancy-related anxiety[21], fear of vaginal delivery[22], a more negative birth experience[23], and a larger number of depressive symptoms[24]. Yet, studies exploring the role of neuroticism in obstetric and neonatal complications are limited. A few reports suggest that high neuroticism or corresponding measures are associated with negative outcomes such as preterm delivery contractions[25], preterm birth[26], foetal growth restriction[27], and foetal distress[22,23]. One study found associations between neuroticism and epidural analgesia, prolonged delivery, severe birth canal tears, assisted vaginal delivery, and emergency caesarean section[23]. Nevertheless, results are inconsistent, with some investigations reporting no associations with preterm birth or low birthweight[28,29].

Potential mediators may be considered for the association between neuroticism and obstetric and neonatal complications. First, high levels of stress during delivery are associated with prolonged delivery[30], which may predispose for instrumental vaginal delivery, emergency caesarean section, postpartum haemorrhage, and low neonatal Apgar scores, a method to quickly summarize the health of a newborn[31]. Second, pregnant women reporting high neuroticism less often quit smoking[32], and smoking increases the risk of several obstetric and neonatal complications (e.g., preterm delivery and low birthweight)[33]. Third, while obesity and the metabolic syndrome

[1]Department of Neuroscience, Psychiatry, Uppsala University, Uppsala, Sweden. [2]Department for Women's and Children's Health, Uppsala University, Uppsala, Sweden. [3]These authors contributed equally: Cathrine Axfors and Patricia Eckerdal. *email: patricia.eckerdal@kbh.uu.se

are overrepresented in individuals with high neuroticism[16,34], maternal obesity conveys a heightened risk of gestational diabetes mellitus (GDM), preeclampsia, instrumental vaginal delivery, caesarean section, and certain foetal outcomes (e.g., large for gestational age (LGA), foetal distress, and intrauterine foetal death (IUFD))[35]. Furthermore, cardiovascular disease is associated with neuroticism[15,17], possibly extending to placenta-related disorders (e.g., gestational hypertension, preeclampsia, and placental abruption), and foetal outcomes (e.g., spontaneous premature birth and small for gestational age (SGA)). Lastly, antenatal depression, which is associated with adverse neonatal outcomes, e.g., GDM, caesarean section, preeclampsia, premature birth, and SGA[36–38], might also act as a mediator.

The present study aimed to assess whether neuroticism is associated with adverse obstetric or neonatal outcomes.

Results

Descriptive statistics. Delivery started spontaneously for 77.7% of the women and ended with non-instrumental vaginal delivery for 71.3%. Other descriptive statistics are presented in Table 1.

Main results. Young age, lower educational level, underweight, overweight, smoking during pregnancy, and psychiatric morbidity were crudely associated with neuroticism (Table 2). In the logistic regression models (Table 3) a significant crude association was found between neuroticism and GDM. Women with higher neuroticism scores (by 63 units, corresponding to the IQR) had 2.5 times higher odds of GDM. After adjustment for maternal characteristics, the OR was estimated at 3.6. After considering even psychiatric morbidity, the association was not significant in the unimputed dataset; however, it was statistically significant in the dataset with imputed missing data (see below). In addition, crude associations were present with vacuum extraction and placental retention but not after adjustment for maternal characteristics. No associations with neuroticism were found on the other study outcomes.

Results were equivalent after the exclusion of non-applicable cases for certain outcomes (Table S1). Imputation of missing values for BMI, maternal height, and smoking during pregnancy yielded similar results as the non-imputed models, except that the association between neuroticism and GDM remained significant after adjustment for psychiatric morbidity.

Discussion

Despite research linking neuroticism with diverse negative health conditions, our study in general found no associations between neuroticism and a range of obstetric or neonatal outcomes in first-time mothers with singleton pregnancies, besides a positive association between neuroticism and GDM.

Thus far, this is the largest study on neuroticism and obstetric and neonatal complications. Yet, a limitation of the study pertains to the fact that some outcomes, including GDM, are rare and the number of observations is often very small; these would preferably be examined in even larger settings or using another study design. We used a combination of self-report personality measures and national register data on complication rates, which avoids the potential mono-method and recall bias that could occur when complications are self-reported. Nonetheless, some diagnoses may be falsely reported.

Although the gathering of personality data across different study populations and settings possibly led to a varied sample, with women of different ages and life situations, and even though the personality scores do not seem to deviate from previously reported Swedish norms[39], we cannot ascertain their representability of pregnant women at the time.

Even though the applied instrument for personality holds a moderate concordance with the Big Five counterpart[40], there may be differences. The SSP-neuroticism includes the aspects of "lack of assertiveness", "embitterment", and "mistrust", which might possibly be conceptualized as belonging to the personality domain (non-) agreeableness in the Big Five.

Furthermore, women born outside Sweden were underrepresented in that their first childbirth was more likely not to be recorded in Swedish national registers. We cannot exclude the possibility that associations between neuroticism and adverse obstetric or neonatal outcomes may be present among less socioeconomically advantaged women.

In this study maternal factors (younger age, lower education, underweight and overweight, smoking, and psychiatric morbidity) were associated with neuroticism in accordance with earlier studies[16,23,32,34,41]. However, for obstetric and neonatal outcomes, no robust associations were seen. Some of our results contradict a study by Johnston and colleagues[23], which shows associations with self-reported emergency caesarean section, failure to progress, foetal distress, and episiotomy or severe birth canal tears. However, basing the complication rates on medical health registers, such as in our study, has an advantage over self-report rates because the latter may introduce recall bias. A German study demonstrates that only childbirth-specific anxiety, not general anxiety, is associated with longer delivery duration[42]. Although neuroticism is not equivalent to general anxiety, these concepts share the feature of non-specified distress. It has been argued that pregnancy-specific anxiety is an entity of its own and more strongly predicts adverse obstetric and neonatal outcomes[43], a claim which is consistent with the present findings. In our study women with high neuroticism did not give birth more often via caesarean section (neither by elective nor by emergency caesarean section). Yet, in line with national recommendations promoting a vaginal delivery for pregnant women without specific maternal or foetal indications, the caesarean section rates are lower in Sweden compared with other European countries[44]. Possibly, caesarean section on maternal request in women with high neuroticism might be more common in countries with higher rates of caesarean section.

Neither preterm birth nor SGA infant birth were more common in women with high neuroticism. Whereas the associations between antenatal depression and preterm birth and SGA are well-established[36], results are mixed regarding associations with maternal anxiety. In a large population-based Norwegian cohort study Vollrath *et al.*[26]

Variable	N (%), or mean [SD] mdn	Missing
Neuroticism score	294.9 [45.1] 292.0	0
Maternal age (year)		0
14–24	633 (32.1)	
25–30	712 (36.2)	
31–43	624 (31.7)	
No college or university education	713 (36.3)	3
Maternal height (cm)		109
143–164	649 (34.9)	
165–169	577 (31.0)	
170–186	634 (34.1)	
BMI at first antenatal care visit (kg/m^2)		244
<18.5	42 (2.4)	
18.5–25.0	1168 (67.7)	
>25.0	515 (29.9)	
Year of delivery		0
1984–1996	156 (7.9)	
1997–2012	1813 (92.1)	
Smoking at first antenatal care visit or at gestational week 32	169 (9.0)	81
Chronic somatic disease[a]	27 (1.4)	0
Involuntary childlessness[b]	318 (16.2)	0
Psychiatric morbidity[c]	176 (8.9)	0
Vaginal delivery, non-instrumental	1404 (71.3)	0
Vaginal delivery, vacuum extraction	261 (13.3)	0
Any caesarean section	304 (15.4)	0
Elective caesarean section	80 (4.1)	0
Emergency caesarean section	224 (11.4)	0
Deliveries starting with emergency caesarean section	25 (1.2)	0
Gestational diabetes mellitus	10 (0.5)	0
Gestational hypertension or Preeclampsia	115 (5.8)	0
Induction of delivery	334 (17.0)	0
Prolonged delivery[d]	444 (23.8)	0
Severe tears[e]	134 (8.0)	0
Placental retention[e]	56 (3.4)	0
Postpartum haemorrhage	124 (6.3)	0
Premature birth <37 weeks[f]	99 (5.0)	0
Small for gestational age <10th percentile[f]	116 (5.9)	8
Large for gestational age >90th percentile[f]	139 (7.1)	8
Apgar 5 minutes <7	23 (1.2)	0
Composite worst-case variable[g]	47 (2.4)	0

Table 1. Participants descriptive information (n = 1969). Note. Abbreviations: body mass index (BMI), median (mdn), standard deviation (SD). [a]Pre-gestational hypertension, diabetes mellitus or chronic kidney disease. [b]*In vitro* fertilization or self-reported involuntary childlessness >1 year. [c]Mental disorders due to psychoactive substance use', 'affective disorders', 'anxiety, stress-related and somatoform disorders', 'eating disorders', 'personality disorders', 'disturbances of activity and attention', or prescription of antidepressant or anxiolytic drugs during pregnancy. [d]Excluding deliveries starting with emergency caesarean section (n = 25) and elective caesarean section. [e]Excluding any caesarean section. [f]Excluding stillborn (n = 3). [g]Stillborn, eclampsia, severe preeclampsia, premature birth <32 weeks, small for gestational age below minus 2.5 standard deviations (0.6%), placental abruption.

report substantial associations between trait anxiety and late preterm birth. Unlike the present results, no adjustment was made for psychiatric morbidity. Nevertheless, not even in our crude analysis was there any relation between neuroticism and preterm birth. Notably, their four-item trait anxiety measure was used exclusively during pregnancy[26]. In the current study, neuroticism report dates were removed to secure the anonymity of the participants. Therefore, we could not ascertain whether neuroticism was measured before, during, or after pregnancy. On the one hand, personality is relatively consistent in adulthood[45], with a tendency of normative change[46]. However, studies exploring the course of trait anxiety across the peripartum period are few and contradictory, some reporting no differences[47,48] and one reporting increasing levels[49]. Our null findings on preterm birth are supported by two studies[27,29] that measure anxiety-related personality traits during pregnancy; however, one of these[27] notes a relationship with low birthweight. Perhaps a state-dependent component of maternal distress,

Variable	Neuroticism mdn (IQR)	*p*
Age (years)		<0.001
14–24	309 (68)	
25–30	285 (60)	
31–34	287 (60)	
Educational level		<0.001
College or university	283 (58)	
No college or university	305 (66)	
Maternal height (cm)		Ns
143–164	295 (61)	
165–169	292 (61)	
170–186	288 (64)	
BMI at first antenatal care visit (kg/m²)		<0.001
<18.5	311 (51)	
18.5–25.0	289 (59)	
>25.0	297 (68)	
Year of delivery		Ns
1984–1996	287 (58)	
1997–2012	292 (63)	
Smoking at first antenatal care visit or at gestational week 32		<0.001
No	290 (61)	
Yes	308 (82)	
Chronic somatic disease[a]		Ns
No	292 (63)	
Yes	319 (66)	
Involuntary childlessness[b]		Ns
No	291 (63)	
Yes	294 (61)	
Psychiatric morbidity[c]		<0.001
No	289 (62)	
Yes	318 (68)	

Table 2. Potential confounder variables and bivariable associations with neuroticism. Note. Abbreviations: body mass index (BMI), interquartile range (IQR), median (mdn), non-significant (ns). Mann-Whitney *U* test for binary variables; Kruskal-Wallis test for variables with three categories. [a]Pre-gestational hypertension, diabetes mellitus or chronic kidney disease. [b]*In vitro* fertilization or self-reported involuntary childlessness >1 year. [c]'Mental disorders due to psychoactive substance use', 'affective disorders', 'anxiety, stress-related and somatoform disorders', 'eating disorders', 'personality disorders', 'disturbances of activity and attention', or prescription of antidepressant or anxiolytic drugs during pregnancy.

which might better be detected by other measure than personality, may carry more valence for preterm birth and low birthweight. Using psychologists' assessment of distress during pregnancy, Rondó *et al.*[50] find associations with premature birth as well as with low birthweight.

To our knowledge, an association between neuroticism and GDM has not been previously reported. However, in a recent meta-analysis, an association of GDM and postpartum depression is reported[37], and in the Norwegian cohort study on preterm birth[26], a crude association between trait anxiety and GDM is incidentally mentioned. Still, the relation presented in our article was based on a small number of cases (n = 10) and should thus be regarded as preliminary. As a speculation, a possible pathway between neuroticism and GDM might be heightened stress levels and chronic inflammation that induces insulin resistance[51]. Moreover, in our cohort, as well as in others[16,34], there was a positive correlation between neuroticism and obesity. The latter, together with other maternal characteristics and earlier psychiatric morbidity, could act as mediators in the association between neuroticism and GDM.

The prevalence of GDM was slightly lower in our cohort (0.5%) as compared with previous Swedish figures[52]. Some maternal diagnoses may be under-reported in the Medical Birth Register (MBR)[53] from which the data were drawn. Nonetheless, the discrepancy could also be explained by the sample constitution as a low-risk cohort for GDM taking into account educational level and country of birth[52].

Future studies could acknowledge a greater complexity of personality than given by the one domain of neuroticism. On the domain level, there was no association with obstetric or neonatal complications. Studies using sub-components of neuroticism or the combination of neuroticism and pregnancy-specific anxiety measures might advance this field of inquiry still further.

Outcome	Cases	Total	Crude OR (95% CI)	Adj OR (95% CI) Model 1	Adj OR (95% CI) Model 2
Vaginal delivery, non-instrumental	1404	1969	1.09 (0.95–1.26)	1.08 (0.92–1.28)	1.07 (0.91–1.26)
Vaginal delivery, vacuum extraction	261	1969	0.79 (0.65–0.95)	0.82 (0.66–1.01)	0.85 (0.68–1.05)
Any caesarean section	304	1969	1.06 (0.89–1.26)	1.06 (0.87–1.30)	1.05 (0.85–1.28)
Elective caesarean section	80	1969	1.03 (0.76–1.41)	0.97 (0.68–1.39)	0.94 (0.65–1.34)
Emergency caesarean section	224	1969	1.07 (0.88–1.29)	1.09 (0.87–1.38)	1.09 (0.87–1.38)
Gestational diabetes mellitus	10	1969	2.53 (1.20–5.33)	3.57 (1.32–9.65)	2.70 (0.92–7.95)[d]
Gestational hypertension or Preeclampsia	115	1969	1.07 (0.82–1.39)	1.13 (0.85–1.50)	1.12 (0.84–1.50)
Induction of delivery	334	1969	1.04 (0.88–1.23)	1.06 (0.88–1.28)	1.01 (0.84–1.22)
Prolonged delivery	444	1969	0.95 (0.82–1.11)	0.99 (0.84–1.17)	0.99 (0.83–1.17)
Severe tears	134	1969	0.91 (0.71–1.17)	0.88 (0.67–1.17)	0.92 (0.70–1.22)
Placental retention	56	1969	0.66 (0.44–0.99)	0.70 (0.45–1.09)	0.71 (0.46–1.11)
Postpartum haemorrhage	124	1969	0.95 (0.74–1.23)	0.97 (0.73–1.29)	0.94 (0.70–1.26)
Premature birth <37 weeks[a]	99	1966	0.87 (0.65–1.16)	0.95 (0.69–1.33)	0.96 (0.69–1.35)
Small for gestational age <10th percentile[a,b]	116	1958	1.12 (0.87–1.45)	1.15 (0.86–1.54)	1.11 (0.82–1.49)
Large for gestational age >90th percentile[a,b]	139	1958	1.14 (0.90–1.45)	1.07 (0.82–1.41)	1.06 (0.80–1.39)
Apgar 5 minutes <7	23	1969	0.77 (0.42–1.41)	0.92 (0.48–1.77)	0.87 (0.45–1.70)
Composite worst-case variable[c]	47	1969	0.86 (0.57–1.30)	0.86 (0.54–1.38)	0.83 (0.51–1.34)

Table 3. Logistic regression-derived odds ratios (ORs) with 95% confidence intervals (CIs) for obstetric and neonatal outcomes by an increase of 63 units of neuroticism (equaling the interquartile range). Note. Model 1 adjusted (adj) for maternal age at childbirth, educational level, height, body mass index at first health care visit during pregnancy, year of delivery, smoking at first antenatal care visit and/or at gestational week 32. Model 2 also adjusted for psychiatric morbidity. [a]Excluding stillborn (n = 3). [b]According to Swedish sex-specific reference curves. [c]Stillborn, eclampsia, severe preeclampsia, premature birth < 32 weeks, Small for gestational age below −2.5 SD (0.6%), placental abruption. [d]The association was significant in the analyses with imputed missing values.

Conclusion

Neuroticism, while associated with age, education, body mass index (BMI), and psychiatric history, was not an independent risk factor for adverse obstetric or neonatal outcomes, besides an increased risk of GDM. Future studies are needed to replicate this finding and they may choose to even investigate neuroticism sub-components or both neuroticism and pregnancy-specific anxiety.

Methods

Sample. In the years 2005–2011 personality measures were distributed as part of several projects based in Uppsala, Sweden, with female participants. The projects investigated oral contraceptive use (n = 118)[54], infertility (n = 320)[55], induced abortion (n = 1320)[56], premenstrual mood disorder (n = 44)[57], and wellbeing during pregnancy (n = 1017)[24]. More than two-thirds of these women were residing in Uppsala at the time of data collection while the remaining third were recruited from Obstetrics and Gynaecology centres in Umeå, Örebro, Linköping, and Stockholm, or referred to Uppsala from nearby counties.

Of the original cohort of 2819 women, the Swedish personal identity numbers[58] of 2810 with full data on personality measures were used to link information from several Swedish health registers: the Medical Birth Register (MBR)[53] from 1984–2012 concerning participants' first childbirth (previous somatic and psychiatric health, medication at first antenatal booking, information on pregnancy and delivery), the Patient Register[59] from 5 years before childbirth to 1 year after childbirth (diagnoses from hospital admissions and outpatient clinic visits), the Swedish government agency Statistics Sweden (socioeconomic factors), and the Prescribed Drug Register[60] (prescribed antidepressants and anxiolytics during pregnancy). Women who had not given birth or whose first childbirth took place before 1984 or outside Sweden (n = 809) and twin pregnancies (n = 32) were excluded, leaving a final sample of 1969 participants (Fig. 1). Most of the participants had their first childbirth in the later part of the study period (mean year = 2006, SD = 5.3 years, median year = 2008).

Measures and study variables. Neuroticism was self-reported in the Swedish universities Scales of Personality (SSP)[39], a revised version of the Karolinska Scales of Personality, with a reduced number of items and improved psychometric quality. The SSP has a similar factor structure in pregnant women as in the reference population[24], including three personality domains: neuroticism, aggressiveness, and sensation seeking (the latter two were not addressed in this study). The neuroticism domain of the SSP contains 42 statements rated on four-point scale from "not applicable at all" to "applies completely". The items form six scales named after their content: Somatic Trait Anxiety, Psychic Trait Anxiety, Stress Susceptibility, Lack of Assertiveness, Embitterment, and Mistrust. The SSP scores on each scale were transformed into normative T-scores, adjusted for age and gender, based on a representative Swedish non-patient sample[61]. The neuroticism score equals the sum of the T-scores from the six scales constituting this domain (median = 292, IQR = 63, range = 194–474). Internal consistency (Cronbach's α) of the six subscales range from 0.74–0.82[39]. In the present material, the whole 42-statement neuroticism domain had $\alpha = 0.94$.

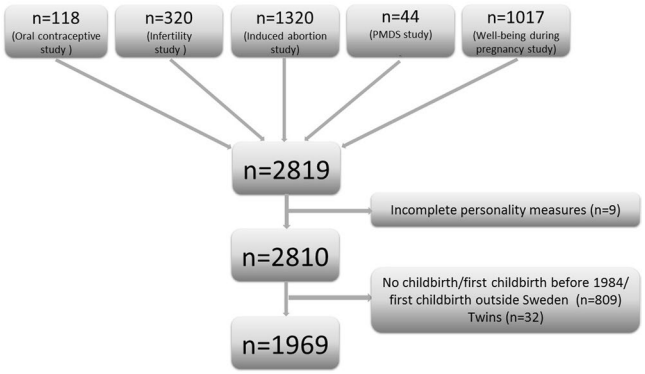

Figure 1. Flowchart of the included studies and participants.

Obstetric and neonatal outcomes were obtained from the MBR, a register that is based on health records from maternal health services and obstetrics and gynaecology centres. Diagnostic codes from International Statistical Classification of Diseases and Related Health Problems (ICD)[62] versions 8–10 were used to categorize the outcomes (Table S2). Additional to diagnostic codes, MBR-specific variables relating to first visit during pregnancy and delivery were also used. Obstetric outcomes included non-instrumental vaginal delivery, vaginal delivery assisted by vacuum extraction (VE; no case of forceps use was reported), any caesarean section, elective caesarean section, emergency caesarean section, GDM, gestational hypertension, preeclampsia, induction of delivery, prolonged delivery, severe tears (tear of the anal sphincter, cervix rupture, or complex vaginal lacerations), placental retention, and postpartum haemorrhage. Neonatal outcomes comprised premature birth (before gestational week $37+0$), SGA (below the 10^{th} percentile, according to the Swedish sex-specific reference curves for gestational age[63]), LGA (above the 90^{th} percentile), and a 5-minute Apgar score below seven. Finally, a composite worst-case variable was created out of IUFD, eclampsia, severe preeclampsia, premature birth before gestational week $32+0$, SGA < -2.5 SD (lowest 0.6%), and placental abruption. Gestational hypertension and preeclampsia were grouped together because of their low frequency and common aetiology.

Information about possible confounders was extracted from Statistics Sweden, the MBR, the Patient Register, and the Prescribed Drug Register. These variables included maternal age at childbirth, educational level, maternal height, BMI at first antenatal care visit, year of delivery, smoking reported at the first antenatal care visit or in gestational week 32, chronic somatic disease (pre-gestational hypertension, diabetes mellitus, or chronic kidney disease), involuntary childlessness ($\geq$1 year or use of *in vitro* fertilization), and psychiatric morbidity. Psychiatric morbidity consisted of ICD codes[62] from hospital admissions and out-patient clinics from 5 years before the delivery to 1 year after delivery for the following: 'mental disorders due to psychoactive substance use', 'affective disorders', 'anxiety, stress-related and somatoform disorders', 'eating disorders', 'personality disorders', 'disturbances of activity and attention', and the prescription of antidepressant or anxiolytic drugs during pregnancy. Maternal age and height were categorized into approximately three equal groups. BMI was classified according to the World Health Organization criteria (underweight $<18.5\,kg/m^2$, normal range $18.5–25\,kg/m^2$, overweight $>25\,kg/m^2$).

Statistical analysis. Logistic regression models were used to explore the association between neuroticism as a continuous exposure and each of the obstetric and neonatal outcomes, which were all binary (two-categorical, coded as 0 or 1). Odds ratios (ORs) for the outcomes with 95% confidence intervals (CIs) were calculated for a 63-unit increase in neuroticism, which equals the interquartile range (IQR). Because the model is linear, this may also be interpreted as the OR comparing women at the 75^{th} and 25^{th} percentiles of neuroticism. Crude and adjusted models were estimated. All variables listed above as possible confounders were applied for adjustment, except for chronic somatic disease because of its low frequency. Since psychiatric disorders may be considered as a potential mediator between personality and outcome, we chose to add the variable psychiatric morbidity only in a second adjusted model. In Table 2, bivariable associations between the possible confounders and neuroticism are exemplified (Mann-Whitney *U* for binary variables, Kruskal-Wallis test for three-categorical variables). In a separate version of the models, missing data were replaced by multiple imputation (regarding the variables with more than a few missing items: BMI, maternal height, and smoking during pregnancy). We did not perform any correction for multiple tests, as we considered the outcomes as distinct and separate, most without bearing on each other.

Additional analyses were made for some of the outcomes, where "non-applicable" cases were excluded in order to test the robustness of the results. In contrast with the main analyses, where the denominator was "all deliveries", the exclusion of non-applicable cases changed the denominator to "vaginal deliveries" for the outcomes VE, severe tears and placental retention (excluded women undergoing elective or emergency caesarean section, as they could not be at risk for e.g. vaginal tears). Regarding emergency caesarean section, the denominator was changed to "deliveries intended as vaginal" (excluded elective caesarean section). Similarly, for induction of delivery and for prolonged delivery, the denominator was changed to "deliveries intended as vaginal" (excluded elective caesarean section as well as those deliveries starting with emergency caesarean section). For elective caesarean section, deliveries starting with emergency caesarean section were excluded since they may have been intended as elective caesarean sections.

Details of ethics approval. All women who gave their written informed consent were told about the course and aim of the individual original studies. The investigation was carried out in accordance with the Declaration of Helsinki and the study protocol was approved by the Regional Research and Ethics Committee of Uppsala (Dnr 2014/092) in June 2014.

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Author contributions

A.S., I.S.P. and L.E. conceived the idea of the study; A.S., H.V. and I.S.P. were responsible for the acquisition of data; C.A. and P.E. performed the data analysis; C.A., P.E., A.W., L.E., M.R., I.S.P., and A.S. contributed substantially with the interpretation of data. C.A. and P.E. drafted the article. All other authors, H.V., A.W., L.E., M.R., I.S.P. and A.S. revised it critically for important intellectual content.

Competing interests

The authors declare no competing interests.

Additional information

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Correspondence and requests for materials should be addressed to P.E.

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