Links between Perinatal Risk Factors and Maternal Psychological Distress: A Network Analysis

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Availability of data and material: The University of London Centre for Longitudinal Studies owns the copyright for the Millennium Cohort Study (MCS) data used in this study. The MCS data are held/curated by the UK Data Service. Anyone wishing to use the MCS data (found at: https://discover.ukdataservice.ac.uk/series/?sn=2000031) must register and submit a data request to the UK Data Service at http://ukdataservice.ac.uk/. Additional terms and conditions of access are outlined here: https://www.ukdataservice.ac.uk/get-data/how-to-access/conditions.

Code availability: The restructuring and merging script is provided on GitHub: https://github.com/Lydia-G-S/Millennium-Cohort-Study-Data-Restructuring-in-R

Authors' contributions: LGS conceptualized and designed the study, conducted analyses, drafted the initial manuscript, and reviewed and revised the manuscript. HAH and AU made substantial contributions to analysis and interpretation of data and critically reviewed the manuscript for important intellectual content. ALM, ML and BA made substantial contributions to the conception and design of the study and critically reviewed the manuscript for important intellectual content. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Abstract

Introduction: This paper explores a range of perinatal risk factors that may increase maternal vulnerability to postnatal psychological distress in a sample of 17531 women participating in the Millennium Cohort Study, a diverse British, longitudinal birth cohort study.

Materials and Methods: Using a graphical network modelling framework, this study models links between postnatal psychological distress and perinatal risk factors while controlling for socio-demographic factors and history of depression and anxiety. Postnatal psychological distress was assessed at nine-months post-partum using the Rutter Malaise Inventory.

Results: Results of the graphical network models indicate that lower levels of happiness about the pregnancy (Edge weight (*w*)=0.084, *CI*=0.069 to 0.100, *b*=0.095), smoking during pregnancy (*w*=0.026, *CI*=-0.009 to 0.060, *b*=0.029), infection during pregnancy (*w*=0.071, *CI*=0.024 to 0.118, *b*=0.090), hyperemesis gravidarum (*w*=0.068, *CI*=0.013 to 0.123, *b*=0.083), baby in special care (*w*=0.048, *CI*=-0.004 to 0.099, *b*=0.062), not being White (*w*=0.101, CI=0.062 to 0.140, b=0.118), being from a more deprived area (*w*=-0.028, *CI*=-0.051 to -0.005, *b*=-0.039), lower income (*w*=-0.025, *CI*=-0.055 to 0.005, *b*=-0.036) and history of depression or anxiety (*w*=0.574, *CI*=0.545 to 0.603, *b*=0.764) are associated with increased psychological distress.

Conclusion: While some perinatal risk factors may be directly associated with postnatal psychological distress, many risk factors appear to be primarily associated with demographic factors. This emphasizes the importance of taking a holistic approach when evaluating an individual's risk of developing postnatal psychological distress.

Keywords: pregnancy; perinatal risk factors; postnatal psychological distress; graphical model; millennium cohort study

Abbreviations:

PD – postnatal psychological distress

MCS – Millennium Cohort Study

RMI – Rutter Malaise Inventory

Key Message: Most perinatal risk factors are primarily associated with demographic factors. History of depression or anxiety seems to be the strongest risk factor for postnatal psychological distress. A holistic approach is needed when evaluating an individual's risk of developing postnatal depression.

1 Introduction

Depressive symptoms are one of the most common health problems for women in the postnatal period, affecting around 10 to 18 percent of women and ranging in severity from 'maternity blues' to a clinical diagnosis of postpartum depression[1,2]. Evidence suggests that postpartum depression may affect not only women's health and wellbeing but also their children's cognitive and behavioral development[3,4]. Previous research has identified a wide array of risk factors for postnatal psychological distress (PD), most focusing on socio-demographic risks and on history of mental health difficulties which have been associated with higher risks of developing postnatal depression[5–8]. However, less attention has been paid to the role of perinatal risk factors in postnatal mental health difficulties with existing studies finding conflicting evidence[9–11]. Further, many analyses used in previous studies were limited in that they focused on the relations between postnatal maternal mental health and one specific focal risk factor, which ignores potential confounding and risk factor relations. Thus, findings on individual risk factors might be misleading and differ when a broader range of additional risk factors are taken into account. An alternative approach to analyzing the effect of perinatal risk factors on PD is an integrated analysis that looks at the relations of all variables at once in the form of a graphical model[12].

This study aims to explore a wide range of perinatal factors that may increase maternal vulnerability to postnatal depression, using data acquired in the Millennium Cohort Study (MCS). In addition to using traditional analysis strategies such as regressions to model the relations between individual risk factors and PD, this study uses a graphical network approach to model the dependencies between all risk factors and thereby provides a more comprehensive understanding of how these risk factors are connected to each other as well as to maternal mental health difficulties. The results of this study extend the postpartum depression literature and contribute to a better understanding of perinatal risk factors that are associated with an increased risk of developing postnatal mental health problems. We further show that network based analysis might be preferable for researchers working in this or similar domains, given its obvious strengths with respect to appropriately accounting for dependence structures in relations among multiple variables while still offering an intuitive visualisation and interpretation.

2 Materials and Methods

2.1 Design and Study Population

The MCS is a longitudinal, nationally representative study of around 19,000 children born in the United Kingdom. To date, there have been seven sweeps of data collection starting in 2001 when the children were around nine-months old (N = 18,553 families). For details, see MCS documentation[13]. The current study included biological mothers who completed the Rutter Malaise Inventory (RMI), a measure of psychological distress, at nine-months postpartum. Mothers with missing data on the RMI (N=765) and mothers of multiples (N=226) were excluded, which resulted in a final sample size of 17531 women.

2.2 Measures

Outcome

Postnatal psychological distress was measured through interviews which took place nine-months post-delivery using a 9-item scale adopted from the Rutter Malaise Inventory (RMI)[14]. For details, please see the online supporting information.

Risk factors

A wide range of potential perinatal risk factors were ascertained nine-months after delivery from maternal self-reports. All available risk factors measured in the MCS were included to allow for a comprehensive analysis. Women were asked whether the pregnancy was planned, whether they had fertility treatment, how they felt when they became pregnant (scale from 1 to 5, 1 indicating very happy, 5 indicating very unhappy), whether they received antenatal care and whether they attended antenatal classes. They further indicated the place of birth (home or hospital), the type of delivery (normal, assisted, planned cesarean, emergency cesarean, other), type of pain medication (none, epidural, gas and air, opiate injection, other) and whether the labour was induced. Women were furthermore asked whether there were any complications during labour (abnormal lie, very long labour, very rapid labour, fetal distress), whether they had any illness during pregnancy (infections (urinary tract infection or other/non-trivial infection), hyperemesis gravidarum, diabetes, preeclampsia, anemia, bleeding in early pregnancy, bleeding in late pregnancy) and whether they smoked during pregnancy. They also indicated the sex of the baby, whether the new-born had to spend time in special care, when the new-born came home (age in days after leaving hospital), and how many weeks they breastfed. In addition, gestational age in days and birth weight in kilo-grams were derived from hospital records at the time of birth. For wording of interview questions on maternal illness during pregnancy, please see the online supporting information.

Covariates

A priori confounders that previous research has shown to be associated with postnatal psychological distress included maternal age, level of education, ethnicity, whether the mother is a single parent, whether the mother is a first time mother, socio-economic status, maternal attachment, and history of depression and anxiety[5–7]. Age, ethnicity (White or other ethnicity), education (equivalent of National Vocational Qualification level 1 or above Yes/No), whether the mother is a single parent, whether they are first time mothers and their history of depression or anxiety ("Has a doctor ever told you that you suffer from depression or serious anxiety?") were all ascertained from maternal self-reports at nine-months post-partum. The index of multiple deprivation (IMD) and weighted OECD equivalised income quintiles were derived as measures of socio-economic status[15].

2.3 Statistical Analyses

To analyze the relations between the individual perinatal risk factors and psychological distress at nine-months post-partum, simple linear regressions were fitted and then extended using multiple linear regressions, accounting for all socio-demographic covariates as well as for history of depression or anxiety. To control for multiple comparisons, significance was accepted at a Bonferroni corrected alpha level of .001. In addition, all regression models were adjusted for the complex survey design of the Millennium Cohort Study based on the recommendations given in the MCS guidelines[16]. To extend the traditional methodological framework, this study proposes the use of Pairwise Markov Random Field (PMRF) models to model the dependencies between risk factors and maternal psychological distress. Two such models were built: one model only included the perinatal risk factors and another model also included sociodemographic factors and history of maternal depression or anxiety. Models were estimated using the R package *mgm*[17]. For details, see the online supporting information.

2.4 Ethical approval

Data used in this study came from sweep one of the Millennium Cohort Study which was approved by the National Health Service Ethical Authority in February 2001 (MREC/01/6/19)[18].

3 Results

3.1 Descriptive Statistics

On average, women were 28.79 (*SD* = 5.86) years old and scored 1.62 (*SD = 1.73*) on the Rutter Malaise Inventory. Characteristics of the study population are presented in Table 1 and Table 2.

[Table 1 about here]

[Table 2 about here]

3.2 Regression Analysis

The univariate analysis showed that the following factors were associated with greater postnatal psychological distress after adjusting for multiple comparisons: unplanned pregnancy, not receiving antenatal care, not attending antenatal classes, lower levels of happiness about the pregnancy, induction of labour, infection during pregnancy, hyperemesis gravidarum, anemia during pregnancy, bleeding in early pregnancy, bleeding in late pregnancy, shorter duration of breastfeeding, baby in special care, smoking during pregnancy, lower birthweight, younger gestational age and baby coming home from hospital later. However, after adjusting for potential confounders, fertility treatment, attending antenatal classes, induction of labour and breastfeeding were no longer associated with PD, whereas abnormal lie, long labour and fetal distress were now associated with PD. Table 3 shows parameter estimates for risk factors that were predictors of PD in the multivariate analysis. For results of the univariate analysis and non-associated risk factors see the online supporting information Table S1.

[Table 3 about here]

3.3 Network Analysis

The first graphical model, which included all risk factors but did not adjust for demographic factors or maternal history of depression or anxiety, is displayed in Figure 1. It shows that lower levels of happiness about the pregnancy, not attending antenatal classes, induction of labour, baby in special care, smoking during pregnancy, infections during pregnancy and hyperemesis gravidarum share edges with maternal psychological distress, however these edges were not particularly strong (see supporting information Table S2). After adding demographic factors and history of depression or anxiety, PD was no longer related to attendance of antenatal classes and induction of labour. PD shared edges with income,

deprivation, maternal ethnicity and history of depression or anxiety with the remaining variables being related to the outcome only indirectly through these variables (Figure 2).

[Figure 1 about here]

[Figure 2 about here]

To quantify the uncertainty associated with these edges, we used 1000 bootstrap samples to compute the 95% confidence intervals (CI) of the bootstrapped sampling distribution (see Table 4 for variables sharing an edge with PD in the adjusted model; for full results see the online supporting information Table S2 and Table S3). In the model including confounders, only the CI's for edges between hyperemesis gravidarum, infections during pregnancy, levels of happiness about the pregnancy, deprivation, maternal ethnicity, history of maternal depression or anxiety did not include zero, suggesting a high probability of these edges representing true relations. However, as we used LASSO regularization to estimate the graphical models, edge weights were already biased towards zero which means that the bootstrapped CI's were not centered on the true parameter value and the test is conservative[19].

[Table 4 about here]

In addition to obtaining edge weights which offer information on the strengths of the relations between nodes (higher values indicate stronger associations between two variables), parameter estimates can be obtained to better understand the direction of relations (Table 4). These estimates can be interpreted as the expected change in standardized PD scores per one standard deviation increase in continuous variables or a change of level for categorical variables, when holding all other variables constant. These parameter estimates showed that having a history of depression or anxiety was associated with the biggest increase in psychological distress levels at nine-months postpartum, followed by not being White, lower levels of happiness about the pregnancy, having an infection during pregnancy, suffering from hyperemesis gravidarum, baby spending time in special care, living in a more deprived area, having lower income and having smoked during pregnancy.

Finally, we estimated node predictability which is visualized in the form of rings around nodes in Figures 1 and 2. Due to its ability to account for dependencies across predictors, the graphical

model offered insights into the accuracy of the model for all variables, showing that maternal education, maternal ethnicity and history of depression or anxiety were particularly well explained by the other variables in the model as is indicated by the high accuracy of the model for these predictors (85.1%, 88.5% and 78.4% respectively). For maternal PD, overall accuracy of the fully adjusted model was 17.1%.

4 Discussion

This study used a graphical network modelling framework to gain unique insights into the relations between maternal psychological distress at nine-months postpartum and multiple perinatal and demographic risk factors as well as history of depression or anxiety. Identified perinatal risk factors for developing PD included: lower levels of happiness about the pregnancy, smoking during pregnancy, having an infection during pregnancy, suffering from hyperemesis gravidarum and having a baby that needs to spend time in special care. Apart from infections during pregnancy, these risk factors have been previously identified to be associated with PD. In line with previous research, our results further emphasize the role of history of depression and anxiety as the strongest risk factor for the development of PD[3].

Several mechanisms might explain our findings. First, women tend to have particular expectations about the perinatal period. When these expectations are not met, for example when a baby requires hospitalization, women might struggle with unforeseen challenges (and may for example, experience feelings of failure) which can lead to the development of depressive symptoms or even post-traumatic stress[20]. This effect would probably be amplified in women who were not initially happy about being pregnant as they have been found to be more likely to struggle bonding with their child, which has been shown to mediate the relationship between negative attitudes towards pregnancy and PD[21]. Another potential mechanism for some of these findings is changes in physical morbidity. Suffering from hyperemesis gravidarum or having an infection during pregnancy can lead to pain, tiredness and reduced levels of activity which are well-known risk factors for experiencing depressive symptoms[22]. The association between infections and PD could potentially also be explained by changes in women's immune response following an infection. Lower levels of inflammatory markers, such as Interleukin-10, in late pregnancy have been shown to increase the risk of developing depressive symptoms postpartum[23]. This mechanism could also come into play for hyperemesis gravidarum and

smoking during pregnancy which have also been shown to be associated with changes in levels of inflammatory markers[24,25].

The graphical network modelling approach provided increased insight into the relations between risk factors and PD compared to a typical linear regression analysis because it investigated risk factors and their relations to each other as well as with PD. The factors identified to be associated with PD in the network model were also found to be related to PD in the multiple regression analysis. However, many other risk factors identified by the regression analysis did not share an edge with PD in the fully adjusted network model, indicating a lack of direct relations between these risk factors and PD and suggesting that perhaps, while these factors may be correlated, they are not itself a source of variation in PD. This difference occurs because the graphical network model allows identification of conditional dependencies between variables simultaneously, rather than examining individual variables in isolation. For example, the node for planned pregnancy in Figures 1 and 2 is shown to be highly connected to receiving fertility treatment as well as to levels of happiness about the pregnancy. Hence, if accounting for all of these factors simultaneously there is no connection between PD and planned pregnancy as they are conditionally independent given levels of happiness about the pregnancy. This might be expected since a woman who had planned to get pregnant would be more likely to express happiness about the pregnancy[26]. Similarly, for receiving antenatal care, Figure 2 shows that it shares edges with maternal age, maternal education, maternal ethnicity and income. It is reasonable to assume that whether a woman receives antenatal care would be related to her socio-economic status, and all of these factors are related to the mother's SES[27]. Hence, PD is conditionally independent of receiving antenatal care given those demographic measures. The fully adjusted graphical model highlights that perinatal risk factors are often primarily associated with demographic factors and potentially only indirectly with PD, and thus, emphasizes the importance of taking a holistic approach when analyzing such relations as well as when evaluating an individual's risk of suffering from postnatal psychological distress.

This study is the first to use graphical models to investigate the links between perinatal risk factors, socio-demographic factors and history of depression or anxiety, and postnatal psychological distress. These methods offer much more detailed insights into the relations between risk factors and PD compared to more traditional methods such as linear regressions. Graphical models estimate all predictor, covariate and outcome relations simultaneously and

test for multiple dependencies in the data, offering a novel perspective to the well-studied phenomena of postnatal psychological distress. Since the data used in our study was collected as part of a large UK-wide birth cohort study, our participants are based on a nationally representative sample of women, which enabled us to look at many potential risk factors and demographic factors simultaneously.

The main limitation is that all information on perinatal risk factors was collected retrospectively at nine-months postpartum and is based on women's self-reports. Hence, some of the data could have been subject to recall-error and the results should, therefore, be interpreted with caution. However, research on agreement between self-reports and medical records has generally been shown to be high (e.g. agreement of ~90% for self-reported gestational diabetes)[28], with a tendency for self-reports to underreport illnesses[29]. Thus, our findings might be more conservative than if we had relied on medical records. Postnatal depression typically has an onset soon after giving birth and is often resolved after several weeks or months[30]. This could mean that some mothers had suffered from postnatal depression and recovered by the time of assessment, which would lead to an under-reporting of PD and are therefore not captured adequately in this study. On the other hand, the women with higher PD scores in this study, may have suffered more severe and persistent symptoms of PD, putting them at greatest risk of adverse outcomes. Future studies should aim to replicate these findings using data based on hospital records or registry data. Also, the final model only accounted for 17.1% of the variance in PD scores, indicating the complexity of explaining PD using the combination of variables available in this paper. Future studies should look at additional factors that might affect PD to improve the overall explanatory power of the models.

5 Conclusion

This study shows that lower levels of happiness about the pregnancy, smoking during pregnancy, infections during pregnancy, hyperemesis gravidarum and induction of labour are associated with an increased risk of having high levels of psychological distress at nine-months postpartum. This study further underlines the recommendation that future research should take a comprehensive approach to analyzing risk factors. Future studies should also aim to analyze the pathways that lead to the observed associations with increased postnatal psychological distress and certain risk factors and should further focus on mitigations of PD that are targeted on a demographic basis. It is important that healthcare professionals working with mothers are

aware of these risk factors for postnatal psychological distress as well as the increased risk for women from certain demographic groups. These women may benefit from earlier and more regular screening to facilitate timely intervention and to help prevent the maternal and child sequelae of postnatal psychological distress.

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Tweetable Abstract

Perinatal risk factors often only indirectly associated with postnatal psychological distress – important to take a holistic approach when analyzing postnatal mental health.

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Table 1. Population characteristics

Variable	***Mean***	***SD***	***Range***	***N***
Age	28.79	5.86	14-48	17525
Postnatal Psychological Distress	1.62	1.73	0-9	17531
	Category		***N***	***%***
Ethnicity	White		15034	85.9
	Other Ethnicity		2465	14.1
	Missing		32	
College Qualification	Yes		14877	85.0
	No		2633	15.0
	Missing		21	
First Time Mother	Yes		10129	57.8
	No		7398	42.2
	Missing		4	
Single Parent	Yes		3006	17.2
	No		14521	82.8
	Missing		4	
Income	Lowest Quintile (Lowest Income)		4241	24.3
	20 - <40%		3879	22.2
	40 - <60%		3352	19.2
	60 - <80%		3136	17.9
	Highest Quintile (Highest Income)		2878	16.5
	Missing		45	
Deprivation	Lowest Decile (Most Deprived)		2932	16.7
	10 - <20%		2552	14.6
	20 - <30%		2220	12.7
	30 - <40%		1792	10.2
	40 - <50%		1546	8.8
	50 - <60%		1412	8.1
	60 - <70%		1177	6.7
	70 - <80%		1247	7.1
	80 - <90%		1323	7.5
	Highest Decile (Least Deprived)		1329	7.6
	Missing		1	
History of Depression and Anxiety	Yes		4362	24.9
	No		13168	75.1

Note: Mean and standard deviations (*SD*) were corrected for the survey design of the MCS.

Table 2. Population characteristics of perinatal risk factors

Variable	*Mean*	*SD*	*Range*	*N*
Breastfeeding Duration in Weeks	11.83	14.35	0-47.14	17304
Birthweight in Kilograms	3.38	0.57	0.39-7.23	17513
Gestational Age in Weeks	39.42	1.95	24-43	17376
Age Baby Home from Hospital in Days	4.07	10.16	0-270	17510
	Category		***N***	***%***
Planned Pregnancy	Yes		9473	54.1
	No		8033	45.9
	Missing		25	
Fertility Treatment	Yes		411	2.5
	No		17092	97.7
	Missing		28	
Received Antenatal Care	Yes		16916	96.5
	No		608	3.5
	Missing		7	
Attended Antenatal Classes	Yes		6013	35.5
	No		10903	64.5
	Missing		615	
Happiness Levels about the Pregnancy	Very Happy		9826	56.2
	Happy		4561	26.1
	Neutral		1148	6.6
	Unhappy		1342	7.7
	Very Unhappy		591	3.4
	Missing		63	
Place of Birth	Hospital		17153	97.9
	Home		339	1.9
	Other		36	0.2
	Missing		3	
Type of Delivery	Normal		12033	68.6
	Assisted		1688	9.6
	Planned Cesarean		1616	9.2
	Emergency Cesarean		2119	12.1
	Other		79	0.5
	Missing		5	
Type of Pain Relief	None		1371	8.1
	Gas and Air		12192	71.6
	Epidural		2115	12.4
	Opiate Injection		647	3.8
	Other		704	4.1
	Missing		502	
Labour Induced	Yes		5447	31.1
	No		12069	68.9
	Missing		15	
Labour Complication: Abnormal Lie	Yes		973	5.6
	No		16551	94.4
	Missing		7	
Labour Complication: Very Long Labour	Yes		1237	7.1
	No		16287	92.9
	Missing		7	
Labour Complication: Very Rapid Labour	Yes		435	2.5
	No		17089	97.5
	Missing		7	

Labour Complication: Fetal Distress	Yes	2592	14.8
	No	14932	85.2
	Missing	7	
Illness: Infection	Yes	1307	7.5
	No	16218	92.5
	Missing	6	
Illness: Hyperemesis Gravidarum	Yes	1007	5.7
	No	16518	94.3
	Missing	6	
Illness: Diabetes	Yes	284	1.6
	No	17241	98.4
	Missing	6	
Illness: Preeclampsia	Yes	1278	7.3
	No	16247	92.7
	Missing	6	
Illness: Anemia	Yes	447	2.6
	No	17078	97.4
	Missing	6	
Illness: Bleeding in Early Pregnancy	Yes	1084	6.2
	No	16441	93.8
	Missing	6	
Illness: Bleeding in Late Pregnancy	Yes	628	3.6
	No	16897	96.4
	Missing	6	
Baby went to Special Care	Yes	1418	8.1
	No	16106	91.9
	Missing	7	
Smoked during Pregnancy	Yes	3202	21.5
	No	11716	78.5
	Missing	0	
Sex of the Baby	Female	8500	48.5
	Male	9026	51.5
	Missing	5	

Note: Mean and standard deviations (*SD*) were corrected for the survey design of the MCS.

Table 3: Regression parameter estimates for risk factors associated with PD in the multivariate analysis

Risk Factor	*B* (95% CI)	*p*
Planned Pregnancy (Reference: Yes)	1.56 (1.43-1.69)	
No	0.19 (0.13-0.26)	<.001**
Received Antenatal Care (Reference: Yes)	1.63 (1.50-1.76)	
No	0.23 (0.03-0.43)	.02*
Happiness Levels about the Pregnancy	1.89 (1.75-2.02)	
Linear Trend	0.51 (0.38-0.63)	<.001**
Type of Pain Relief (Reference: None)	1.60 (1.44-1.75)	
Gas and Air	0.06 (-0.07-0.18)	.37
Epidural	0.05 (-0.05-0.16)	.32
Opiate Injection	-0.02 (-0.18-0.15)	.85
Other	0.23 (0.08-0.39)	<.001**
Labour Complication: Abnormal Lie (Reference: No)	1.64 (1.51-1.76)	
Yes	0.19 (0.07-0.31)	<.001**
Labour Complication: Very Long Labour (Reference: No)	1.63 (1.50-1.76)	
Yes	0.13 (0.03-0.24)	.01*
Labour Complication: Fetal Distress (Reference: No)	1.64 (1.51-1.77)	
Yes	0.08 (0.00-0.15)	.05*
Illness: Infection (Reference: No)	1.64 (1.51-1.77)	
Yes	0.36 (0.24-0.48)	<.001**
Illness: Hyperemesis Gravidarum (Reference: No)	1.63 (1.50-1.76)	
Yes	0.31 (0.18-0.44)	<.001**
Illness: Anemia (Reference: No)	1.64 (1.51-1.77)	
Yes	0.22 (0.07-0.36)	<.001**
Illness: Bleeding in Early Pregnancy (Reference: No)	1.64 (1.51-1.77)	
Yes	0.13 (0.02-0.25)	.03*
Illness: Bleeding in Late Pregnancy (Reference: No)	1.65 (1.52-1.77)	
Yes	0.16 (0.02-0.30)	.02*
Baby went to Special Care (Reference: No)	1.62 (1.50-1.75)	
Yes	0.26 (0.16-0.36)	<.001**
Smoked during Pregnancy (Reference: No)	1.63 (1.50-1.76)	
Yes	0.17 (0.09-0.25)	<.001**
Birthweight in Kilograms	1.83 (1.62-2.04)	
Linear Trend	-0.06 (-0.11--0.01)	.02*
Gestational Age in Weeks	2.35 (1.78-2.92)	
Linear Trend	-0.02 (-0.03--0.00)	.01*
Age Baby Home from Hospital	1.62 (1.49-1.75)	
Linear Trend	0.01 (0.00-0.01)	<.001**
Sex of Baby (Reference: Female)	1.62 (1.49-1.74)	
Male	0.06 (0.01-0.11)	.02*

Note: [1]Analyses are adjusted for socio-demographic characteristics and history of depression or anxiety; all analyses have been adjusted for the sampling design of the MCS; Reference *B* = Intercept, *significant at $p < .05$, **significant at $p < .001$ (Bonferroni corrected alpha level)

Table 4: Edge weight, bootstrapped mean weight and 95% confidence interval's (CI) and standardized parameter estimates (*b*) for nodes sharing an edge with maternal psychological distress in the adjusted model

		Bootstrapped	*95% CI's*		
Node	***Weight***	***Mean Weight***	***Lower***	***Upper***	***b***
Happiness Levels about Pregnancy	0.084	0.084	0.069	0.100	0.095
Smoking during Pregnancy	0.026	0.020	-0.009	0.060	0.029
Infection during Pregnancy	0.071	0.066	0.024	0.118	0.090
Hyperemesis Gravidarum	0.068	0.062	0.013	0.123	0.083
Baby went to Special Care	0.048	0.035	-0.004	0.099	0.062
Income[1]	-0.025	-0.014	-0.055	0.005	-0.036
Deprivation[2]	-0.028	-0.026	-0.051	-0.005	-0.039
Maternal Ethnicity	0.101	0.100	0.062	0.140	0.118
History of Depression or Anxiety	0.574	0.572	0.545	0.603	0.764

Note: [1]baseline = lowest income, [2]baseline = most deprived

Figure Legends

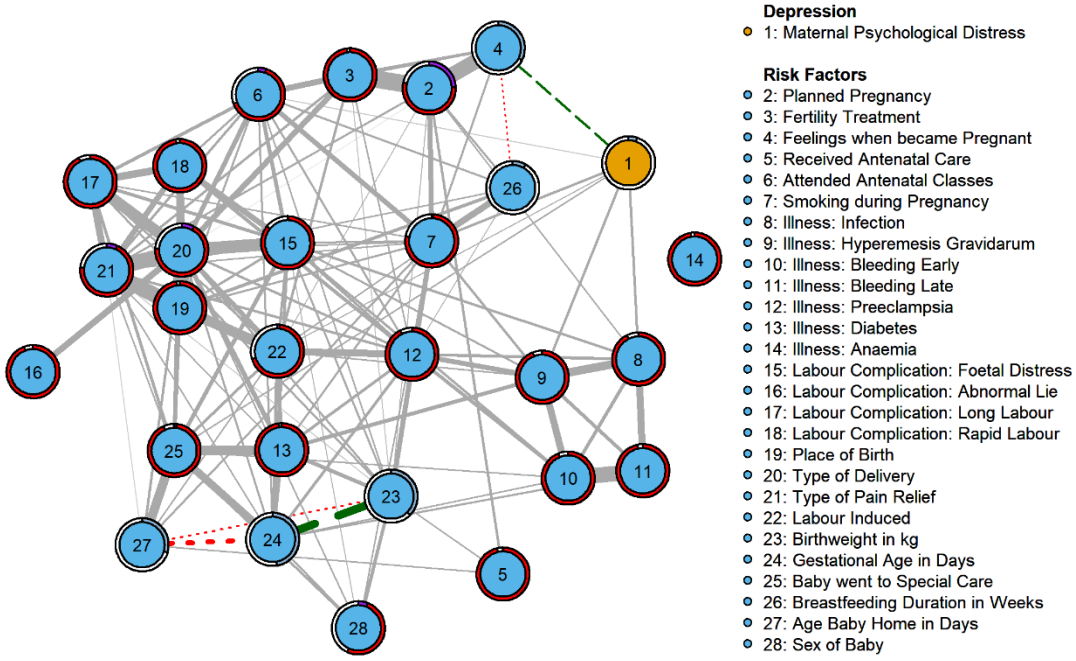

Fig. 1 Network displaying the relations between maternal psychological distress and perinatal risk factors. The width of the edges is proportional to the absolute weight of the edge-parameter, visualizing the strength of the relationship between two variables (the wider the edge, the stronger the association). Green edges (dashed) indicate a positive relation; red edges (dotted) a negative relation and grey edges (solid) indicate a relation between categorical variables. The ring around the nodes indicates the accuracy, that is, variance explained by all other nodes in the model. The blue ring shows the proportion of explained variance for continuous variables. For categorical variables, the purple part of the ring indicates the accuracy of the intercept model. The red part of the ring is the additional accuracy achieved by all remaining variables. The sum of both is the accuracy of the full model.

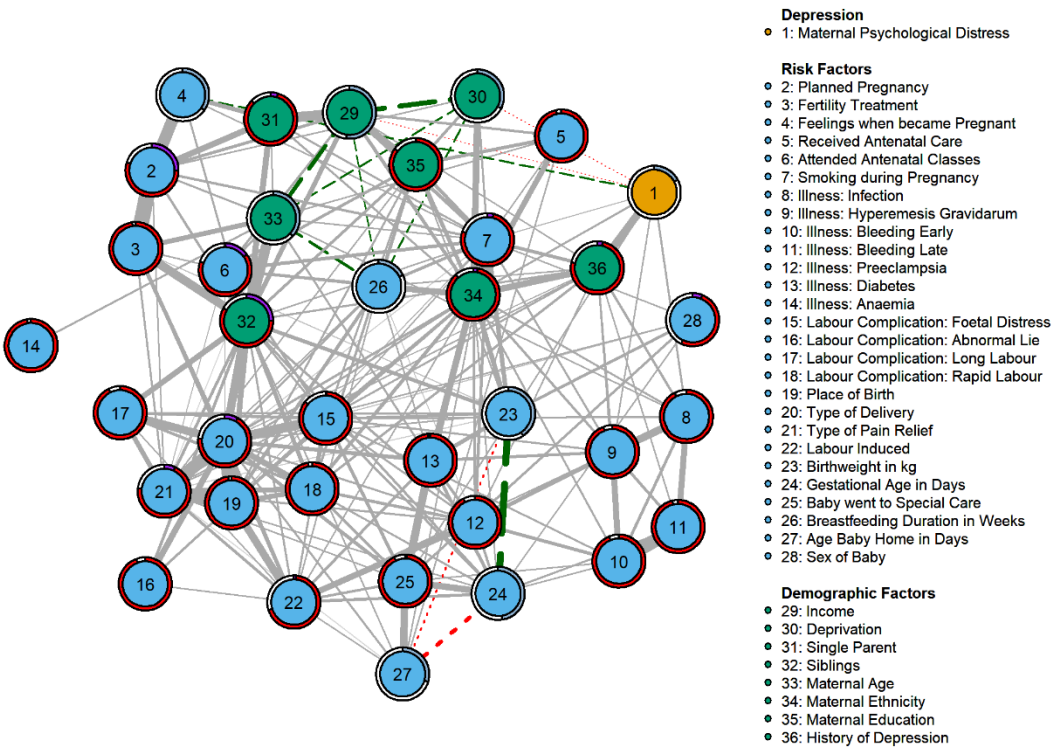

Fig. 2 Network displaying the relations between maternal psychological distress and perinatal risk factors after adding demographic variables and history of depression or anxiety. The width of the edges is proportional to the absolute weight of the edge-parameter, visualizing the strength of the relations between two variables (the wider the edge, the stronger the association). Green edges (dashed) indicate a positive relation; red edges (dotted) a negative relation and grey edges (solid) indicate a relation between categorical variables. The ring around the nodes indicates the accuracy, that is, variance explained by all other nodes in the model. The blue ring shows the proportion of explained variance for continuous variables. For categorical variables, the purple part of the ring indicates the accuracy of the intercept model. The red part of the ring is the additional accuracy achieved by all remaining variables. The sum of both is the accuracy of the full model.

Supporting Information Legends

Rutter Malaise Inventory: additional information on scoring of the RMI as well as on specificity and sensitivity

Maternal Illness During Pregnancy: additional information on wording of interview questions for maternal illness during pregnancy

Statistical Analysis: additional information on how the analysis was conducted and extra information on graphical models

Table S1: Unadjusted and adjusted regression parameters for all risk factors

Table S2: Edge weights and bootstrapped 95% confidence interval's (CI) for all potential edges with maternal psychological distress

Table S3: Edge weights and bootstrapped 95% confidence interval's (CI) for all potential edges with maternal psychological distress for the fully adjusted model