Nordic Journal of Psychiatry

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/ipsc20

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To cite this article: Maria A. Karalexi, Malin Eberhard-Gran, Unnur Anna Valdimarsdóttir, Hasse Karlsson, Trine Munk-Olsen & Alkistis Skalkidou (2022): Perinatal mental health: how nordic data sources have contributed to existing evidence and future avenues to explore, Nordic Journal of Psychiatry, DOI: 10.1080/08039488.2021.1998616

To link to this article: https://doi.org/10.1080/08039488.2021.1998616

NORDIC JOURNAL OF PSYCHIATRY
https://doi.org/10.1080/08039488.2021.1998616

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REVIEW ARTICLE

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Perinatal mental health: how nordic data sources have contributed to existing evidence and future avenues to explore

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ABSTRACT

Purpose: Perinatal mental health disorders affect a significant number of women with debilitating and potentially life-threatening consequences. Researchers in Nordic countries have access to high quality, population-based data sources and the possibility to link data, and are thus uniquely positioned to fill current evidence gaps. We aimed to review how Nordic studies have contributed to existing evidence on perinatal mental health.

Methods: We summarized examples of published evidence on perinatal mental health derived from large population-based longitudinal and register-based data from Denmark, Finland, Iceland, Norway and Sweden.

Results: Nordic datasets, such as the Danish National Birth Cohort, the FinnBrain Birth Cohort Study, the Icelandic SAGA cohort, the Norwegian MoBa and ABC studies, as well as the Swedish BASIC and Mom2B studies facilitate the study of prevalence of perinatal mental disorders, and further provide opportunity to prospectively test etiological hypotheses, yielding comprehensive suggestions about the underlying causal mechanisms. The large sample size, extensive follow-up, multiple measurement points, large geographic coverage, biological sampling and the possibility to link data to national registries renders them unique. The use of novel approaches, such as the digital phenotyping data in the novel application-based Mom2B cohort recording even voice qualities and digital phenotyping, or the Danish study design paralleling a natural experiment are considered strengths of such research.

Conclusions: Nordic data sources have contributed substantially to the existing evidence, and can guide future work focused on the study of background, genetic and environmental factors to ultimately define vulnerable groups at risk for psychiatric disorders following childbirth.

ARTICLE HISTORY
Received 11 April 2021
Revised 14 September 2021
Accepted 20 October 2021

KEYWORDS
Perinatal mental health; Nordic countries; longitudinal dataset; national registers

Introduction

Perinatal mental health, recognized since the time of Hippocrates and commented on through the centuries, is an umbrella term encompassing different disorders, such as depression, anxiety, obsessive-compulsive disorders, post-traumatic stress disorder (PTSD) and postpartum psychosis [1]. The reported prevalence of each of these conditions varies greatly due to different settings, underlying data sources, designs and study populations [2]. Overall, these disorders affect a significant number of women perinatally, with debilitating and potentially life-threatening consequences for both parents and their children [3]. Additionally, suicide risks are substantial after delivery and cannot be ignored [4]. In the UK and Norway, peripartum suicide is the leading indirect cause of maternal death during the first year after childbirth, while in Sweden four women lose their lives every year during the postpartum period [5–7].

An extensive body of research on perinatal mental illnesses has been published so far. Most of the existing studies have focused on incidence estimates and assessment of single risk factors [8–15]. However, current evidence regarding the etiology and biological mechanisms behind perinatal mental health conditions remains inconclusive [16,17]. Moreover, few studies have aimed to address the large heterogeneity in phenotypes and cardinal symptoms of each perinatal mental disease, which could allow for more individualized treatment and interventions [18,19].

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Supplemental data for this article can be accessed online at https://doi.org/10.1080/08039488.2021.1998616

In the present study, we aimed to appraise how studies from Nordic countries have contributed to existing evidence on perinatal mental health, to provide examples of such studies in Denmark, Finland, Iceland, Norway and Sweden and to discuss how the Nordic countries are positioned to continue to contribute with new evidence in the future.

Data sources

The present study provides and summarizes examples of published evidence derived from large population-based longitudinal datasets and register-based data stemming from five Nordic countries, Denmark, Finland, Iceland, Norway and Sweden, which can be used to address questions around perinatal mental health. The selection of included examples of studies was aimed at presenting a range of work based on large sample sizes, long follow-up, the biological sampling, the use of novel methods and the possibility to link data to national registries. The detailed characteristics of each data source are presented in Supplementary Material.

Examples of danish studies

In Denmark, an example of research on perinatal mental health is a recent study which used data from the iPSYCH study (The Lundbeck Foundation Initiative for Integrative Psychiatric Research) which was linked to the Danish Psychiatric Central Research Register. This study examined how personal psychiatric history, parental psychiatric history and genetic vulnerability to psychiatric disorders measured through polygenic risk score influence risk of postpartum psychiatric disorders [20] (Table 1). The applied polygenic risk scores were derived from the large genetic collaborative projects, all part of the Psychiatric Genomics Consortium (https://www.med.unc.edu/pgc/). Results from this study showed polygenic risk score for major depression was associated with increased risk of postpartum psychiatric disorders in both women with (odds ratio [OR]: 1.44, 95% confidence intervals [CI]: 1.19–1.74) and without (OR: 1.88, 95% CI: 1.26–2.81) personal psychiatric history. By contrast, schizophrenia genetic risk score was only minimally associated with postpartum disorders, jointly suggesting postpartum mental disorders overlaps with depression more than schizophrenia. Another Danish study based solely on register-data explored the association of first-time parents with psychiatric hospital admission or outpatient contact 0 to 12 months after childbirth [21]. The results documented primiparous women had increased risk of incident hospital admission with any mental disorder through the first 3 months after childbirth, with the highest risk occurring 10 to 19 days postpartum (relative risk [RR]: 7.31, 95% CI: 5.44-9.81). In contrast, fatherhood was not associated with increased risk of hospital admission or outpatient contact. Lastly, a register-based Danish study linking information from the Danish IVF Register, the Danish Psychiatric Central Register, the Danish National Hospital Register, and the Integrated Database for Longitudinal Labor Market Research explored the association between childbirth and mental health in a group of women having *in vitro* fertilization (IVF). This study simulated a natural experiment [22], and IVF-treated mothers had increased risk of a psychiatric episode 0-90 days postpartum (incidence rate ratio [IRR]: 2.9, 95% CI: 2.0-4.2), compared with women who did not conceive after IVF treatment.

Examples of finnish studies

The FinnBrain Birth Cohort Study [www.finnbrain.fi] was established in 2010 to prospectively study the effects of early life stress (ELS) also comprising prenatal stress (PS), on child's brain development and health [23]. This population-based pregnancy cohort with a primarily neurodevelopmental focus has collected a sample of 4000 families and eventually aims at identifying biomarkers related to PS and ELS exposures as well as trajectories for common psychiatric and somatic illnesses (e.g. depression, anxiety and cardiovascular illness). So far, more than 120 articles have been published and the next measurement point at child age of 9 years starts in autumn 2021. Current findings show that prenatal stress associates to a wide variety of child's brain developmental and health outcomes [24–26].

Other Finnish data sources include a register-based study, the Helsinki Birth Cohort Study where individuals born between 1934 and 1944 were studied. Data on birth weight was extracted from birth records, and time, type and reason of retirement between 1971 and 2011 was extracted from the Finnish Centre for Pensions. The results show, that among men, higher birth weight is associated with lower hazard of transitioning into disability pension, namely pension due to mental disorders. These results provide some evidence that disability pension among men, particularly due to mental disorders, may have its origins in prenatal development [27]. Another example from this cohort is a study based on hospital birth records, including 341 offspring born to grand multiparous mothers during 1934-1944. From Finnish national hospital discharge and causes of death registers, the researchers identified 1682 participants diagnosed with mental disorders during 1969-2010. Women born to grand multiparous mothers were at an increased risk of severe mental disorders and suicide attempts across adulthood [28].

Examples of icelandic studies

Stressful and traumatic life events have been suggested as potent risk factors of adverse perinatal mental [29] and physical [30] health e.g. through several research initiatives in Iceland based on the national registers and established cohorts. The 2008 economic collapse in Iceland yielded a surge in high stress levels among women [31] which further was associated with a transient rise in gestational hypertension [30] and births of low birthweight infants [32]. Secondly, following pregnancies and births of more than 1000 women who had previously attended the Rape Trauma Service (RTS) in Landspítali National Hospital, Reykjavik, from 1993-2010, history of severe sexual violence was associated with reduced probability of smoking cessation during pregnancy

Table 1. Selected studies on perinatal mental health derived from three Nordic data sources (Denmark, Norway, and Sweden).

Author	Year	Recruitment period	Region	Cohort size	Source of information	Population characteristics	Exposures examined	Outcomes examined	Adjusted for	Main results
Danish data sources										
Bauer	2019	1981-2005	Denmark	8850	iPSYCH2012 cohort linked to the Danish Psychiatric Central Research Register	Sample selected from the Danish Civil Registration System of all singleton births who were alive and resided in Denmark at one year of age and whose mother was known	Personal and parental psychiatric history, genetic risk score based on genome-wide data from Psychiatric Genomics Consortium sample	Postpartum psychiatric disorders	age, age squared, parental psychiatric history, country of origin, parity	• Parental psychiatric history associated with postpartum psychiatric disorders among women with previous psychiatric history (OR, 1.14; 95% CI 1.02–1.28) • Genetic risk score for major depression associated with an increased risk of postpartum psychiatric disorders in both women with (OR, 1.44; 95% CI: 1.19–1.74) and without (OR, 1.88; 95% CI: 1.26–2.81) personal psychiatric history • Schizophrenia genetic risk score only minimally associated with postpartum disorders
Munk-Olsen	2006	1973-2005	Denmark	630,373 women; 547,431 men	Register-based cohort formed by linking information from Danish health and civil service registers	Danish-born persons followed up from their 15th birthday or January 1, 1973, whichever came later, until date of onset of the disorder in question, date of death, date of emigration from Denmark, or July 1, 2005	First-time parents	First-time psychiatric hospital admission or outpatient contact 0 to 12 months after becoming a parent	age, calendar time	Primiparous women had increased risk of incident hospital admission with any mental disorder through the first 3 months after childbirth • The highest risk 10 to 19 days postpartum (RR 7.31; 95% CI: 5.44-9.81) • Risk increased for psychiatric outpatient contacts through the first 3 months after childbirth, also with the highest risk occurring 10 to 19 days postpartum (RR, 2.67; 95% CI, 1.99-3.59). Fatherhood not associated with increased risk of hospital admission or outpatient contact
Munk-Olsen	2015	1994-2005	Denmark	21,276	Danish IVF Register, Danish Psychiatric Central Register, Danish National Hospital Register, Integrated Database for Longitudinal Labor Market Research	All women having IVF and their partners with recorded information in the IVF register covering fertility treatments in Denmark at all public and private treatment sites	Childbirth	First-time psychiatric episodes (first psychiatric inpatient or outpatient treatment)	adoption, age, calendar year, income, education, comorbidity Index, psychiatric disorder in spouse, death of spouse, abortion history, number of IVF treatments	• IRR for any type of psychiatric disorder 0-90 days postpartum 11.3 per 1000 person-years (95% CI: 8.2-15.0), and 3.8 (3.4-4.3) among women not giving birth • IVF-treated mothers increased risk of a psychiatric episode

(*continued*)

Table 1. Continued.

Author	Year	Recruitment period	Region	Cohort size	Source of information	Population characteristics	Exposures examined	Outcomes examined	Adjusted for	Main results
										postpartum (IRR: 2.9, 95% CI: 2.0-4.2) • Risk of psychiatric episodes from 90 days postpartum and onwards decreased (IRR: 0.9, 95% CI: 0.7-1.0).
Finnish data sources										
Lehtola	2020	2011-2015	Finland	80	FinnBrain Birth Cohort Study	Families who participated in the newborn scan whose parents filled in prenatal and 3- and 6-month postnatal questionnaires. Scanned infants all born at gestational week 36 or later, weighed more than 2500 g, had Apgar scores >6 at 5 min after birth, did not have any diagnosed CNS anomaly or abnormal findings in the MRI scan.	Newborn white matter fractional anisotropy (FA), a measure of white matter maturity	Maternal postpartum depressive symptoms and infant negative reactivity at 6 months	infant sex, parity,maternal alcohol/tobacco use, maternal prenatal depressive symptoms and post-conceptional age	• -Maternal depressive symptoms positively related to infant negative reactivity among infants with high or average FA in the whole brain and in corpus callosum and cingulum, but not among those with low FA. • -The link between maternal depressive symptoms and infant negative reactivity was moderated by newborn FA
von Bondorff	2015	1971-2011	Finland	10,682	Helsinki Birth Cohort Study & Finnish Centre for Pensions	The Helsinki Birth Cohort Study comprises 13 345 individuals born in Helsinki, Finland at Helsinki University Central Hospital or Helsinki City Maternity Hospital between 1934 and 1944 and who had data on birth anthropometry extracted from birth records	Body size at birth	Disability pension (DP)	birth order, socioeconomic status in childhood, highest educational attainment and highest occupational class in adulthood.	• -Among men, higher birth weight associated with a lower hazard of transitioning into DP, adjusted hazard ratio (HR) 0.94 (95% confidence interval [CI] 0.88–0.99 for 1 SD increase in birth weight). • -Among women no associations between body size at birth and all-cause DP
Lahti	2014	1969-2010	Finland	13,243	Helsinki Birth Cohort Study	According to hospital birth records, 341 offspring were born to grand multiparous mothers. From Finnish national hospital discharge and causes of death registers, identified 1682 participants with mental disorders.	Maternal grand multiparity	Severe Mental Disorders in Adult Offspring	mothers' and father's occupational statuses in childhood, the birth weight of the offspring, and maternal BMI at childbirth.	• -Maternal grand multiparity predicted significantly increased risks of mood disorders (Hazard Ratio $= 1.64$, $p = 0.03$), non-psychotic mood disorders (Hazard Ratio $= 2.02$, $p = 0.002$), and suicide attempts (Hazard Ratio $= 3.94$, $p = 0.01$) in adult offspring
Icelandinc data sources										
Hauksdóttir	2013	2007-2009	Iceland	3,755	Icelandic national cohort	Public Health Institute in Iceland conducted a mailed health survey, Health and Well-being in Iceland 2007. Based on a	Major national economic collapse	self-reported levels of psychological stress	Age, sex, education, marital status, and size of residency area.	• -Age-adjusted mean stress levels increased between 2007 and 2009 ($p = 0.004$), though the increase was observed only for women

(*continued*)

Table 1. Continued.

Author	Year	Recruitment period	Region	Cohort size	Source of information	Population characteristics	Exposures examined	Outcomes examined	Adjusted for	Main results
						stratified random sample ($n = 9,807$) of the Icelandic national population.				($p = 0.003$), not for men ($p = 0.34$) • -The odds ratios for experiencing high stress levels were increased only among women (odds ratio (OR) = 1.37), especially among women who were unemployed ($OR = 3.38$)
Gisladottir	2014	1993-2011	Iceland	$N = 915$ cases; $n = 1641$ controls	Rape Trauma Service	Register-based cohort study, linking data from the RTS at the Accident and Emergency Department of Landspitali University Hospital with data from the national Icelandic birth register (IBR).	Characteristics and risk factors during pregnancy, including maternal smoking, body mass index, weight gain during pregnancy, illicit drug use	Sexual violence	Age, parity, year of delivery and gestational length at first weight measurement for BMI and weight gain.	• -Compared with unexposed women, sexually assaulted women were younger and more often primiparous in subsequent pregnancy, more likely not to be employed (7.8% vs. 4.3%; aRR 2.42, 95% CI 1.49-3.94), not cohabiting (45.6% vs. 14.2%; aRR 2.15, 95% CI 1.75-2.65), smokers (45.4% vs. 13.5%; aRR 2.68, 95% CI 2.25-3.20), and more likely to have used illicit drugs during pregnancy (3.4% vs. 0.4%; aRR 6.27, 95% CI 2.13-18.43).
Norwegian data sources										
Adams	2012	2008-2010	Akershus University Hospital, Norway	2206	ABC study	Women with a singleton pregnancy and intended vaginal delivery recruited at the routine fetal ultrasound examination at 18 weeks of gestation	Fear of childbirth assessed by the Wijma Delivery Expectancy Questionnaire Version A, and defined as a sum score ≥ 85	Labor duration in hours	labor induction, labor augmentation, emergency caesarean delivery, instrumental vaginal delivery, birthweight and maternal age	• Fear of childbirth present in 7.5% of women • Labor duration significantly longer in women with fear of childbirth (adjusted unstandardized coefficient 0.78; 95% CI: 0.20–1.35, corresponding to a 47-minute difference)
Garthus-Niegel	2017	2008-2010	Akershus University Hospital, Norway	1472	ABC study	Women recruited during their routine fetal ultrasound examination, performed at 17 weeks' gestation, and asked to complete questionnaires at 17 weeks' gestation, 32 weeks' gestation, 8 weeks and 2 years postpartum	Postpartum PTSD symptoms	Child development, assessed by means of the Ages & Stages Questionnaire (ASQ-3) and the ASQ-Social-Emotional (ASQ:SE): gross motor, fine motor, communication and socio-emotional development	Sex, maternal depression and anxiety or infant temperament	• Postpartum PTSD symptoms had a prospective relationship with poor child social-emotional development 2 years later • Child sex and infant temperament moderated the association between maternal PTSD symptoms and child social–emotional development
Kjeldgaard	2017	1998-2008	Norway	731	Norwegian MoBa study	All pregnant women scheduled to give birth at 50 of Norway's 52	History of depression	Hyperemesis gravidarum	Symptoms of current depression, maternal age, parity, body	• A lifetime history of depression associated with higher odds for

(*continued*)

Table 1. Continued.

Author	Year	Recruitment period	Region	Cohort size	Source of information	Population characteristics	Exposures examined	Outcomes examined	Adjusted for	Main results
						hospitals with maternity units received a postal invitation to participate together with appointments for routine ultrasound examination at around week 17 of pregnancy			mass index, smoking, sex of the child, education and pelvic girdle pain	hyperemesis gravidarum ($OR = 1.49$, 95% CI (1.23; 1.79)). - Two thirds of women with hyperemesis gravidarum had neither a history of depression nor symptoms of current depression • − 1.2% of women with a history of depression developed hyperemesis gravidarum
Swedish data sources										
Asif	2020	2012-2019	Uppsala, Sweden	2990	BASIC study	Swedish-speaking women in Uppsala $\geq$ 18 years, vaginally delivered with singleton pregnancies	Obstetric perineal lacerations	PPD (assessed with the Depression Self-Reporting Scale, completed at 6 weeks postpartum)	BMI, education, parity, vacuum extraction	Significant association of severe lacerations with PPD in women with low resilience (OR: 5.5, 95% CI: 1.2-26.0)
Esscher	2016	1980-2007	Sweden	103	Swedish Cause of Death Register, Medical Birth Register, National Patient Register	Women died by suicide during pregnancy, or within 1 year after delivery, through linkage of the Swedish Cause of Death Register with the Medical Birth Register	NA	Maternal suicide during pregnancy	None	• Maternal suicide ratio: 3.7 per 100 000 live births • Suicide ratio higher in women born in low-income countries (OR: 3.1, 95% CI: 1.3-7.7)
Henriksson	2019	NR	Uppsala, Sweden	45	BASIC study	Plasma samples selected from a subgroup of women participating in the BASIC project: Swedish-speaking women in Uppsala who were $\geq$ 18 years	- Untargeted gas chromatography–mass spectrometry plasma metabolomics - Seasonal differences in the metabolic profiles	Antenatal depressive symptoms based on EPDS score cut off of $\geq$ 12 points	None	• Independently of season, no differences were observed • Seasonal differences in the metabolic profiles of control samples, suggesting favorable cardiometabolic profile in the summer vs. winter (lower glucose and sugar acid and lactate to pyruvate ratio, and higher abundance of arginine and phosphate) • Similar differences between cases and controls among summer pregnancies: association between a stressed metabolism and depressive symptoms

ABC: Akershus Birth Cohort study; BASIC: Biology, Affect, Stress, Imaging, Cognition study; BMI: body mass index; CI: confidence intervals; EPDS: Edinburgh Postnatal Depression Scale; iPSYCH2012: Integrative Psychiatric Research; IRR: incidence rate ratio; IVF: *in vitro* fertilization; MobA: Mother and Child Cohort Study; NA: not applicable; NR: not reported; OR: odds ratio; PPD: peripartum depression; PTSD: post-traumatic stress disorder; RR: relative risk.

[33], maternal distress during labor, prolonged first stage of labor, and emergency instrumental delivery [34].

With support from the European Research Council and the Icelandic Research Fund, the Stress-And-Gene Analysis -SAGA- cohort was established in 2018 with the overarching aim to increase knowledge of the role trauma and stressful life events in women's health (www.afallasaga.is). In 2018-2019, 31.795 women, representing approximately 30% of the total female population in Iceland, responded to an extensive questionnaire on lifetime exposure to trauma and stressful life events, as well as on the status of their general health, with emphasis on mental health, including symptoms of posttraumatic stress disorder, depression, anxiety as well as female specific symptomologies, e.g. lifetime history of premenstrual symptoms and pregnancy- and postpartum depression measured with the modified version of Edinburgh Perinatal Depression Scale (lifetime version). With the unique national genetic resources in Iceland as well as ongoing record linkages to the national registers, this cohort offers great opportunities to significantly advance the existing knowledgebase on the role of genetic- and environmental factors in maternal mental health.

Examples of norwegian studies

In Norway, mounting research on perinatal mental health has been performed, exploiting datasets of large magnitude, such as the Norwegian Mother, Father and Child Cohort Study (MoBa; www.fhi.no/en/studies/moba/), as well as the Akershus Birth Cohort Study (ABC; www.med.uio.no/klinmed/forskning/prosjekter/favn-om-fodselen-studien/) (Table 1). An example of such research is the ABC Study of 2206 women examining the association between fear of childbirth and duration of labor, revealing that duration was significantly longer in women with fear of childbirth (adjusted unstandardized coefficient 0.78; 95% CI: 0.20-1.35), corresponding to a 47-minute difference [35]. Another Norwegian study, based on the MoBa dataset (linked to the Norwegian Medical Birth Registry), investigated whether previous depression is associated with hyperemesis gravidarum (HG; $n = 731$ pregnancies with HG and $n = 81{,}055$ pregnancies without). The results indicated that a lifetime history of depression increased the odds for hospitalization for HG by approximately 50%. However, two-thirds of women with HG had neither a history of depression nor symptoms of depression at week 17th of gestation. Given the fact that only 1.2% of women with previous depression developed HG, depression did not appear to be a main driver in the etiology and pathogenesis of HG [36]. Lastly, another recent ABC Study on 1472 pregnant women assessed the association between postpartum PTSD symptoms and child's development focusing on gross motor skills, fine motor skills, communication development and socio-emotional development [37]. The study revealed that symptoms of postpartum PTSD had a prospective relationship with child's poor social-emotional development 2 years later (Table 1).

Examples of swedish studies

Swedish studies on perinatal mental health are the longitudinal population-based cohorts UPPSAT (UPPSala-AThens) [38] and 'Biology, Affect, Stress, Imaging, Cognition (BASIC) study' (www.basicstudie.se) in Uppsala [39], with extensive self-reports and biological samples from nearly 8.000 pregnancies. Works address both biological as well as psychosocial correlates and try to disentangle associations. A first study, given as an example, assessed the association between obstetric perineal lacerations and PPD showing a statistically significant association of severe lacerations with PPD, but only among women with low resilience (adjusted OR: 5.50, 95% CI: 1.20-26.00) and not the whole sample [40]. The second study examined whether untargeted gas chromatography–mass spectrometry plasma metabolomics are associated with antenatal depressive symptoms based on the Edinburgh Postnatal Depression Scale (EPDS) score cut off of $\geq$12 points, and whether there are seasonal differences in the metabolic profile of these women [41]. Seasonal differences were found in the metabolic profiles of control samples, suggesting favorable cardiometabolic profile in the summer versus winter, as indicated by the lower glucose and sugar acid and lactate to pyruvate ratio, and the higher abundance of arginine and phosphate. Similar differences were noted between cases and controls among summer pregnancies, providing evidence for an association between a stressed metabolism and depressive symptoms (Table 1). The ongoing national Mom2B study, based on a mobile application, has as an aim to predict women at high risk for peripartum depression (www.mom2b.se).

Other big longitudinal Swedish cohorts in the area include the KUB study (Kvinnors Upplevelse av Barnafödande: Women's Experience of Childbirth) [42], the BETTI-study [43], as well as the South East Sweden Birth Cohort (SESBiC) [44] and the Linköping cohorts [45].

An example of national register-based research is a 2016 Swedish study, which examined the prevalence of maternal suicide during pregnancy or within one year after childbirth using register-based data through linkage of the Swedish Cause of Death Register, the Medical Birth Register, and the National Patient Register [6]. The maternal suicide ratio was estimated at 3.7 per 100 000 live births, relatively stable during past decades. Compared to women born in high-income countries, the suicide ratio was higher in women born in low-income countries (OR: 3.10, 95% CI: 1.30-7.70; Table 1).

Current Nordic research contributions

Nordic countries have one of the lowest levels of maternal and neonatal morbidity and mortality worldwide [46]. These countries have developed a unique constellation of free of charge health care and universal screening programs provided by primary healthcare systems, attended by the vast majority of pregnant women [35,47]. As all women who actively seek help can get this, all relevant information on an entire female population is available in national registers covering both health care, but also e.g. socioeconomic and

partner status. These high-quality, nationwide and population-based data sources and the possibility to link individual data between each of them render the Nordic countries uniquely positioned to fill current evidence gaps in the field of perinatal mental health.

In addition, during the past decades, considerable efforts have been made in several countries to establish large longitudinal pregnancy or birth cohorts. Nordic countries are at the forefront in this respect with the Danish National Birth Cohort (DNBC), the Norwegian MoBa and ABC Studies, the FinnBrain Birth Cohort Study, the Icelandic SAGA cohort and the Swedish BASIC and Mom2B studies [37,39,48,49]. These cohort studies are some of the most extensive of its kind [50]. The large sample size, long follow-up, multiple measurement points, large geographic coverage, biological sampling and the possibility to link data to national registries renders them unique. Such databases facilitate the study of the prevalence of perinatal mental disorders, and further provide the opportunity to prospectively test etiological hypotheses, yielding comprehensive suggestions about the biological mechanisms behind these disorders. Moving into the field of precision medicine, these unique data sources may also assist deep phenotyping of individuals through the development of precise disease classification systems [42,51,52]. Another obvious strength is the large sample size, which allows the study of relatively rare risk factors and outcomes/disorders as well as of gene-environment interactions. The use of novel methods and approaches, such as the use of digital phenotyping data in the novel application-based Mom2B Swedish cohort (www.mom2b.se), recording even voice qualities and digital phenotyping, or the Danish study design paralleling a natural experiment are also considered strengths of such research [18,53]. Lastly, Denmark and Sweden have already established international collaborations by contribution to the Mom Genes Fight PPD (previously called PPD Act), a research study developed by Postpartum Depression: Action Towards Causes and Treatment (PACT) Consortium on genetic and social correlates of peripartum depression (www.pactforthecure.com; www.momgenesfightppd.org/) [54].

All data sources entail limitations, included those presented here for the Nordic countries. The described mother–-infant cohorts provide some of the biggest datasets focusing on perinatal mental health internationally. However, the number of women suffering from perinatal mental illness is still relatively low, directly compromising the power of the studies. Given the low occurrence of often both exposure and outcome, case–control studies could be considered when designing studies using the mother-infant cohorts, but we note such approaches could entail other sources of bias. Moreover, symptoms of depression have been assessed using self-reports, not psychiatric examinations in some datasets for practical reasons and given the high number of participants, which may have introduced misclassification bias. Lastly, regarding register-based studies, despite the large number of information registered in each country, this information is routinely recorded through the registries and not specifically collected to address a research question; thus, some additional data may not be available in these studies.

Conclusions-Future avenues

Overall, current research on perinatal mental health employing the unique methods and approaches implemented by Nordic data sources could give valuable examples in guiding future work focused on investigations that integrate study of background, genetic and environmental risk factors to ultimately define vulnerable groups at risk for psychiatric disorders following childbirth. This research background can be further enriched by increasing study power in the context of pooled analyses of primary Nordic data [55] and meta-analyses of the existing published studies. Basic research is also deemed necessary to replicate these results and comprehensively delineate the biological mechanisms behind perinatal mental disorders. Lastly, validation studies could provide clinically useful suggestions that would allow timely, cost-effective and targeted interventions to meet the end goal of prevention.

Acknowledgments

The authors sincerely thank all women who participated in the individual Nordic studies. We would also like to express our gratitude to all personnel for their valuable help in the data collection and administration of the studies.

Disclosure statement

The authors declare that they have no conflict of interest.

Funding

No fund was received for the present review study.

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