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From Prenatal Period to Middle Childhood

Maternal and paternal mental health predicting child mental health and development

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ACADEMIC DISSERTATION
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Sinä elämä, annoit minulle
tämän tehtävän.
Enkä minä rohjennut siitä kieltäytyä.

Hiukset ovat vielä kosteat, käsi haroo tyhjää.
Minun tehtäväni on
tarttua tähän käteen
ja taluttaa koko alkumatka.

Pieneksi tunnen minä itseni,
vielä pienemmäksi,
kuin tämä vastasyntynyt.

- Eeva-Liisa Kantola -

The love of a child

They're not looking for perfection
You're their parent; their all.
They just want to know they're loved
And that you'll come when they call.
They don't look at you in horror
When you haven't brushed your hair.
In fact, they don't care what you look like;
They just love that you are there.
They look to you for answers,
Perhaps a million questions a day
Because you're their source of wisdom
So it matters what you say.
It's not about status
Or diamonds and gold.
It's about genuine smiles
And a warm hand to hold.
And they look to you for kindness;
For unconditional love.
You are mum. You are dad.
You are more than enough.

- Ms Moem -

Contents

Abstract

Background: The transition to parenthood provides an opportunity to psychological growth, but also vulnerability to mental health problems, with potential long-term consequences on child mental health and development. This dissertation study aimed to examine the impact of pre- and postnatal parental mental health on children's psychosocial, cognitive and psychophysiological development in middle childhood. First, we identified distinct maternal and paternal mental health subgroups (latent trajectory groups) according to the timing and course of depression and psychological distress symptoms across the transition to parenthood. Second, we investigated parental symptoms separately and together as predictors of children's internalizing and externalizing mental health symptoms and social and cognitive developmental problems at 7-8 years as well as children's physiological stress regulation through salivary cortisol at 10-11 years. Third, we analyzed intrafamilial dynamics between mothers' and fathers' early mental health. We also investigated, whether and how the timing and course of fathers' early mental health symptoms were associated with early fathering experience. Finally, we examined the impact of family's former infertility on early parental mental health and its association with child mental health and development.

Method: The dissertation was part of a multidisciplinary prospective study, the Psychosocial Aspects after Assisted Reprocutive Tratment (PAART) that has followed Finnish families with and without infertility history from pregnancy to middle childhood. Participants consisted of 763 couples, about a half of them having conceived with assisted reproductive treatments (ART-group; *n* = 406) and another half being naturally conceiving (NC-group, *n* = 357). The couples were followed longitudinally over their transition to parenthood at three time points: the second trimester of pregnancy (T1), the early postpartum (T2, child two months), and the late postpartum (T3, child twelve months). They were again contacted when the children were 7-8 years old (T4), and a selection of them (*n* = 102) when the children were 10-11 years old (T5).

Results: First, we found stability and continuation of good parental mental health, but considerable variability in the timing and course of mental health problems across the transition to parenthood. *Stable and low levels of symptoms* were characteristic to majority of the mothers (75%) and fathers (79%). *Moderate increasing levels of symptoms* were typical of a group of fathers (9%), who reported low levels of symptoms during the pregnancy

that then gradually increased toward the early and the late postpartum, yet, not reaching clinical significance. Mental health problems were typically suffered only at a particular time point: during the *pregnancy only* (mothers 6%, fathers 5%), in the *early postpartum only* (mothers 9%, fathers 3%), or in the *late postpartum only* (mothers 6%). Also, *chronic or high sporadic mental health problems* throughout the transition were typical of small groups of mothers (4%) and fathers (4%).

Second, the results pointed out the importance of early parental mental health for later child mental health and development. Chronic or high sporadic maternal problems were especially harmful, as they predicted increased internalizing symptoms and cognitive developmental problems at 7-8 years. We found a specific timing effect of the early postpartum period, as maternal problems at two months predicted children's internalizing symptoms at 7-8 years as well as dysregulated diurnal cortisol patterns at 10-11 years. When maternal and paternal symptoms were analyzed together, maternal problems alone were found to form risk for children's internalizing symptoms, whereas additive effects of both maternal and paternal problems predicted problems in executive function.

Third, our study found two kinds of intrafamilial dynamics between mothers' and fathers' early mental health: *co-occurrence*, possibly reflecting spillover of emotions, and *compensation* for problems. In addition, the timing and course of fathers' early mental health symptoms were associated with early fathering experience. Fathers with stable and low levels of symptoms showed the most positive fathering experiences, whereas fathers with chronic or high sporadic problems the most negative ones. Mental health problems in the early fatherhood were associated with a timing-limited negative fathering experience, reported only when the child was two months old. Finally, our results support the argument of minor definite impact among families with former infertility, as infertility did not affect the timing and course of early parental mental health symptoms or their association with later child mental health and development.

Conclusions: This dissertation study emphasizes a heterogeneous, dynamic, and timing-specific nature of early maternal and paternal mental health problems. It highlights the importance of maternal mental health for later child mental health and physiological stress regulation, and the importance of both maternal and paternal mental health for later child cognitive development. Clinically, our findings emphasize the critical role of maternity clinics and child health centers in screening both parents for mental health symptoms. Providing help to families at multiple time points during the pre- and postnatal period should aim at avoiding mental health problems to impair early parenting and further on child development.

Tiivistelmä

Tausta: Siirtymä vanhemmuuteen tarjoaa mahdollisuuden psykologiseen kasvuun, mutta voi myös altistaa mielenterveysongelmille. Väitöskirjatyön tavoitteena oli tutkia äitien ja isien raskauden ja lapsen ensimmäisen elinvuoden aikaisten mielenterveysoireiden vaikutuksia lapsen psykososiaaliseen, kognitiiviseen ja psykofysiologiseen kehitykseen keskilapsuudessa. Ensiksi, muodostimme äitien ja isien spesifit mielenterveyden osaryhmät (latentit trajektoriryhmät) masennuksen ja psyykkisen kuormittuneisuuden ajoituksen ja kulun suhteen vanhemmuuteen siirtymässä. Toiseksi, selvitimme, kuinka äitien ja isien oirehdinta erikseen ja yhdessä ennusti lapsen mielenterveysoirehdintaa sekä sosiaalista ja kognitiivista kehitystä 7-8 vuoden iässä sekä psykofysiologista stressinsäätelyä syljen kortisolista analysoituna 10-11 vuoden iässä. Kolmanneksi, analysoimme äitien ja isien varhaisten mielenterveysoireiden perheensisäistä dynamiikkaa. Selvitimme myös, millä tavoin isän mielenterveysoireiden kulku ja ajoitus olivat yhteydessä varhaiseen isyyskokemukseen. Lopuksi, tarkastelimme perheen lapsettomuustaustan vaikutusta vanhempien mielenterveysoireiden ajoitukseen ja kulkuun sekä vanhempien mielenterveyden ja lapsen mielenterveyden ja kehityksen väliseen yhteyteen.

Menetelmä: Väitöstutkimus oli osa monitieteistä pitkittäistutkimusta (Psychosocial Aspects after Assited Reproductive Treatment, PAART), joka on seurannut suomalaisia lapsettomuustaustaisia ja verrokkiperheitä raskausajalta keskilapsuuteen. Tutkimme 763:a perhettä, joista noin puolet (n = 406) oli tullut raskaaksi hedelmöityshoidoilla. Perheet osallistuivat tutkimukseen vanhemmuuden siirtymän aikana kolmesti: raskauden toisella kolmanneksella (T1) sekä lapsen ollessa kahden kuukauden (T2) ja kahdentoista kuukauden ikäinen (T3). Perheitä tutkittiin jälleen lapsen ollessa 7-8 vuotias (T4), sekä osaa heistä (n = 102) lapsen ollessa 10-11 vuotias (T5).

Tulokset: Ensiksi, tulokset osoittivat hyvän mielenterveyden tasaista pysyvyyttä, mutta merkittävää dynaamisuutta ja vaihtelua mielenterveysongelmien ajoituksessa ja kulussa. *Tasainen, matala oirehdinta* oli tyypillistä valtaosalle äitejä (75%) ja isiä (79%). *Kohtalainen, lisääntyvä oirehdinta* kuvasi isäryhmää (9%), joka raportoi matalaa oirehdintaa raskausajalla, mutta asteittain lisääntyvää oirehdintaa lapsen syntymän jälkeen. Oirehdinta ei kuitenkaan ollut kliinisesti merkitsevää. Äidit ja isät kärsivät

mielenterveyden ongelmista tyypillisesti vain yhdessä vanhemmuuden siirtymän vaiheessa: *ainoastaan raskausaikana* (äidit 6%, isät 5%), *ainoastaan lapsen ollessa kahden kuukauden ikäinen* (äidit 9%, isät 3%), tai *ainoastaan lapsen ollessa kahdentoista kuukauden ikäinen* (äidit 6%). Lisäksi, *krooninen tai korkea vaihteleva oirehdinta* läpi vanhemmuuden siirtymän oli tyypillistä pienelle ryhmälle äitejä (4%) ja isejä (4%).

Toiseksi, tulokset osoittivat vanhempien mielenterveyden raskausaikana ja lapsen ensimmäisen elinvuoden aikana olevan tärkeä lapsen myöhemmälle hyvinvoinnille ja kehitykselle. Äidin krooninen tai korkea vaihteleva oirehdinta oli erityisen haitallinen, ennustaen lapsen lisääntynyttä sisäänpäin suuntautunutta mielenterveysoirehdintaa sekä kognitiivisen kehityksen pulmia. Vauvan ensimmäiset elinkuukaudet näyttäytyivät lapsen hyvinvoinnin kannalta keskeiseksi vaiheeksi, sillä äidin oirehdinta lapsen ollessa kahden kuukauden ikäinen ennusti lapsen myöhempää sisäänpäin suuntautunutta mielenterveysoirehdintaa sekä kortisolisäätelyn pulmia. Kun äitien ja isien oirehdintaa tarkasteltiin yhdessä, äidin ongelmat (riippumatta isästä) ennustivat lapsen mielenterveysoirehdintaa, kun taas kummankin vanhemman oirehdinnalla oli oma merkityksensä lapsen kognitiiviseen kehitykseen.

Kolmanneksi, tutkimuksessa löydettiin kahdenlaista perheensisäistä dynamiikkaa äitien ja isien mielenterveysoirehdinnassa: *yhteisesiintymistä* (co-occurrence), heijastaen mielenterveyden oireiden siirtymisiä puolisoiden välillä, sekä puolison oirehdinnan *kompensointia*. Lisäksi, isien mielenterveysoirehdinnan ajoitus ja kulku oli tärkeä varhaiselle isyyskokemukselle. Tasainen, matala oirehdinta oli yhteydessä myönteisimpään isyyskokemukseen, kun taas krooninen tai korkea vaihteleva oirehdinta kielteisimpään kokemukseen. Oirehdinta ainoastaan lapsen ollessa kahden kuukauden ikäinen oli yhteydessä lyhytkestoiseen kielteiseen isyyskokemukseen kyseisenä ajankohtana. Lopuksi, tulokset antoivat tukea käsitykselle hedelmöityshoitoja saaneiden perheiden vähäisistä erityispiirteistä, sillä lapsettomuustausta ei vaikuttanut vanhempien mielenterveyden ajoitukseen ja kulkuun, tai sen yhteyteen lapsen mielenterveyteen ja kehitykseen.

Johtopäätökset: Tutkimus korostaa vanhempien varhaisten mielenterveysongelmien heterogeenista, dynaamista ja aika-spesifiä luonnetta. Se nostaa esiin äidin varhaisen mielenterveyden merkitystä lapsen myöhemmälle mielenterveydelle ja stressinsäätelylle, sekä molempien vanhempien mielenterveyden merkitystä lapsen kognitiiviselle kehitykselle. Kliinisesti, tulokset korostavat neuvoloiden roolia molempien vanhempien oirehdinnan seulomisessa. Apua tulisi tarjota perheille useina vanhemmuuden siirtymän ajankohtina, jotta oirehdinta ei häiritsisi varhaista vanhemmuutta ja edelleen lapsen kehitystä.

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List of original publications

The thesis is based on the following three original publications, referred in the text as Articles I-III. The fourth part of the thesis (Article IV) has not yet been published but has been accepted for publication in Family Relations -journal.

I. Vänskä, M., Punamäki, R-L., Tolvanen, A., Lindblom, J., Flykt, M., Unkila-Kallio, L., Tiitinen, A., Repokari, L., Sinkkonen, J., & Tulppala, M. (2011). Maternal pre- and postnatal mental health trajectories and child mental health and development: Prospective study in a normative and formerly infertile sample. *International Journal of Behavioral Development*, 35(6), 517–531. doi: 10.1177/0165025411417505

II. Vänskä, M., Punamäki, R-L., Tolvanen, A., Lindblom, J., Flykt, M., Unkila-Kallio, L., Tulppala, M., & Tiitinen, A. (2016). Paternal mental health trajectory classes and early fathering experiences: Prospective study on a normative and formerly infertile sample. *International Journal of Behavioral Development.* doi: 10.1177/0165025416654301

III. Vänskä, M., Punamäki, R-L., Lindblom, J., Tolvanen, A., Flykt, M., Unkila-Kallio, L., Tulppala, M., & Tiitinen, A. (2015). Timing of early maternal mental health and child cortisol regulation. *Infant and Child Development, 25*, 461–483. doi: 10.1002/icd.1948

IV. Vänskä, M., Punamäki, R-L., Tolvanen, A., Lindblom, J., Flykt, M., Unkila-Kallio, L., Tulppala, M., & Tiitinen, A. (in press). Parental pre- and postpartum mental health predicts child mental health and development. *Family Relations.*

1 Introduction

Conception means beginning of new life. It triggers a physiological process in female body that begins with a fertilized egg and, in optimal case, inescapably leads to a fully developed fetus, ready to embrace life outside the womb. At the same time, conception marks a beginning of new life period for future parents. A gradual transformation and reorganization begins to unfold in their minds, preparing them for new responsibilities of parenthood. Once the child is born, the family starts to build its unique patterns of early interaction, composed of touch, voice, movement and gaze. Across the child's first year, these communication patterns become more diverse, but also increasingly stable, enabling for the family, for example, its unique ways of experiencing proximity and separation. Although family life changes continuously, its most important foundations are constructed during the pre- and postpartum period; from parental perspective, the transition to parenthood.

The transition to parenthood with its intensive reorganization provides a significant opportunity to psychological growth, but, at the same time, also vulnerability to mental health problems (Aber, Weiss, & Fawcett, 2013; Cohen & Slade, 2000; Cowan & Cowan, 2000). Mothers as babies' primary caregivers have been under intensive developmental research for decades. The impact of their mental health, particularly depression, on children has been widely studied. Compared to children of non-depressed mothers, children of depressed mothers are over three times more likely to suffer from depression themselves and the likelihood of other mental health and developmental problems is also increased (Weissman et al., 2016). Unlike mothers, fathers have often been sidelined in developmental research as well as in health and social services. The paternal role in infant and child development has been largely undermined, despite significant changes in Western societies over the past decades (Crespi & Ruspini, 2015). Fathers of today are not only welcomed, but expected to participate in prenatal care, delivery, and most importantly in nurturing and caring for their infants and children (Caracciolo di Torella, 2014). The importance of their well-being for children is becoming realized (Gutierrez-Galve, Stein, Hanington, Heron, & Ramchandani, 2015; Sethna, Murray, Netsi, Psychogiou, & Ramchandani, 2015).

Multiple research gaps exist in the study fields of family mental health and developmental psychopathology, which is where this dissertation aims to contribute its findings. First, concerning early parental mental health, a better understanding of variability between individuals in the longitudinal patterns of symptoms is needed. Accordingly, this study utilizes a person-oriented approach to investigate heterogeneity in the timing and course of mothers' and fathers' symptoms across the transition to parenthood. Second, neurodevelopmental studies suggest the existence of sensitive developmental periods (Pechtel & Pizzagalli, 2011; Rincón-Cortés, & Sullivan, 2014), but research among infants is scarce. Therefore, this study investigates the existence of children's age-specific sensitive periods to maternal mental health during the pre- and postpartum period, by analyzing the unique importance of different timings of maternal problems for child development. Third, family relations comprise children's primary developmental environments, and to better understand the individual patterns of adjustment and maladjustment, richer characterizations of the interplay between different family members is needed (Cowan & Cowan, 2000; Davies & Cicchetti, 2004). Accordingly, this study aims at merging family systemic and developmental psychopathology approaches, by focusing on the complex interplay between maternal and paternal mental health symptoms in predicting child development. Finally, more information is needed regarding potentially unique characteristics of family mental health and child development among families with early risks. This study includes a medical risk group of families who have suffered involuntary infertility and achieved parenthood through fertility treatments.

Figure 1 presents the conceptual map of this dissertation. The uppermost part of the figure focuses on the *transition to parenthood*, introducing key concepts and associations related to early maternal and paternal mental health. These will be covered in detail in Chapter 2. The lowest part of the figure focuses on *child mental health and development*, encompassing the four central child developmental phases of this study: the fetal period, the early and late infancy, and the middle childhood. These will be covered in Chapter 3. The central part of the figure presents *the impact of early maternal and paternal mental health on child development*, introducing potential mechanisms, child- and family-related contextual factors, as well as suggested theoretical models explaining joint parental mental health impacting children. These will be covered in Chapter 4. Finally, the figure illustrates also concepts and associations that are not empirically analyzed in this study, but are important for a deeper understanding of the research area. Those are marked in the figure with gray, italicized font.

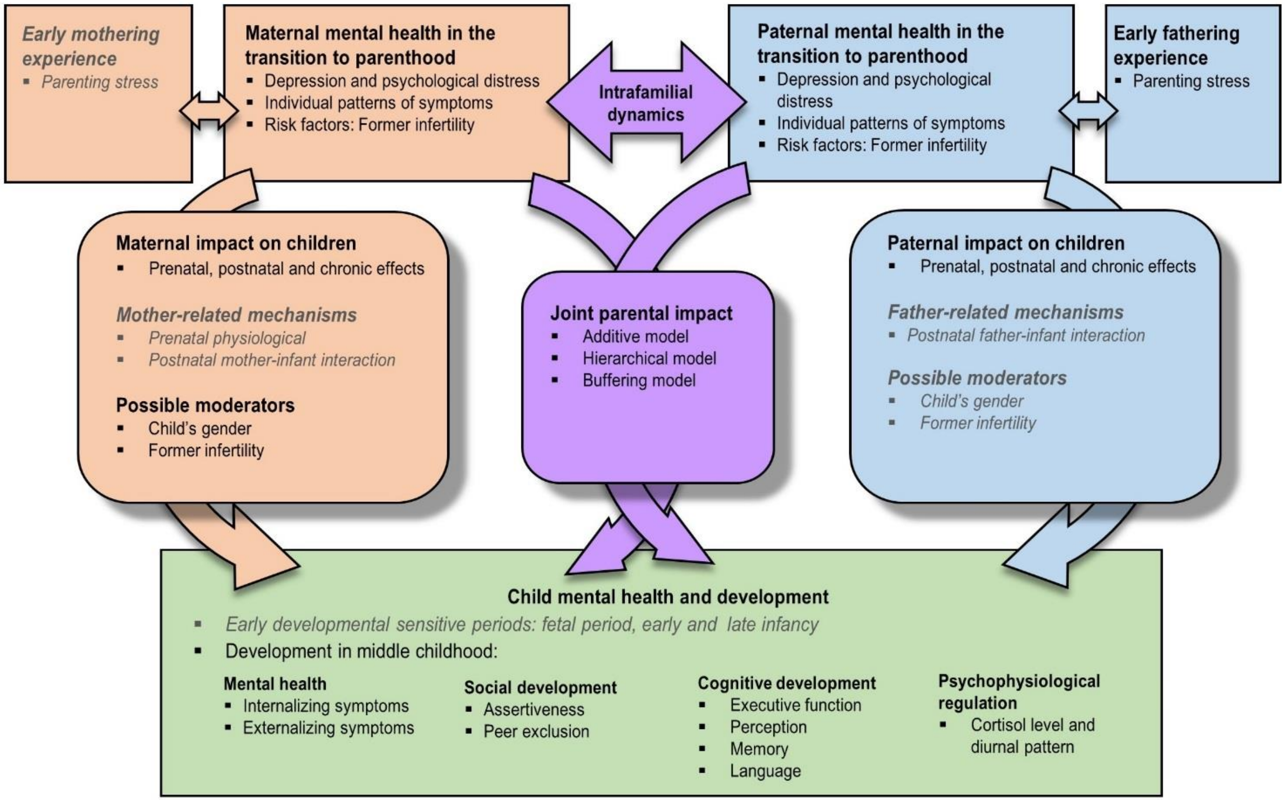

Figure 1. Conceptualization of early parental mental health and its impact on child mental health and development

2 Maternal and paternal mental health in the transition to parenthood

The transition to parenthood begins with the hope of a child, continues through pregnancy and birth and further on to the postpartum period (Aber et al., 2013; Deave & Johnson, 2008). It describes the physical, social and psychological transition from a non-parenting person to a mother or a father, or among multiparous parents, from the parent of a single child to the parent of multiple children, and so on for subsequent children (Stern, 1995). From the perspective of psychological well-being, the transition to parenthood is characterized by complexity and innate conflict: becoming a parent is usually experienced as an important source of joy and purpose in life, but also a significant source of stress and worry (Cohen & Slade, 2000; Cowan & Cowan, 2000; Nelson, Kushlev, & Lyubomirsky, 2014). Mental health symptoms during this period are relatively common.

This chapter will focus on maternal and paternal mental health in the transition to parenthood (see Figure 1). Particular attention will be given to heterogeneity of timing and course of problems, leading to individual patterns of symptoms across the transition. In addition, mental health risk factors, particularly the role of family's former infertility, will be covered. Finally, associations between maternal and paternal mental health symptoms, called intrafamilial dynamics, as well as the role of mental health in the early parenting experience will be addressed.

2.1 Depression and psychological distress

Mental health problems in the transition to parenthood are known to affect approximately 20-40% of mothers (Figueiredo & Conde, 2011; Lee et al., 2007; O'Hara, 2009) and 10-20% of fathers (Figueiredo & Conde, 2011; Paulson & Bazemore, 2010; Smith, Eryigit-Madzwamuse, & Barnes, 2013). The term *mental health problem* is widely used when referred to a variety of psychiatric conditions, varying from mild symptoms of distress to severe psychiatric disorders. In this dissertation, we focus on relatively mild and common mental health problems, including both clinical and subclinical levels of symptoms.

Depression is a condition typically chracaterized by persistent low mood and a loss of interest or pleasure in life. A depressed person can suffer from chronic fatigue, feelings of worthlessness and guilt, changes in appetite and sleep, as well as difficulty in concentrating (American Psychiatric Association, 2013). When depressive symptoms are severe and pervasive, the condition is referred to as a major depression; with milder and fewer symptoms, it is called a minor or a subclinical depression. Depression in the transition to parenthood has been widely studied. A systematic review by Gavin et al. (2005) found that over 18% of mothers suffer depressive symptoms during the pregnancy, with as much as 13% having major depression; in the postpartum period depressive symptoms affected 19% and severe symptomatology 7% of mothers. Concerning fathers, studies have reported significantly lower depression levels throughout the transition, with about 5-10% suffering depression prenatally and about 3-5% during the early postpartum period (Bradley & Slade, 2011; Ramchandani & Psychogiou, 2009).

In addition to depression, other distress symptoms may also be significant in describing the mental health of expecting and new parents. *Psychological distress* is a term used to describe a combination of relatively mild psychological problems, including depression, anxiety and other distress symptoms (e.g. Kingston, Tough, & Whitfield, 2012). *Anxiety* refers to disorders and symptoms that share features of excessive fear and anticipation of future threat (American Psychiatric Association, 2013). An anxious person typically has high muscle tension, is vigilant and cautious, and may avoid situations and behaviors that appear threatening. Although much less studied, anxiety in the transition to parenthood seems to be at least as common as depression, and together they are the two most common mental health problems in the transition to parenthood (Lee et al., 2007). Prenatal anxiety has been suggested to affect as much as 32 - 36% of mothers (Lee et al., 2007) and postnatal anxiety approximately 20-30% of mothers (Seymour, Giallo, Cooklin, & Dunning, 2015; Vismara et al., 2016). The limited number of studies that have analyzed paternal anxiety have suggested lower levels of symptoms compared to mothers throughout the transition (Matthey, Barnett, Howie, & Kavanagh, 2003; Figueiredo & Conde, 2011; Vismara et al., 2016). For instance, Figueiredo and Conde (2011) reported that about 8-10% of fathers suffered anxiety during the pregnancy, and only about 4-8% in the early postpartum.

The higher incidence of depression and anxiety among new mothers compared to fathers may reflect various differing experiences. First, it may relate to a general gender-typical difference in the frequency of these symptoms, with women experiencing and reporting more depression and anxiety throughout the life-span

(Hopcroft & Bradley, 2007; Van de Velde, Bracke, & Levecque, 2010). Second, it may reflect maternal and paternal role differences in the transition to parenthood. Mothers as carriers of the pregnancy as well as infants' usual primary caregivers may be more profoundly affected by the demands of the transition, and thus more vulnerable to mental health problems (Escribà-Agüir & Artazcoz, 2011). Third, depression and anxiety can be difficult to assess in fathers, as most scales used to detect problems may neglect important symptoms present in men (Melrose, 2010). For example, depressed fathers may be less melancholic and sad, and more irritable, angry and cynical (Marcus et al., 2005; Winkler, Pjrek, & Kasper, 2005). They are likely to display sleeping difficulties and social dysfunction, such as withdrawal from family and other interactions (Marcus et al., 2005). Therefore, to capture a comprehensive picture of both maternal and paternal problems, a wider spectrum of psychological distress symptoms should be studied.

In the transition to parenthood, *sleeping difficulties* are a common source of distress among both mothers and fathers (Facco, Kramer, Ho, Zee, & Grobman, 2010; Gay et al., 2004). Across the pregnancy, maternal amount and quality of sleep decreases, and at the same time, daytime sleepiness increases; at the end of the pregnancy, two thirds of mothers experience their overall sleep quality as bad, which is mainly due to discomfort and pain (Hutchinson et al., 2012). In the postpartum period, mothers experience significant sleep disruption related to infant sleep and feeding patterns (Mc Guire, 2013). Even though the total amount of sleep may be sufficient, fragmented sleep poses substantial problems (Bonnet & Arand, 2003). Importantly, also new fathers are affected by the infant sleep-wake cycles and nighttime childcare. According to Gay et al. (2004), fathers obtain even less sleep than mothers in the postpartum period, when measured objectively throughout the entire 24-hour day. Both maternal and paternal sleeping difficulties are of particular concern due to their robust associations with other mental health problems. In particular, studies show maternal prenatal sleeping difficulties to predict postpartum depression (Okun, Hanusa, Hall, & Wisner, 2009) and postpartum sleeping difficulties to predict depression symptom severity (Postmontier, 2008b).

Social dysfunction refers to inability to perform everyday tasks and social activities. In the transition to parenthood, it relates for instance to difficulties in running the household, taking care of the infant and other children, maintaining marital and social relationships and providing income for the family (Postmontier, 2008a). Studies have shown that about half of the postpartum women achieve their pre-pregnancy functional levels by six weeks postpartum, and three-fourths by twelve weeks postpartum (Mc Veigh, 1997). However, parents with mental health problems may face more difficulties in performing these every-day activities. Posmontier's study (2008b) found that postpartum depression predicts decreased social functioning among mothers. Interestingly, studies show social dysfunction to persist even after the remission of depression (Kennedy, Foy, Sherazi, McDonough, & McKeon, 2007), thus continuing to interfere with parental psychosocial well-being, even if other distress symptoms would be no longer present.

In order to capture a comprehensive picture of the relatively mild and common parental mental health problems, this study uses two mental health indicators: depression and psychological distress, with the latter comprising symptoms of anxiety, depression, sleeping difficulties, and social dysfunction.

2.1.1 Longitudinal course of symptoms

Research focusing on the course of parental pre- and postnatal mental health symptoms has provided conflicting evidence. Some studies have suggested stability of symptoms to characterize both maternal and paternal experiences from the pre- to postnatal period. For instance, Paulson, Bazemore, Goodman, and Leiferman (2016) reported that 75% of prenatally depressed mothers and 86% of fathers remained depressed until six months postpartum. Other studies have instead suggested considerable variability in the course of symptoms, with elevated levels of symptoms being most apparent only at specific pre- or postnatal time points. Matthey, Barnett, Ungerer, and Waters (2000) reported that a majority of the mothers and fathers who were depressed during the transition showed clinically significant symptom levels only at one assessment point. In their study, 73% of the mothers who were depressed at early postpartum had not been depressed during the pregnancy, and 70% of the fathers who were depressed at late postpartum had not been depressed either prenatally or during the early postpartum.

Concerning mothers, majority of current and recent research has suggested prenatal depression and anxiety rates to be higher than the postnatal ones (e.g. Figueiredo & Conde, 2011; Paulson et al., 2016), thus potentially pointing pregnancy as the most intensive maternal reorganizational phase of the transition. Furthermore, longitudinal analysis of the prenatal period has revealed that maternal depression and anxiety are more prevalent in the first and third trimesters and less prevalent in the second trimester (Lee et al., 2007). Such a U-shaped relationship between stages of pregnancy and the incidence of maternal anxiety and depression may relate to the typical consideration of the course of pregnancy: whereas most marked physiological, hormonal and psychological challenges usually take place in the early and late stages of gestation, the mid-pregnancy is often described as a time of maternal balance and 'blossom'. Mental health problems during the second trimester of pregnancy may therefore be indicative of a more severe prenatal symptomatology.

In the postpartum period, higher maternal depression and anxiety have been reported during the early as compared to the late months of the child's first year. As an example, in the study of Escribá-Aguir and Artazcoz (2011) 9% of mothers displayed depression at three months postpartum, whereas only 4% at twelve months postpartum. Such declining course of postnatal symptoms is likely to reflect an intensive adaptation period during the first few months of motherhood, with normalization of feelings and routines of childcare becoming more apparent toward the end of the first year. Instead of a steady decline, some studies have reported a more variable course of postnatal maternal depressive symptoms. For instance, Luoma et al. (2001) found repeated episodes to be typical to maternal postnatal depression.

Among fathers, some studies have not found any changes in the rates of mental health symptoms from the pre- to postnatal period (e.g. Deater-Deckard, Pickering, Dunn, & Golding, 1998). Others have instead suggested a more variable course of symptoms, by reporting a decrease in the prevalence of paternal depression from the pregnancy to the early postpartum, and then a gradual increase toward the late postpartum (Cox, 2005; Matthey et al. 2000). According to a meta-analysis by Goodman (2004), paternal postnatal depression is typical to follow an earlier onset of depression in mothers, with the incidence among fathers increasing across the first postnatal year.

In an attempt to capture the longitudinal course of both maternal and paternal early mental health symptoms, this study focuses on three specific measurement points across the transition to parenthood: the second trimester of pregnancy, as well as two months and twelve months postpartum. Importantly, the conflicting prior evidence concerning the course of early parental symptoms may reflect uniqueness of experiences between individuals. Thus, instead of describing the average symptom course of *all* mothers or fathers, we aim at capturing some of these personal experiences, by utilizing a person-oriented approach.

2.1.2 Individual patterns of symptoms

Significant individual differences are likely to exist in the longitudinal course of early maternal and paternal mental health symptoms. For instance, postpartum depression may be a short-lived episode in some parents, but a chronic condition in others. Similarly, some parents may display clinical levels of symptoms during the pregnancy only, whereas symptoms in others may peak at multiple pre- and postnatal time points. Furthermore, some new parents may experience symptoms that do not reach clinical severity at any point of the transition; yet, these subclinical symptoms may pose significant problems to parental functioning, thus making their recognition relevant (Goodman & Tully, 2009; Weinberg et al., 2001). However, traditional variable-oriented approach has been unable to reach such diversity of experiences between individuals, mainly because it assumes that all individuals follow the same course of mental health symptoms, and thus tends to focus on clinical cut-off scores or average levels of symptoms in the population.

The *person-oriented approach* is better able to detect subtle variability between individuals (Bergman & Lundh, 2015; Magnusson, 1999). The paradigm stresses unique individual experiences and complexity of processes. Despite complexity, individual development is lawful and structured, which allows, at a more global level, the identification of often occurring, typical developmental patterns (Bergman & Trost, 2006). In other words, person-oriented methods aim to detect separate homogenous groups of individuals based on patterns across multiple variables. Concerning mental health, these groups can represent unique profiles and/or changes over time.

Following the person-oriented approach, research has begun to examine individual differences in the course of mental health symptoms, by describing early maternal depression trajectories. Those describe unique and meaningful subgroups of mothers, based on the timing and course of depression symptoms in the transition to parenthood. Two studies have described maternal trajectories from pregnancy into two years of mothering (Guyon-Harris, Huth-Bocks, Lauterbach, & Janisse, 2016; Mora et al., 2009), one from pregnancy into adolescence (Luoma, Korhonen, Salmelin, Helminen, & Tamminen, 2015), and one from postpartum into middle childhood (Campbell, Matestic, von Stauffenberg, Mohan, & Kirchner, 2007). In these studies, the majority of mothers belonged to trajectories with low stable or low decreasing symptom course (Campbell et al. 82%, Guyon-Harris et al. 70%, Luoma et al. 71% and Mora et al. 71%). Some mothers displayed postpartum depression that decreased (Mora et al. 9% and Campbell et al. 6%) or increased across the child's early years (Guyon-Harris et al. 8%, Mora et al. 7% and Campbell et al. 6%). Furthermore, a proportion of mothers suffered from prenatal depression only (Mora et al. 6%), chronic high symptoms (Campbell et al. 3% and Mora et al., 7%), or intermittent symptoms (Luoma et al. 3%).

To our knowledge, no study has so far identified paternal pre- and postnatal mental health trajectories, and studies on maternal trajectories have focused merely on depressive symptoms. This dissertation focuses on multiple psychological distress symptoms in addition to depression, as we identify early maternal and paternal trajectories from the pregnancy to the late postpartum.

2.2 Mental health risk factors

Multiple factors influence mental health in the transition to parenthood. First, a person's genetic background forms the biological basis of his or her mental health and its vulnerability to dysfunction. Yet, experiences during the early and - to some extent - later development can strongly affect the impact of genes. Second, intensive multilevel changes take place in the transition to parenthood, demanding psychological adaptation and reorganization. These demands can play a significant role in the development of early parental mental health problems. Third, some families are exposed to specific social or medical risks, such as poverty, single-parenthood or parental somatic illnesses, which can increase maternal and paternal vulnerability to mental health problems. This study includes a medical risk group of families who have suffered involuntary infertility and achieved parenthood through fertility treatments.

2.2.1 Genetic background and early-life experiences

Research shows moderate to high heritability of mental health problems. For example, heritability of depression appears to be 40-50%, perhaps even higher in severe cases (Edvardsen et al., 2009). A person with a close relative who suffers from depression is three to five times as likely to develop it him- or herself. Furthermore, propensity to other psychological distress symptoms, such as anxiety, is similarly heritable (Mihoko, Takeshi, & Hettema, 2015). However, like most common diseases and disorders, depression and psychological distress are not simply 'caused' by any specific genes. Instead, there seem to be combinations of genetic changes that can make people particularly sensitive to stress, prone to negative affectivity, and thus vulnerable to depression, anxiety and other mental health problems (Bogdan, Nikolova, & Pizzagalli, 2013).

Importantly, *epigenetic* studies have shown that the activation of genes is strongly impacted by environmental factors and developmental experiences (Pembrey, Saffery, & Bygren, 2014). Genes can also interact with the environment in determining the course of individual development and well-being. As an example of gene-environment interaction, individuals with different genotypes have *differential susceptibility* to both risks and benefits in their social environments, thus making some people genetically more vulnerable to mental health problems under adverse social conditions (Hartman & Belsky, 2016). Early-life experiences during the pre- and postnatal period can be particularly important in directing development until adulthood, together and in interaction with genes. These early-life processes and mechanisms will be discussed in more detail in Chapter 3.

2.2.2 Multilevel changes in the transition to parenthood

Although exciting and delightful, becoming a parent is characterized by profound need for adaptation (Cohen & Slade, 2000; Cowan & Cowan, 2000). In both men and women, it involves physical, hormonal and neurobiological alterations (Feldman, 2007; Gray, & Campbell, 2009; Kim et al., 2010), significant psychological changes (Ammaniti, Trentini, Menozzi, & Tambelli, 2014; Stern, 1995), and social adjustments (Cowan and Cowan, 2000; Bost, Cox, Burchinal, & Payne, 2002). Although these intensive multilevel changes provide significant opportunities to growth and psychological integrity, they also make the transition to parenthood a high-risk period for the development of mental health problems (Bradley & Slade, 2011; O'Hara, 2009).

Importantly, despite marked reorganization in both parents, unique experiences characterize transition to mother- and fatherhood. Among *mothers*, the most intensive transformation takes place during the pregnancy, when physical and psychological levels of experience are deeply intertwined (Broden, 2004; Rafael-Leff, 1991). First, hormonal changes such as increases in estrogen and progesterone affect the body and may induce maternal emotional sensitivity, fatigue, nausea, and changes in appetite. Second, the size and shape of maternal body changes dramatically over the course of pregnancy, thus challenging psychological ability to accept the changing body figure and its' restrictions. Third, on psychological level, the mother begins to construct fantasies and representations of the baby from early pregnancy on (Cohen & Slade, 2000). These representations play an important role in the reorganization process that prepares the mother to meet the real child and the responsibility of motherhood (Flykt, 2014). As the psychoanalytic literature has described, this reorganization is challenging and therefore intrinsically involves also ambivalent and negative feelings related to pregnancy and parenthood (e.g. Broden, 2004). To sum it up, difficulty in accepting and managing the consequences of prenatal hormonal and physiological changes as well as the ambivalent feelings related to parenthood may increase the likelihood of maternal pre- and postnatal mental health problems.

Interestingly, also *paternal* physiology goes through a substantial transformation during the pregnancy, with psychological consequences. For instance, prenatal decline in the testosterone hormone allows biological basis for psychological preparation to fatherhood (Gray & Campbell, 2009). These paternal prenatal processes have been largely ignored in research, and it is therefore not clear to what extent mothers and fathers experience similar or different phenomena. Some studies have suggested that, similar to mothers, fathers form representations and attachment to the child already in early pregnancy (Habib & Lancaster, 2006) and they remain relatively stable until the late postpartum (Vreeswijk, Maas, Rijk, Braeken, & van Bakel, 2014). Other studies have instead suggested quite weak prenatal psychological preparation among fathers, with most adaptation taking place only after the birth of the child (e.g. Genesoni & Tallandini, 2009), thus making the postpartum period psychologically more demanding for fathers.

Giving birth represents a profound landmark for couples. For the mother it is an extreme challenge, comprising a unique combination of intense pain, risk of physical injury, emotional stress, vulnerability, permanent role change, as well as responsibility for a dependent, helpless newborn child (Simkin, 1992). A positive birth experience can be profoundly empowering, whereas negative experience may be traumatizing, with long-term negative impact on maternal well-being (Kendall-Tackett, 2015). Once the baby is born, an instant shift from anticipating and preparing for parenthood to engaging in early parenting tasks is needed. New parents may feel overwhelmed by this rapid change, and mixed emotions such as happiness and pride, combined with uncertainty, fear and frustration are common (Chin, Hall, & Daiches, 2011; Cowan & Cowan, 2000). New mothers, in particular, are faced with a considerable amount of disruption in life style, as the intensive demands of infant care, fatigue, and loss of personal time and space become a reality (Aber et al., 2013). New fathers, in turn, can experience confusion over their role in early family life and childcare (Chin et al., 2011). Furthermore, as both parents undergo significant transformation, the marital relationship changes as well. In particular, couples with babies can find it challenging to combine both the marital and parenting roles in the emergence of new triadic family organization (Adamsons, 2013). A decline in marital satisfaction from pre- to postnatal period is typically experienced (Lawrence, Cobb, Rothman, Rothman, & Bradbury, 2008). To sum it up, negative birth experiences, as well as difficulties in managing the uncertainties and changes of early parenthood can induce the development of maternal and paternal postpartum mental health problems.

Throughout the transition, psychological vulnerability - possibly induced by genetic factors, adverse childhood experiences, and/or previous psychological problems - can markedly increase the likelihood of mental health problems (Lee et al., 2007; Keeton, Perry-Jenkins, & Sayer, 2008). Similarly, current external factors such as social support and family economic security play an important role in the early parenting, and vulnerabilities in them can predispose new parents to problems (O'Hara & Swain, 1996; Perren, von Wyl, Burgin, Simoni, & von Klitzing, 2005). In addition, some mothers and fathers have medical problems, such as somatic dysfunctions or diseases that can increase the likelihood of mental health problems. One example of such medical risks is the couple's *infertility history*, in other words, difficulties in achieving the pregnancy and parenthood. Half of the couples in this study had suffered infertility and got pregnant through assisted reproductive treatment (ART), which is why the impact of infertility on early parental mental health is a specific focus of the study.

2.2.3 Role of former infertility

Infertility - the inability to achieve pregnancy within a year of regular unprotected intercourse - is common. It affects nearly one in six couple in the western world and more than five percent of Finnish children are today born after ART (National Institute of Health and Welfare, 2017). Those include in vitro fertilization (IVF), intrauterine insemination (IUI), intracytoplasmic sperm injection (ICSI) and frozen embryo transfer (FET). In 2015, about 18% of all ART treatments in Finland led to live births (NIHW, 2017). Due to risks related to multiple pregnancies, single embryo transfers are typically conducted.

Importantly, infertility and ART might negatively impact parental mental health in the transition to parenthood at least through two different mechanisms:

increased medical risks related to ART pregnancies as well as direct psychological effects of infertility. First, pregnancies after ART involve more risks than pregnancies of naturally conceiving (NC) couples. Some, but not all of them could be explained by the higher prevalence of multiple pregnancies and the average higher age of the mother in ART pregnancies (Schieve et al., 2007). However, even with these obstetric risks controlled, a greater proportion of premature birth and low birth weight infants have been reported (for a review, see Pandey, Shetty, Hamilton, Bhattacharya, & Maheshwari, 2012). In addition, maternal prenatal vaginal bleeding, reduced placenta function, preeclampsia and gestational diabetes have found to be more typical in the ART than NC pregnancies (Koivurova et al., 2002; Poikkeus, Gissler, Unkila-Kallio, Hyden-Granskog, & Tiitinen, 2007). Concerning birth, induction of delivery and caesarian section are significantly more common among ART mothers (Helmerhorst, Perquin, Donker, & Keirse, 2004; Poikkeus et al., 2007). Importantly, these pregnancy and birth complications are known to increase the likelihood of early parental mental health problems. For example, preterm delivery may be a traumatic event for the mother, with both immediate and long-term mental health consequences (Misund, Nerdrum, Bråten, Pripp, & Diseth, 2013).

Second, infertility is usually stressful, and treatments, particularly unsuccessful ones, burdening (Burns, 2007). ART pregnancies are often preceded by prolonged periods of uncertainty and disappointment, as well as high emotional and other investments. Identification with the label 'infertile' may be enduring (Hjelmstedt, Widström, Wramsby, & Collins, 2004). In line with this, some studies do suggest ART parents to be at increased risk of early depression and anxiety (Fisher, Hammarberg, & Baker, 2005; Monti et al., 2015), as well as early parenting difficulties (Fisher et al., 2005). Particularly ART mothers are prone to pregnancy- and fetal-health-related anxiety (McMahon, Ungerer, Beaurepaire, Tennant, & Saunders, 1997). Some studies have also suggested higher prenatal aggression and anxiety (Hjelmstedt, Widström, Wramsby, Matthiesen, & Collins, 2003) and lower self-esteem (McMahon & Gibson, 2002) among ART fathers. In contrast, other studies, including a systematic review by Hammarberg, Fisher and Wynter (2008), suggest none or minor differences in the mental health between ART and NC parents. To our knowledge, no previous study has directly compared the timing and course of early mental health problems between ART and NC parents. We utilize latent mental health trajectories to analyze the longitudinal course of problems across the transition to parenthood among ART and NC mothers and fathers.

2.3 Intrafamilial dynamics in early parental symptoms

Family systems perspective has proposed the idea of individuals being inseparable parts of emotional entities - families - and thus unable to be understood in isolation from one another (Cox & Paley, 1997; Minuchin, 1985). Interaction patterns, emotional expressions, and ways of coping with stress and negative emotions are examples of psychological processes that can strongly influence other family members. Regarding family mental health, maternal and paternal symptoms are likely to be interconnected in multiple ways. It is essential to acknowledge the interplay of mental health symptoms within a couple, to provide effective family based interventions (Paulson & Bazemore, 2010; Paulson et al., 2016).

Co-occurrence of parental mental health symptoms has often been reported. It possibly reflects a spillover effect, where emotions and symptoms transfer directly from one parent to the other (Paulson, Dauber, & Leiferman, 2006). Conflicting views remain concerning the direction of the effect. One study evidenced reciprocal associations: depressive symptoms in either parent at three months postpartum predicted symptoms in the other parent at six months postpartum, proposing that mothers and fathers would be equally affected by difficulties of the partner (Vismara et al., 2016). Other studies have instead suggested mothers as children's primary caregivers to be more dependent on partner well-being. In the study of Paulson et al. (2016), paternal prenatal depression predicted a significant increase in maternal postnatal symptoms, but not the other way round. Other studies have instead suggested fathers to follow their spouses' lead in mood and emotional states. For instance, Areias et al. (1996) found maternal early postpartum depression to predict later occurrence of depression in spouse.

In addition to co-occurrence, interparental *compensation* may also occur (Edhborg, Lundh, Seimyr, & Widström, 2003; Markey, Funder, & Ozer, 2003; Nelson, O'Brien, Blankson, Calkins, & Keane, 2009). In the context of family studies, compensation refers to a tendency of one parent to make up the weaknesses of the other parent through own optimal behaviors. In line with the view, studies have reported depressed parents with jeopardized parenting abilities to have spouses who compensate for their weaknesses e.g. by taking increased responsibility for children (Edhborg et al., 2003; Nelson et al., 2009). However, not all studies have supported the idea of compensation. Instead, Goodman (2008) reported less positive father-infant interaction in families with depressed compared to non-depressed mothers.

This study aims to identify the possible intrafamilial co-occurrence and/or compensation between mothers' and fathers' early mental health symptoms, by analyzing the overlap between early maternal and paternal symptoms of depression and psychological distress. Using parental mental health trajectories, we analyze the symptom overlap at each specific time point (pregnancy, early postpartum and late postpartum) as well as throughout the transition to parenthood. We can expect to find the following intrafamilial early parental mental health groups: healthy parents, who both show good mental health; families with solely maternal or solely paternal problems; and families with both maternal and paternal mental health problems.

2.4 Early parenting experience

During the early postnatal months, mothers and fathers construct their individual parenting identities; find their ways of adapting to the early needs and temperamental features of the baby; and, most importantly, create a unique relationship with him or her. Although much of the change is usually experienced positively, some mismatch between expectations and child-care realities typically occur. Therefore, hand-in-hand with positive emotions, new parents are prone to negative experiences that have been conceptualized also as *parenting stress* (Abidin, 1995). Understanding early parenting is important, because mothers and fathers with negative experiences are prone to adverse parenting behaviors, such as a lack of sensitivity and a frequent display of negative feelings, rejection and hostility towards the child (Rodgers, 1998).

Abidin (1990) presented a *parenting stress model* (originally developed by Abidin and Burke, 1978) that focuses on negative experiences that arise from various parent- and child-related sources. The model includes factors that appear still today essential for the experience of early parenting. Those include the parent's overall sense of competence, his/her ability to form dyadic interaction relationship with the child, as well as the child's early temperamental characteristics such as adaptability or demandingness. According to the model, new parents are likely to feel stressed when demands of parenting exceed the expected and actual resources available, whether that is due to excessive expectations of the parenting role, demanding characteristics of the child, or difficulties in early dyadic interaction. In addition, social factors such as the marital relationship and support from the family and friends are considered important determinants of the early parenting experience. Importantly, contemporary research has broadened our understanding to many additional factors relevant in early parenting. Those include, for instance, parental sensitivity and reflective capacity to read the mind of the infant (Fonagy, Gergely, & Target, 2007), parent-infant psychophysiological processes as components of early dyadic interaction (Feldman, 2012), as well as the infant's genetic predispositions as provokers of parental behaviors (Fearon et al., 2015).

A reciprocal connection has been reported between mental health and parenting experience in mothers. Both the pre- and postnatal depression and anxiety are known to predict negative parenting experience in mothers (Crugnola et al., 2016: Saisto, Salmela-Aro, Nurmi, & Halmesmäki, 2008), but the negative experience can also increase persistence of postnatal depression (Vismara et al., 2016). Unlike for mothers, research on early *fathering* experience is insufficient, particularly concerning its linkages with paternal mental health problems. One can assume that mental health problems during the pregnancy are harmful to early fathering, as they can interfere with the prenatal preparation to fatherhood (Habib & Lancaster, 2006; Vreeswijk et al., 2014). Some evidence confirms this association. For instance, the study by Saisto et al. (2008) followed families from pregnancy to toddlerhood and found that fathers' prenatal depression predicted negative fathering experience at two to three years. Importantly, however, paternal postpartum mental health problems could have a particularly negative effect on early fathering, through negative early father-infant interaction and decreased paternal sensitivity to the child's needs (Wilson & Durbin, 2010).

To increase knowledge of the role of mental health in early fathering, this study investigates the impact of paternal problems at specific pre- and postnatal time points on the early fathering experience. We further investigate, whether and how the fertility history of the family (ART or NC) plays a role in the association between paternal mental health and early fathering experience.

3 Child mental health and development

Developmental times when experience exerts a particularly strong influence on the brain and behavior are conceived as *sensitive periods*, characterized by rapid neural growth and acquisition of new skills in response to experience (Curley & Champagne, 2016; Knudsen, 2004). Neurodevelopmental and behavioral research have suggested the existence of sensitive periods in child development (Pechtel & Pizzagalli, 2011; Rincón-Cortés, & Sullivan, 2014), but research focusing on specific pre- and postnatal time-periods is scarce.

This study focuses on four distinctive child developmental phases: the fetal period, particularly the second trimester of pregnancy; the early infancy, when the child is two months old; and the late infancy, when the child is twelve months old. The fourth developmental period of the study is the middle childhood, encompassing the child's early school age (7-11 years). In this chapter, we aim at describing middle childhood developmental processes and outcomes in the light of early pre- and postnatal origins, by regarding both the fetal period and the infancy as potential sensitive periods for later child development. As depicted in the lowest part of Figure 1, we conceptualize development in middle childhood as children's mental health, consisting of internalizing and externalizing symptoms, as well as their social and cognitive development. Also, as self-regulation plays and important role in child mental health and development, this study focuses on children's psychophysiological stress regulation, particularly the development of *hypothalamic-pituitary-adrenal (HPA) axis*.

3.1 Prenatal development and fetal programming

Prenatal development describes the process of a human embryo and later fetus development from fertilization to birth. The first ten weeks of prenatal development are called embryogenesis, during which the embryo acquires its basic form; after that begins the period of fetal development when the organs are being constructed in strict order. At 18 to 20 weeks of gestation, the particular time when we studied the families, the fetus is reaching a length of about 20 centimeters and has all major organs constructed. The muscles are under intense development, which makes the fetus move actively. Importantly, at this point of the pregnancy, most mothers are beginning to sense the fetal movements, thus making this an important milestone in the formation of prenatal representations and attachment to the fetus (Broden, 2004; Rafael-Leff, 1991). Furthermore, the fetus spends increasing amount of time awake. It can hear, taste and smell, and can sense and react to maternal emotions, thus having achieved some rudimentary ability to 'communicate' with the mother. However, the fetus is still tiny, weighting only about 200 - 300 grams, and many major organs, including lungs, have not yet developed enough to enable survival in life outside the womb.

The fetal brain becomes fully developed during the second trimester, although not yet reaching its full size (Boyd, 2012). Importantly, at around the time period of our measurement (18-20 weeks of gestation), brain cells are beginning to form synapses that later lead to neural circuits, enabling an ongoing collaboration between brain areas (Carlson, 2014). Furthermore, the cerebral cortex starts to form folds and grows fast in thickness and complexity, thus providing the fetus with an important rudimentary basis for the development of memory, attention, perception, and awareness (O'Rahilly, & Mueller, 2008). Myelination begins, allowing for faster processing of information (Andersen, 2003). Furthermore, many brain regions that serve later socio-emotional, cognitive and stress-regulatory functions are under intensive construction, including the hippocampus, the amygdala, the neocortex, and the hypothalamus (Nelson & Bosquet, 2000).

The rapid growth and development of the brain during the pregnancy makes the fetal nervous system particularly sensitive to external influences. The *fetal programming* refers to the ability of environmental factors during the prenatal development to adjust relevant physiological parameters in the fetus (Hocher, 2014). Importantly, the adjustments can endure into adulthood and even affect the next generation, for instance by producing trans-generational non-genetic disorders or dysfunctions. The programming happens in many cases through gene expression, an environmentally affected process by which genetic instructions are used to synthesize gene products (Pembrey, Saffery, & Bygren, 2014).

One example of fetal programming is the prenatal calibration of the genetically built hypothalamic-pituitary-adrenal (HPA) axis (Kapoor, Dunn, Kostaki, Andrews, & Matthews, 2006; Van den Bergh, Mulder, Mennes & Glover, 2005). HPA-axis is a bodily neuroendocrine system, involved in the physiological stress response and regulation, with its end product being the cortisol hormone. Importantly, maternal and fetal cortisol levels are closely connected during the pregnancy, particularly around the mid-gestation (Glover, 2009; Van den Bergh et al., 2005), serving an evolutionary-based programming mechanism, through which unique maternal patterns of cortisol regulation, reflecting her ways of reacting to environment, transmit to the fetus through physiological and biochemical routes. The purpose of this mechanism is to prepare the fetus for life outside the womb, by helping it adjust its physiology to meet the presumed demands of the future environment.

3.2 Early and late infancy: mechanisms of plasticity

Newborn babies are primed to be ready for social input, with remarkable capacities that help them to identify voices, faces and smells, and to communicate with and attach to their caregivers (Crockenberg & Leerkes, 2000; Stern, 1985). At the same time, babies at birth are entirely dependent on their caregivers for nurture and affection. Development during the early infancy is holistic by nature; regulation of somatic states is inseparable from emotion and stress regulation. The child's emotional expressions are undifferentiated reactions to early experiences and physiological states, and his/her early regulatory abilities are highly fragile and limited in number (Holodynski & Friedlmeier, 2006). The main task of the caregiver at this point is to respond to infant's physiological needs of hunger, discomfort, sleep and touch, and to protect the baby from excessive stimulation (Calkins & Hill, 2007). Importantly, at around or shortly after the time when we studied the children (two months), infant development undergoes a significant qualitative leap. At this point, the baby becomes able to spend longer periods of time awake and to display new kind of focused attention (Stern, 1985). It finds face-to-face interactions with tones of voice and facial expressions highly attractive, starts to vocalize more in response to parental stimulation, and establishes the social smile as an important feedback of the pleasure that the interaction has brought (Crockenberg & Leerkes, 2000; Sroufe, 1995).

Across the child's first year and toward the late infancy, parent–infant interaction becomes even more reciprocal, as infants learn more diverse ways of communication. Two important social developmental achievements emerge: the ability to pay attention to intentions and emotions of others, called intersubjectivity, and the ability to share one's interests with others, called joint attention (Stern, 1985). Also, the baby acquires new active emotion regulation tactics, such as active exploration of new events, that replace more infantile strategies (Holodynski & Friedlmeier, 2006; Sroufe, 1995). By the end of the first year, relatively stable patterns of attachment emerge between infants and parents, providing them with unique ways of experiencing proximity and separatation (Stern, 1985). Infants, whose emotional needs have been sensitively and coherently responded to, can depend that their parents will help them to express and regulate all emotions, and are therefore able to explore their surroundings freely (Crockenberg & Leerkes, 2000).

Growth and maturation of the nervous system enable the emergence of new developmental achievements in infancy. For instance, changes in the hippocampus, a limbic structure related to recognition and memory, underly the infant's developing ability to focused attention (Uematsu et al., 2012). At the same time, baby's early experiences of the physical and social world are vital in shaping the nervous system towards greater diversity. For instance, consolidation of language circuits in the frontal and temporal lobes across the infancy is strongly influenced by the language that the child hears (Imada et al., 2006). Furthermore, guided by early experiences, the brain in infancy forms synapses at a faster rate than at any other developmental period, leading to an overproduction of them (Nelson & Bosquet, 2000). These surplus connections become gradually eliminated across childhood through the selective pruning of synapses, a process in which some connections become enhanced, while others are being selectively attenuated. Importantly, the excess of synapses in the early development makes the brain especially sensitive and plastic to external input. In other words, brain in infancy is able to exploit experiences more efficiently than at later points of development, when the pruning of synapses is underway. This early developmental plasticity has both positive and negative effects on development. On the positive side, it means that infant brain is more open to learning and enriching influences. On the negative side, it also means that it is more vulnerable to developmental risks in early environments.

Also children's physiological stress regulation goes through important attunement during the course of infancy. First, cortisol *resposes* to stressful events are typically high among newborns and small infants, but they gradually diminish and become difficult to provoke by the end of the first year, particularly under conditions of sensitive and responsive care (Gunnar & Donzella, 2002). This early childhood *cortisol hyporesponsiveness* develops when children learn to expect that their attachment behaviors and signals of distress will elicit aid from caregivers. In sensitive early interaction, children can rely on adult protection and thus better cope with threat. This developmental hyporesponsive period has presumably developed to protect the rapidly developing brain from the toxic impact of elevated cortisol, and lasts therefore throughout the early childhood. Another postnatal mechanism of HPA-axis calibration derives from *bio-behavioral synchrony*. According to Feldman (2012), physiological and behavioral processes between infants and parents become synchronized in moment-by-moment repeated interactions, involving matched patterns of gaze, affect, vocal and touch. Importantly, such moments of synchronized interaction create an 'endocrine fit' between maternal and infant hormonal processes and, over time, the child's HPA becomes calibrated toward maternal patterns of regulation and reactivity (Pawluski, Lonstein, & Fleming, 2017).

3.3 Developmental achievements during the middle childhood

The middle childhood, ages from six to twelve years, has sometimes been described as the 'forgotten years' of childhood, as the great majority of research has focused either on the early childhood or the adolescence (Mah & Ford-Jones, 2012). Yet, middle childhood is rich in potential for physical, cognitive, social, and emotional achievements (Cole, Cole, & Lightfood, 2005). Physically, children at this point get stronger and more coordinated, making it for them possible to succeed in a variety of athletic hobbies. Cognitively, they become more able to abstract thought processes that can concern for instance the future and their place in it. Socially, they begin to show more independence from their parents and family, whereas friends and their acceptance becomes more important. Emotionally, they become increasingly aware of their own as well as others' experiences, feelings and thoughts, and develop more empathy, altruism and moral. All these rapidly developing skills make the middle childhood an important developmental phase that can build a strong foundation for adulthood (Boyd, 2012).

At the same time, children in middle childhood can experience these developmental expectations as stressful: they may feel insecure about having to grasp more autonomy from their parents, become distressed by complicated frienships and social networks, or face difficulties in coping with academic challenges. In line with this, mental health problems in middle childhood, involving both internalizing and externalizing symptoms, have shown to affect as much as 22% of Finnish children, with boys displaying more problems than girls (Almqvist et al., 1999). Nine percent of the children were in urgent need of treatment and a fourth in need of clinical assessment. Concerning social developmental risks, nearly a fifth of children appear to be involved in bulling at school (Yang & Salmivalli, 2013), and approximately 10-15% of children feel rejected, chronically lonely and have no friends (Asher & Paquette, 2003). Finally, cognitive developmental problems and learning disabilities, including difficulties in language, math, memory and executive functions, have been estimated to affect about 10% of children (Johnson, 2017).

Importantly, optimal developmental achievements during the middle childhood are induced by development and maturation of the central nervous system. First, myelination occurs within the corpus callosum and subcortical areas, enabling faster synaptic transmission between the hemispheres and thus more advanced motoric, cognitive and emotional abilities (Rappley & Kallman, 2009). Second, significant adaptation happens in cortical gray matter, which also endorses cognitive development (Mah & Ford-Jones, 2012). Third, brain development in middle childhood relates mostly to the pruning of synapses (Rappley & Kallman, 2009). Thus, the increasing motoric, cognitive and psychosocial capacity across the middle childhood is likely to reflect a gradual loss of synapses, rather than formation of new ones. Selectivity in the pruning leads to a strengthening of the remaining synaptic connections and a suppression of competing irrelevant connections and behaviors. Therefore, with age, fewer and more select regions of the brain become activated in response to a specific stimulus, thus enabling faster and more efficient overall functioning (Chechik, Meilijson, & Ruppin, 1998).

Children's physiological stress regulation develops and matures in middle childhood, becoming relatively adult-like (Gunnar & Donzella, 2002). Importantly, HPA-axis regulation in middle childhood can be indicated by the *level* of cortisol in saliva or circulation, or by the daily diurnal cortisol pattern. Dysregulated cortisol levels can indicate either hypersecretion or hyposecretion. Hypersecretion is suggested to reflect a currently stressed, hyperactive HPA (McEwen & Wingfield, 2003), whereas hyposecretion relates to reduced cortisol production, possibly due to more chronic stress that has caused 'exhaustment' of the mechanisms underlying HPA (Doom, Cicchetti, & Rogosch, 2014; Fries, Hesse, Hellhammer, & Hellhammer, 2005). However, as cortisol secretion fluctuates significantly across day and night, measurements of cortisol level are considered less sensitive markers of dysregulation than the measures of diurnal patterning (Sharpley, Kauter & McFarlane, 2010).

Diurnal pattern, the fluctuation in the amount of secreted cortisol throughout the day, reflects the ongoing change in the need of a person to be alert versus relaxed. Similarly to adults, typical cortisol pattern among school-aged children involve lowest secretion around midnight or wee hours, and an intense trend upward towards morning. The secretion reaches its peak approximately 30 min after awakening but remains elevated for at least another half an hour. This change in cortisol across the first hour after waking from sleep is called the *cortisol awakening* *response* (CAR) (Fries, Dettenborn &Kirschbaum, 2009). Thereafter, towards midday, afternoon and especially evening, the secretion decreases, which has been called the *diurnal cortisol decline* (DCD) (Edwards, Clow, Evans & Hucklebridge, 2001).

Importantly, children's HPA-axis dysregulation – measured through less than optimal cortisol levels or diurnal patterns - is known to exert harmful effects on the functioning and development of vital brain regions such as the hippocampus, the amygdala and the frontal cortex (Carrion, Weems & Reiss, 2007; Frodl & O'Keane, 2013). Presumably mediated by these detrimental neural effects, cortisol dysregulation increases vulnerability to cognitive problems in learning and memory (Heffelfinger & Newcomer, 2001). Furthermore, it jeopardizes children's ability to regulate their behavior and emotions through non-optimal changes in the frontal cortex functioning (Lam, Dickerson, Zoccola & Zaldivar, 2009; Luebbe, Elledge, Kiel & Stoppelbein, 2012). Importantly, however, HPA-axis dysregulation is not considered pathological per se, but can rather index a *psychobiological vulnerability* that increases risk for mental health and developmental problems (Davis, Glynn, Waffarn, & Sandman, 2011).

This study analyzes children's internalizing and externalizing mental health symptoms as well as their social and cognitive developmental problems, as assessed by their parents at the age of 7-8 years. It also analyzes children's saliva cortisol levels and diurnal patterns as an index of HPA-axis functioning at the age of 10-11 years. We aim to provide understanding of the ways how early experiences influence later child development, by analyzing the long-term impact of pre- and postnatal parental mental health on children.

4 Early parental mental health impacting child development

Numerous studies across decades have focused on the impact that maternal mental health, particularly depression, has on child well-being (for a review, see Sanger, Iles, Andrew, & Ramchandani, 2015). In contrast, only a small number of studies have focused on paternal (for a review, see Ramchandani & Psychogiou, 2009) or joint parental mental health effects on children (e.g. Weinfield, Ingerski, & Moreau, 2009). This study analyzes mothers' and fathers' early mental health problems separately and together as risks of child mental health and developmental problems in middle childhood. In particular, it investigates the existence of children's age-specific sensitive periods to maternal mental health during the pre- and postpartum period, by analysing the unique importance of different timings of maternal problems for child development.

The key concepts and associations of this chapter are presented in the central part of the Figure 1. Those include early maternal and paternal mental health effects on child development, and their potential underlying mechanisms. Also, three suggested theoretical models of joint parental mental health effects on children will be described. Finally, child- and family-related contextual factors, particularly the gender of the child and family's fertility history, will be presented as potential moderators in the association between parental mental health and child development.

4.1 Maternal pre- and postnatal effects

Both maternal *prenatal depression and anxiety* have negative effect on child development. They have shown to predict adverse fetal outcomes, such as increased activity and heart rate, decreased growth, and preterm birth (Field, 2011; Field, Diego, Hernandez-Reif, Figueiredo et al., 2010; Wadwha, 2005). Newborns of mothers with prenatal anxiety or depression display less than optimal endocrine and neurotransmitter functioning, such as increased cortisol and norepinephrine and decreased dopamine and serotonin levels (Field, 2011). They also show less than optimal early behaviors, including more disorganized sleep and less responsiveness to stimulation, compared to newborns of mothers without prenatal mental health problems (Field, Diego, Hernandez-Reif, Figueiredo et al., 2010; Wadhwa, 2005). As infants and toddlers, children of mothers with prenatal depression or anxiety are more likely to display negative emotionality, particularly a negative reactivity to novelty (Blair, Glynn, Sandman, & Davis, 2011). Later in childhood, these children are vulnerable to emotional problems, such as negative emotionality, anxiety and depression (Barker, Jaffee, Uher, & Maughan, 2011; Cicchetti et al., 2014; Van den Bergh et al., 2008). They also have a heightened risk for attention deficit hyperactivity disorder (ADHD) (Van den Bergh & Marcoen, 2004; Wolford et al., 2016) and cognitive developmental problems, such as compromised intellectual abilities and learning difficulties (Mennes, Stiers, Lagae, & Van den Bergh, 2006; Sohr-Preston & Scaramella, 2006).

Maternal prenatal mental health problems have also found to increase the risk of later child HPA-axis dysregulation. As an example, O'Connor and colleagues (2005) reported increased levels of awakening and afternoon cortisol in 10-year-old children of prenatally anxious mothers. In adolescence, at the age of 15, the same children were found to display alterations of diurnal cortisol patterning, indexed by reduced cortisol awakening responses (CAR) and diurnal cortisol declines (DCD) (O'Donnell et al., 2013). Also Van den Bergh and colleagues (2008) reported associations between maternal prenatal anxiety and adolescent cortisol, but in their study the dysregulation was indexed by high and flattened daily diurnal patterns. Among girls only, the dysregulation was also associated with depressive symptoms, thus evidencing the involvement of the HPA-axis in the link between prenatal maternal anxiety and children's depressive symptoms. Finally, children of mothers with prenatal depression or anxiety are vulnerable to chronic illnesses, such as asthma and allergies, throughout their childhood (Wright, 2008).

Conflicting evidence exist about possible long-term effects of maternal *postpartum* mental health problems on child development. Some studies suggest that it is the chronicity and severity of problems, not the exact postnatal timing, that is important (Grace, Evindar, & Stewart, 2003; Hammen & Brennan, 2003). As an example, Prenoveau et al. (2017) examined the role of maternal postnatal depression and anxiety on children's emotional and behavioral functioning at the age of 2 years. They found that depression *chronicity* and anxiety *severity* were related to children's negative emotionality and behavior problems, whereas maternal mild short-term postnatal symptoms did not increase the likelihood of problems in children. However, other studies have instead provided evidence of negative impact of subclinical (Skotheim et al., 2013) or short-term (Bureau, Easterbrooks, & Lyons-Ruth, 2009; Essex, Klein, Miech, & Smider, 2001) maternal depression, thus suggesting the significance of even mild and temporary symptoms during the postpartum period. However, methodological problems have made it difficult to conclude about the importance of specific timings; many studies focusing on the impact of maternal postpartum depression have not considered the impact of prenatal or later postnatal symptoms. Therefore, unique effects of the postpartum period have been difficult to separate for certain from the prenatal or later postnatal ones.

Yet, infants of mothers with postpartum depression appear to be more tense and more difficult to soothe than infants of non-depressed mothers (Brennan et al., 2008; McGrath, Records, & Rice, 2008). They are also more likely to display HPA-axis dysregulation, indicated by increased cortisol level and reactivity (Brennan et al., 2008; Letourneau, Watson, Duffett-Leger, Hegadoren, & Tryphonopoulos, 2011). As toddlers, children of mothers with postpartum depression are at increased risk of behavioral problems (Dietz, Jennings, Kelley, & Marshall, 2009; Tissot et al., 2016) and psychofunctional difficulties, such as troubles in daily sleeping and eating habits (Tissot et al., 2016). Later in childhood, they are vulnerable to mental health symptoms, particularly depression and anxiety (Closa-Monasterolo et al., 2017; Halligan, Herbert, Goodyer, & Murray, 2007; Hay, Pawlby, Waters, & Sharp, 2008). Also the risk of behavioral problems and difficulties in cognitive development, such as in intelligence and language, is increased (Mirhosseini et al., 2015). Furthermore, children of mothers with postpartum depression have found to perform less well than other children in defining facial expressions of basic emotions (Meiser, Zietlow, Reck, & Träuble, 2015), with potential negative consequences on their social and peer relations. Finally, whereas research is robust on the effects of maternal postpartum *depression*, studies focusing on other distress symptoms in the postpartum period is more scarce. However, impact of maternal postpartum anxiety on toddler temperamental negativity (Agrati et al., 2015) and socio-emotional difficulties (Cooklin, Giallo, D'Esposito, Crawford, & Nicholson, 2013) have been reported.

To sum it up, the impact of maternal prenatal anxiety and pre- and postnatal depression on children has been widely investigated. In contrast, we were unable to locate research concerning the impact of *other* maternal pre- and postnatal distress symptoms, such as sleeping difficulties or social dysfunction. This study includes maternal pre- and postnatal depression and psychological distress, consisting of symptoms of anxiety, depression, sleeping difficulties and social dysfunction, in the analysis of early maternal mental health predicting children's mental health and development. In particular, we aim at identifying the potential unique, timing-specific effects of the pregnancy and the postpartum period, as compared to the more chronic course of symptoms throughout the transition to parenthood. Maternal mental health trajectories, with unique symptom courses across the pre- and postpartum period, make it possible for us to compare the long-term impact of problems at specific timings, with symptoms at other times being controlled (e.g. prenatal only vs. early postpartum only).

4.2 Maternal pre- and postnatal mechanisms

At least five mechanisms are important in explaining the impact of maternal *prenatal* problems on children. Three of them explain potential physiological paths. First, when a pregnant mother suffers from depression or anxiety, her HPA-axis becomes overly activated or otherwise dysregulated to release multiple hormones, including cortisol, which can negatively affect the fetal development. Increased cortisol in the mother can transmit to the fetus through multiple paths: a) It can pass across the placenta and directly enter the fetal circulation (Singh, Cuffe, & Moritz, 2012). Activity of a placental enzyme (11β-HSD2) serves to protect the fetus from maternal cortisol, by converting it into inactive cortisone. However, maternal depression and anxiety can adversely affect the gene expression of this enzyme and thus predispose the fetus to maternal cortisol (Seth, Lewis, Saffery, Lappas, & Galbally, 2015). b) Increased maternal cortisol can lead to increased maternal corticotropin-releasing hormone (CRH), which can trigger placental CRH production. Placental CRH can in turn stimulate the fetal HPA-axis and thus lead to increased fetal cortisol (Beijers, Buitelaar, & Weerth, 2014). c) Increased cortisol in the mother can affect cortisol concentrations in the amniotic fluid, and thus transmit to the fetus (Beijers et al., 2014).

Second, maternal prenatal depression and anxiety can negatively impact fetal development by inducing epigenetic modifications in the genome, e.g. through altering fetal DNA methylation (Singh et al., 2012). This in turn can induce alterations in the fetal gene expression and thus influence neurodevelopmental processes throughout the development. Third, mother's prenatal anxiety and depression can affect her autonomic nervous system functioning, involving symphatoadrenal hyperactivation and dysregulated release of catecholamines adrenaline and noradrenaline (Beijers et al., 2014). This can reduce the blood flow through the placenta and thus oxygen and nutrients supply to the fetus.

A behavioral mechanism, explaining some of the negative impact of maternal prenatal mental health on child development, relates to maternal direct harmful behaviors such as poor nutrition, lack of exercise, smoking, and alcohol consumption. Those are more typical among mothers with mental health problems, and can impact the fetus development through placental and other physiological processes (Beijers et al., 2014). Finally, prenatal mental health problems can interfere with the preparation to motherhood and the formation of mother-fetus attachment, thus providing a psychological mechanism to explain the impact of prenatal problems on child development (Ahlqvist-Björkroth et al., 2016; Alhusen, Gross, Hayat, Rose, & Sharps, 2012). Ahlqvist-Björkroth et al. (2016) reported that depressed pregnant mothers have an increased risk of distorted prenatal representations, with distortion including low sensitivity to fetal needs and a confused and overwhelmed involvement in the mother-child relationship.

In the *postpartum period*, two important interactional mechanisms to explain the effects of maternal mental health problems on child development are the mother-infant interaction and the marital relationship. First, compared to non-depressed mothers, depressed mothers are less sensitive in their interaction with the child (Edhborg et al., 2003; Feldman, 2007). They provide less warmth, positive affect and touch to their infant, and show difficulty to construct affective synchrony with them (Feldman et al., 2009). Importantly, not only clinical but also subclinical levels of maternal depression have found to be associated with these compromised dyadic interaction characteristics (Behrendt et al., 2016), thus emphasizing the importance of recognizing also mothers with mild symptoms. Mothers with postpartum anxiety can overstimulate and be intrusive towards infants (Feldman, 2007; Murray, Cooper, Creswell, Schofield, & Sack, 2007). They may also display more irritability and frustration in the dyadic interaction (Seymour et al., 2015). Importantly, both maternal depression and anxiety can lead to interactions, in which the infant is left without the important growth-promoting elements of maternal sensitive responsiveness (Feldman et al., 2009). Therefore, the infant becomes less able to form secure attachment with the mother (McMahon, Barnett, Kowalenko, & Tennant, 2006) and has difficulty to develop important physiological protecting and fine-attuning mechanisms, such as the HPA hyporesponsiveness to stressful events (Gunnar & Donzella, 2002) and the bio-behavioral 'endocrine fit' with the mother (Feldman, 2012; Pawluski et al., 2017).

Second, maternal postpartum mental health problems can trigger, or be triggered by, marital problems, such as increased marital conflict (Clout & Brown, 2016, Hanington, Heron, Stein, & Ramchandani, 2012). Research shows that in families with infants, marital problems tend to spillover on parenting (Barnett, Min, Mills-Koonce, Willoughby, & Cox, 2008; Krishnakumar & Buehler 2000). Compared to parents with happy marriages, mothers and fathers with marital problems are less sensitive and playful, and more negative in their interaction with the infant (Corwyn & Bradley, 1999; Krishnakumar & Buehler, 2000). They are also less able to use efficient co-parenting practices, such as negotiation and co-operation (Christopher, Umemura, Mann, Jacobvitz, & Hazen, 2015). Furthermore, exposure to prolonged and repeated interparental conflict can decrease infant's emotional sense of security (Davies & Cummings 1994), as well as its ability to develop efficient emotion regulation (Du Rocher Schudlich, White, Fleischhauer, & Fitzgerald, 2011). In line with these views, marital conflict (Hanington et al., 2012) and the lack of co-parenting (Tissot et al., 2016) have shown to mediate the relationship between maternal postpartum depression and child outcomes.

4.3 Paternal pre- and postnatal effects and mechanisms

A few studies have investigated the role of fathers' early mental health in children's mental health and development. Paternal *postnatal* depression has found to associate with negative infant temperament (Davé, Nazareth, Sherr, & Senior, 2005). It is also known to predict emotional, behavioral and social problems from toddlerhood to middle childhood (Ramchandani, Stein, Evans, & O'Connor, 2005; Ramchandani, Stein et al., 2008; Smith et al., 2013), and cognitive developmental language acquisition problems in early childhood (Paulson, Keefe & Leiferman, 2009). Concerning anxiety, Ramchandani, Stein, Hotopf, and Wiles (2006) found that paternal postnatal symptoms predicted a specific child somatization symptom, recurrent abdominal pain, in middle childhood. To our knowledge, the only study that has examined the impact of paternal *prenatal* mental health on child development is the one by Ramchandani, O'Connor et al. (2008). It did not find any timing-specific effects of paternal prenatal depression on children's mental health when compared to depression in the postpartum period or throughout the transition to parenthood.

Potential *mechanisms* to explain the impact of fathers' early mental health on child development include psychological and interactional processes. First, similarly to mothers, paternal prenatal mental health problems can interfere with the psychological preparation to fatherhood, including the forming of prenatal representations and attachment to the fetus (Ahlqvist-Björkroth et al., 2016; Flykt, 2014). The lack of prenatal preparation might in turn affect the early fathering experience negatively, with possible long-term consequences on child development. Second, paternal mental health problems in the postpartum period can impact child development by affecting the father's ability to care for and interact with the infant (Wilson & Durbin, 2010). Compared to non-depressed fathers, depressed fathers spend less time with their children, are more negative and passive in their interaction with the child, and the father-child relationship is higher in conflict (for reviews and meta-analyzes, see Kane & Garber, 2004; Wilson & Durbin, 2010). However, most research has considered father-child relationships among families with older children, whereas studies focusing on the *early* father-child relationship are limited. Some studies have shown fathers with postpartum depression to be less likely to touch, vocally stimulate and read to their infants, and to be more passive in their play behaviors (Davis, Davis, Freed, & Clark, 2011; McElwain & Volling, 1999; Sethna et al., 2015). Thus, the negative and/or passive early father-infant interaction might affect child development through decreased stimuli.

Third, alike maternal mental health problems, also paternal problems are associated with marital problems (Clout & Brown, 2016). In addition to the negative impact of parental postnatal mental health problems on child development through increased marital conflict (Hanington, 2012), both the pre- and postnatal problems in fathers can lead to a reduced paternal ability to provide psychological support to the mother and the mother-infant relationship (Letourneau, Duffett-Leger, & Salmani, 2009). This, in turn, can increase early maternal parenting stress and negativity towards the infant, and thus affect child well-being (Leahy-Warren, McCarthy, & Corcoran, 2012).

4.4 Joint parental mental health effects

Families comprise children's primary developmental environments, where difficulties in one member are likely to affect the well-being and functioning of others. In the light of every-day family life, it appears likely that mothers' and fathers' mental health have a joint influence on children. Yet, early maternal and paternal mental health and their consequences have mostly been studied separately. There is a need to go beyond the parent–child dyads and to adopt a wider family perspective on child development (Davies, & Cicchetti, 2004). Accordingly, this study focuses on the complex interplay between maternal and paternal mental health symptoms in predicting child mental health and development.

Three alternative *theoretical models* have been suggested, when explaining the ways of joint parental mental health impacting children (Coyne, Downey, & Boergers, 1992; Weinfield et al., 2009). The first model, called *joint additive model* proposes separate significance of both parents for child development. According to the model, both maternal and paternal symptoms contribute independently to child development, above and beyond the contribution of the other parent's symptoms. The second, *joint hierarchical model* assumes instead that the mother as primary caregiver is crucial for child development, whereas the father becomes important only in situations where maternal well-being is compromised. According to the model, father's mental health problems exacerbate risk to children only if they are already at risk due to maternal symptoms. The third, *joint buffering model* emphasizes the importance of one healthy parent, either mother or father, for child development. According to the model, availability of one healthy parent can act as a protective factor against problems in the other parent.

Studies are available to support each of the model (e.g. Brennan, Hammen, Katz, & Le Brocque, 2002; Goodman, Brogan, Lynch, & Fielding, 1993; Mezulis, Hyde, & Clark, 2004; Weinfield et al., 2009), but those can be criticized for focusing solely on depression, involving simple cross-sectional designs, and lacking comprehensive testing of alternative models. This dissertation study contributes to the research, first, by providing a wider conceptualization and assessment of parental mental health, second, by being prospective, and third, by explicitly testing each theoretical model.

4.5 Child- and family-related contextual factors

Child- and family-related contextual and situational factors can influence child development together with early risks, by either protecting or predisposing children to negative effects of early adversity (Sameroff, 2010). In this study, we analyze the role of two such potential moderators in the association between early maternal mental health and child development. First, child's gender has been suggested to play a role in the association between parental mental health and child development, due to potential greater vulnerability of boys. Second, family's former infertility and conception through assisted reproductive treatment (ART) might increase the likelihood of negative consequences of early parental problems on children, due to specific family vulnerabilities.

4.5.1 Child's gender

Several studies suggest that pre- and postnatal parental mental health problems affect more strongly the mental health and development of boys, compared to girls (Brand & Brennan, 2009; Ramchandani et al., 2005). As an example, Carter and Garrity-Rokous (2001) found that maternal pre- and postnatal depressive symptoms predicted behavior problems in toddler boys, but not in girls. Hay and colleagues (2008) found a connection between maternal postpartum depression and adolescent intelligence, but the effect was stronger among boys. However, some other studies have not found any gender effects in the association between early parental mental health and child development (e.g. Cornish et al., 2005; Van den Bergh & Marcoen, 2004).

The possible gender differences are likely to be explained by biological factors, by early mother-infant interaction and/or by gender-specific psychological symptoms. First, compared to females, male fetuses are biologically more vulnerable to adversity (Cieslik & Waszak, 2001; Mueller & Bale, 2008), and the development of boys is more susceptible to neurophysiological problems (Bauermeister et al., 2007). Second, studies on the quality of mother-infant interaction suggest that mothers with depressive symptoms communicate less with their sons than with their daughters (Murray, Kempton, Woolgar, & Hooper, 1993). Finally, boys are found to show more externalizing symptoms such as aggression both in early childhood (Winsler & Wallace, 2002) and in adolescence (Card, Stucky, Sawalani, & Little, 2008). From early adolescence on, girls typically show more internalizing symptoms of depression and anxiety (Crawford, Cohen, Midlarsky, & Brook, 2001; Kistner, 2009). According to Hay et al. (2001), boys may react to maternal mental health problems earlier than girls, but the gender-differences get smaller towards adolescence. This dissertation study examines whether the maternal pre- and postnatal mental health problems differently affect the mental health and development of boys and girls.

4.5.2 Family's former infertility

To our knowledge, no studies on the impact of parental mental health on children have been conducted among ART families. However, one might speculate ART children to be particularly susceptible to early family-related risks, such as parental mental health problems, due to genetic and early medical vulnerabilities. First, infertility itself can be related to genetic differences or health of the couple that undergoes the ART, and this could directly impact the child (Raatikainen, Kuivasaari-Pirinen, Hippelainen, & Heinonen, 2012). Second, the reproductive treatment can negatively impact early embryological processes such as methylation patterns, leading to epigenetic alterations in the child (Winston & Hardy, 2002). Third, complications associated with ART pregnancies can negatively impact child development. For instance, low birthweight infants are at increased risk of later ADHD symptoms as well as behavioral, social and cognitive developmental problems (Ben Amor et al., 2005; Latimer et al., 2012; Tideman, Marsal, & Ley, 2007).

Despite these suggested mechanisms, no significant developmental differences have been documented between ART and NC children and adolescents (for a review see Hart & Norman, 2013). Instead, studies have reported similar intellectual performances, cognitive information processing, attention, and visual-motor functioning (Carson et al., 2011; Leunens, Celestin-Westreich, Bonduelle, Liebaers, & Ponjaert-Kristoffersen, 2008; Punamäki et al., 2016; Wagenaar et al., 2008). For instance, Carson et al. (2011) compared expressive language abilities between 3-year-old ART and NC children, and reported even better skills among ART children. The effect was, however, reduced after adjusting for a range of confounding and mediating factors, and the authors concluded that ART children's cognitive development was similar to that of NC children.

Studies on ART children's mental health have reported more conflicting results. Some studies have found comparable or even better outcomes for ART children. For instance, Barnes et al. (2004) found no differences in emotional and behavioral problems between five-year-old ART and NC children, and Wagenaar et al. (2009) reported even fewer externalizing symptoms among 9-18-year-old ART children. Other studies have instead suggested a slightly increased risk for mental health problems among ART children (Bay, Mortensen, Hvidtjorn, & Kesmodel, 2013; Hart & Norman, 2013; Källen et al., 2011). For instance, Bay et al. (2013) reported a small but systematically increased risk of a range of mental health and neuropsychiatric problems among 8-17 year-old ART children, including internalizing and externalizing symptoms as well as autism spectrum disorders. Similarly, Källen et al. (2011) showed a slightly increased risk of ADHD in ART compared to NC children.

Within our study sample, the ART and NC children did not differ regarding mental health or social and cognitive development in the middle childhood (Punamäki et al., 2016). Interestingly, however, some gender-specific group differences were found. In particular, the ART boys showed lower levels of cognitive problems than the NC boys, whereas the ART girls showed higher levels of cognitive problems than the NC girls. Furthermore, whereas the NC boys showed more externalizing symptoms and social and cognitive developmental problems than the NC girls, these typical gender differences were not found in the ART-group. These results suggest possible existence of unique developmental processes among ART boys and girls. This dissertation study extends the research of ART children's mental health and development to children whose mothers and fathers suffered from early mental health problems. We investigate, whether and how early parental mental health symptoms predict child mental health and development differently among ART and NC families.

4.6 Summary of theoretical background

The transition to parenthood provides an opportunity to psychological growth, but also vulnerability to mental health problems. In line with this, maternal and paternal pre- and postnatal mental health problems, including symptoms of depression and psychological distress, are relatively common and known to affect approximately a third of mothers and a fifth of fathers. Significant individual differences are likely to exist in the longitudinal course of parental mental health symptoms, which can be best captured through person-oriented methods. Those enable detecting of unique homogenous groups of mothers and fathers regarding their longitudinal course of mental health symptoms in the transition to parenthood, with symptoms reaching clinically significant levels at different pre- and postnatal time points.

Early pre- and postnatal child development is characterized by rapid neural growth and acquisition of new skills in response to experience. Both make early development highly vulnerable to environmental risks, such as parental mental health problems. Maternal, and to some extent paternal, mental health problems in the transition to parenthood are known to increase children's vulnerability to emotional, social, cognitive and psychophysiological problems. Yet, the impact of particular pre- and postnatal timing of problems, as well as the impact of joint parental mental health on children is largely unknown. Furthermore, more research is needed on the potential unique processes of families with early medical risks, such as former infertility and conception through assisted reproductive treatment (ART).

This dissertation study is part of a multidisciplinary longitudinal research project *Psychosocial Aspects after ART (PAART)* that was started by obstetricians, child psychiatrists, and family therapists at the Helsinki University Central Hospital and the University of Helsinki in year 1999. The original aim of the project was to provide knowledge of the potential family- and child-related risks and resiliences of ART families (for more information, see Repokari et al., 2005). However, richness of data has enabled us psychologists to focus on family psychological and child developmental issues *in general*, not just in relation to ART specific questions. This dissertation study analyzes the impact of early parental mental health on children both in general and in relation to parental former infertility.

5 Aims of the study

This study aims to understand individual variability in the longitudinal course of maternal and paternal mental health symptoms in the transition to parenthood. It further investigates the impact of early parental mental health on children's psychosocial, cognitive and psychophysiological development in middle childhood. The study analyzes maternal and paternal pre- and postnatal depressive and psychological distress symptoms as predictors of child internalizing and externalizing symptoms, social and cognitive developmental problems, and HPA-axis dysregulation among normative families and those with infertility history. Our specific research questions and hypotheses are as follows:

1. To identify distinct early maternal (Article I) and paternal (Article II) mental health subgroups (i.e. latent developmental trajectory groups) according to timing and course of depression and psychological distress symptoms across the transition to parenthood. We hypothesize that subgroups with specific timings (prenatal, early and late postpartum) and courses (transient vs. chronic) of problems will be found. We further examine the impact of family's former infertility and ART on the timing and course of early parental mental health symptoms.

2. To analyze intrafamilial dynamics between mothers' and fathers' early mental health (Article IV). Family systemic perspective suggests co-occurrence, often caused by spillover effects, and compensation of parental symptoms. We aim to identify potential existence of these dynamics, by analysing overlap in mothers' and fathers' symptoms at three specific time points (the pregnancy, the early postpartum and the late postpartum) as well as across the pre- and postpartum period (from the pregnancy to the child's first year). We expect to find the following intrafamilial early parental mental health groups: healthy parents, who both show good mental health throughout the transition to parenthood; families with solely maternal or paternal problems, in which either the mother or the father displays problems in at least one point of the transtition; and families with both

maternal and paternal mental health problems, where both parents display problems in at least some point of the transition.

3. To investigate, how the timing and course of fathers' early mental health symptoms are associated with early fathering experience, and whether family's former infertility moderates the effect (Article II). A connection has been reported between early mental health and parenting experience in mothers, but research among fathers is scarce. We hypothesize a) chronic and severe course of paternal symptoms to predict the most negative early fathering experience, and b) postpartum mental health problems to predict a more negative experience compared to prenatal problems or no mental health problems at any point of the transition.

4. To examine, how the timing and course of early maternal mental health symptoms (i.e. mental health trajectory groups) predict children's internalizing and externalizing symptoms and social and cognitive developmental problems at the age of 7-8 years (Article I) as well as psychophysiological-hormonal stress dysregulation at the age of 10-11 years (Article III). We also investigate, whether child's gender and family's former infertility moderate the effect between maternal mental health and later child mental health and development. Earlier research has particularly emphasized adverse effects of severe and chronic maternal problems as well as the importance of fetal programming in directing child development. We therefore hypothesize a) chronic and severe course of maternal symptoms to predict the highest level of problems in children, and b) maternal prenatal mental health problems to predict higher level of problems as compared to maternal postnatal mental health problems.

5. To test the importance of theoretical models of early parental mental health in predicting children's mental health and development at the age of 7-8 years (Article IV). In analyzing the predictive value of intrafamilial parental mental health for child internalizing and externalizing symptoms and social and cognitive development, we test the significance of five theoretical models: two separate (mother and father) and three joint parental (additive, hierarchical and buffering) models. To indicate (1) the separate mother or (2) the separate father model, we assume children to show high levels of problems in families where either solely mothers or both parents (or in

separate father model: solely fathers or both parents) suffered from early mental health problems, as compared to children in families with healthy parents or solely paternal (in separate father model: healthy parents or solely maternal) problems. To confirm (3) the joint additive model, we hypothesize children to show high levels of problems in families with both maternal and paternal problems, moderate levels of problems in families with solely maternal or solely paternal problems, and low levels of problems in families with healthy parents. To indicate (4) the joint hierarchical model, we assume children to show high levels of problems in families with both maternal and paternal problems, moderate levels of problems in families with solely maternal problems, and low levels of problems in families with solely paternal problems or healthy parents. To confirm (5) the joint buffering model, we hypothesize children to show high levels of problems in families with both maternal and paternal problems, and low levels of problems in families with healthy parents or with solely maternal or solely paternal problems.

6 Materials and methods

6.1 Participants and procedure

A summary of the research setting, participants and measures of the dissertation is presented in Table 1.

Table 1. Summary of the research setting, participants and measures

	Transition to parenthood (*N* = 763)	**Middle childhood (*N* = 485)**
Timing of assessment	T1: Pregnancy, Second trimester T2: Early postpartum, Child 2 months T3: Late postpartum, Child 12 months	T4: Child 7-8 years T5: Child 10-11 years
Sample size	T1: N = 758 T2: N = 632 T3: N = 556	T4: N = 485 T5: N = 102
Parental measures	***Mental health (T1-T3)*** - Depression: Beck Depression Inventory (BDI-13) - Psychological distress: General Health Questionnaire (GHQ-36) ***Parenting experience (T2-T3)*** - Parenting stress: Parenting Stress Index (PSI-36)	***Mental health (T4)*** - Psychological distress: General Health Questionnaire (GHQ-36)
Child measures		***Mental health (T4)*** - Internalizing and externalizing symptoms: Behavioral Assessment System for Children (BASC) ***Social development (T4)*** -Assertion: Social Skills Rating System (SSRS) - Peer exclusion: Child Behavior Scale (CBS) ***Cognitive development (T4)*** - Executive functions, Perception, Memory and Language: Five to Fifteen (FTF) ***Psychophysiological regulation (T5)*** - Saliva cortisol samples across a day: Awakening (C1), 30 minutes after awakening (C2), One hour after awakening (C3), Late afternoon (C4), Evening (C5)

Participants of the study consisted of 763 married or co-habiting Finnish Caucasian couples with singleton pregnancies. A half of the sample involved couples with infertility history and a successful assisted reproduction treatment with their own gametes (fresh or frozen embryo transfer following IVF or ICSI; ART-group, n = 406) and another half were naturally conceiving couples (NC-group, n = 357). The ART-group was recruited from five infertility clinics in Finland across the year 1999. The NC-group was recruited by a research nurse at Helsinki University Central Hospital from couples participating in routine ultrasonographic examination offered by the community at 18 to 20 weeks of gestation in 1999. Singleton pregnancies only were included in this study. In addition, only NC couples who reported no history of infertility were accepted and, due to a high average age of ART mothers, only mothers over 25 years were included in the NC-group.

Mothers and fathers separately completed questionnaires three times during their transition to parenthood: the second trimester of pregnancy (T1, 18-20 weeks of gestation; mothers N = 758, 99%; fathers N = 756, 99%) and when the child was two months (T2; mothers N = 632, 83%; fathers N = 615, 81%) and twelve months old (T3; mothers N = 556, 73%; fathers N = 506, 66%). The couples were again contacted when the children were 7-8 years old (T4; mothers N = 485, 64%; fathers N = 290, 38%) to fill in questionnaires separately. A selection of the families were recruited again when the children were 10-11 years old (T5; N = 102, 13%), to participate in a psychophysiological part of the study. At this point, the selected families were first contacted via letter and telephone, to inquire about their willingness to participate. If a family agreed to take part, the research assistant visited their home. More detailed information about the research project and setting from pregnancy to 1 year of mothering is presented in Repokari et al. (2005).

Fathers' participation at T3 was higher in the ART than in the NC-group, 69% vs. 62%, p =.04, whereas mothers' participation at T2-T3 was independent of the fertility history. Both maternal and paternal participation at T2-T3 was independent of education, age, parity, length of the partnership, mental health as well as child's gender and birth weight. At T4, when the children were 7-8 years old, maternal and paternal participation did not differ according to family's fertility history. However, the parents who participated were somewhat older, mothers: $t(724) = 2.25, p = .03$; fathers: $t(708) = 3.40, p < .01$, and the participating fathers, but not mothers, were more educated than the drop-outs, $\chi^2(4, 736) = 19.02, p < .01$. Both maternal and paternal participation at T4 was independent of parity, length of the partnership, earlier mental health (T1-T3) as well as child's gender and birth weight. At T5, when the children were 10-11 years, the selected families were representative of the original sample in parental education, age, parity, length of the partnership, earlier mental health (T1-T4) as well as child's gender and birthweight. However, the selected vs. non-selected families differed according to fertility history, χ^2 (1, 689) = 5.07, p = .02, as more NC than ART families agreed to participate in the study.

At the time of the first assessment (T1), about three quarters of the parents worked either as high or low professionals (mothers: 75%, fathers: 67%); nearly a fifth of the mothers (18%) and about a quarter of the fathers (26%) worked as skilled workers; and the rest were unskilled workers, students or unemployed (mothers: 7%, fathers 8%). In most families the couple was married (71%) and expected their first child (59%). Mean age of the mother was 33 years (SD = 3.8) and of the father, 35 years (SD = 4.9). The average length of the partnership was eight years (SD = 4.7). Fifty-one percent of the children were boys, and almost all children were born full-time (93%) and with normal weight (M = 3550g, SD = 487g).

Table 2 shows the demographic variables according to family's fertility history. Results show that the ART and NC-groups differed in marital status (ART parents being more often married), parity (ART parents being more often primiparous), and maternal socioeconomic status (ART mothers being less often professionals and more often skilled workers). Furthermore, the partnership had endured longer in the ART-group, $t(706) = 4.20$, $p < 0.01$. In contrast, the ART and NC-groups did not differ in the length of gestation, child's birthweight or gender, or father's socioeconomic status. Likewise, maternal age and paternal age were similar between the groups.

Table 2. Demographic information according to family's fertility history.

	Assisted reproductive treatment (ART) group		Naturally conceiving (NC) group		χ^2 *(df, n)*
	%	*n*	%	*n*	
Child's gender					0.08
Boy	50.4	201	50.7	180	(1, 754)
Girl	49.6	198	49.3	175	
Child's birthweight					2.67
≥ 2500g	96.8	392	98.6	351	(1,761)
< 2500g	3.2	13	1.4	5	
Marital status					8.07**
Married	74.9	269	65.1	222	(1, 700)
Cohabitant	25.1	90	34.9	119	
Parity					75.86***
Primiparous	69.9	258	36.9	120	(1, 694)
Multiparous	30.1	111	63.1	205	
Socioeconomic status					
Mother					14.14**
High professional	30.3	111	38.7	130	(3, 702)
Low professional	41.0	150	40.5	136	
Skilled worker	22.7	83	12.8	43	
Unskilled worker	6.0	22	8.0	27	
Father					6.52
High professional	31.6	112	38.9	133	(3, 696)
Low professional	30.5	108	31.0	106	
Skilled worker	30.2	107	22.5	77	
Unskilled worker	7.6	27	7.6	26	

Note. N = 763.

*** $p < .001$; ** $p < .01$

6.2 Measures

6.2.1 Parental measures

Maternal and paternal psychological distress was measured in T1-T4, using the 36-item General Health Questionnaire (GHQ-36) by Goldberg and Hiller (1979). It is known to give an effective measure of mild psychiatric disorders – also conceptualized as psychological distress (e.g. Penninkilampi-Kerola, Miettunen, & Ebeling, 2006) – in the general population (Ferdinand & Verhulst, 1994). The items cover symptoms of depression (feelings of hopelessness and suicidal ideation), anxiety (feelings of being under constant pressure and panicking), sleeping difficulties (waking up at night and difficulties in falling asleep), and social dysfunction (feelings of inability to perform everyday tasks and social activities). Mothers and fathers estimated how well the descriptions matched their mental state over the past few weeks on a 4-point scale, ranging from 1 (not at all) to 4 (much more than usual). Cronbach's α values for mean response scores (T1 - T4) ranged between .91 and .95 in both mothers and fathers. In addition, dichotomic variables of clinical significance were calculated, based on the clinical criterion of the cut-off point in Finnish samples (Holi, Marttunen, & Aalberg, 2003). The cut-off point is 9 and above after recoding the original values ranging between 1 and 4 into dichotomous values (the original values 1-2 = 0 and the original values 3-4 = 1).

Maternal and paternal depression was assessed at T1-T3 using a shortened version of Beck's Depression Inventory (BDI-13) by Beck, Ward, Mendelsohn, Mock and Erlaugh (1961). The Finnish version of the BDI has been found valid and reliable in detecting depressive symptoms (Kaltiala-Heino, Rimpelä, & Laippala, 1999). BDI consists of 13 descriptions of low mood, hopelessness and somatic signs of depression. Mothers and fathers estimated their present state on a 5-point scale, ranging from 0 (symptom not present) to 4 (symptom present most of the time). Cronbach's α values for maternal and paternal mean response scores (T1-T3) ranged between .75 and .84. In addition, dichotomic variables of clinical significance were formed based on the clinical criterion of the cut-off point in Finnish samples (Kaltiala-Heino et al., 1999). The cut-off point for mild depression is 5 and above, after recoding the original values (the original values 0 and 1 = 0, the original value 2 = 1, 3 = 2, and 4 = 3).

Early fathering experience was assessed at T2-T3 using the short form of Parenting Stress Index (PSI-36; Abidin, 1995). It consists of three components: The *parent* *domain* (12 items), describing the experience of one's resources and limitations as a parent (e.g. 'After having a child, I can hardly ever do the things that I would want to'). The *interaction domain* (12 items) represents the experience of the dyadic relationship with the child (e.g. 'I often feel that my child doesn't like me or wish to be near me'). The *child domain* (12 items) describes the experience of child's early characteristics regarding easiness vs. demandingness from the caretaker's point of view (e.g. 'My child cries and fusses much more than other children'). Fathers estimated how the descriptions matched their experiences on a 5-point scale, ranging from 1 (completely agree) to 5 (completely disagree), with higher values indicating more positive experience. All three domains correlated at both time points (r's ranging from .50 to .60, $p < .01$). Cronbach's α values for mean response scores (T2-T3) ranged between .82 and .85.

6.2.2 Child measures

Both parents separately reported the child's mental health and social and cognitive development at the age of 7-8 years, and the means of their assessments were calculated. In families where only one parental report was available ($n = 209$; 27.4%), the scales include only this report.

Children's mental health symptoms were measured at T4 using the parent report scales of Behavioral Assessment System for Children (BASC; Reynolds & Kamphaus, 1992), consisting of total of 12 symptom scales (138 items). Four scales were chosen for this study on the basis of representativeness and reliability for internalizing and externalizing problems: *Anxiety* (11 items) measures a child's tendency to be nervous, fearful, or worried about real or imagined problems; *depression* (12 items) represents a child's experiences of sadness and stress with potential difficulty to carry out everyday activities; *somatization* (13 items) reflects a child's alertness towards bodily sensations and a tendency to complain about relatively minor physical discomforts; and *aggression* (13 items) represents a child's verbal or physical hostility towards others. Parents rated the child's behavior on a 4-point response scale, ranging from 1 (never) to 4 (almost always). Cronbach's α values for each mean response score ranged between .70 and .85. Maternal and paternal reports were significantly correlated for all scales, r range: .33 - .53, $p < .01$. For the analyzes, we constructed mean score sum variables for internalizing symptoms (anxiety, depression and somatization scales). For externalizing symptoms, we used aggression mean score and also five items of attention problems from the executive functions -domain of cognitive developmental problems from the Five to Fifteen questionnaire (described below) to represent a wider range of externalizing problems. Attention problems' α:s were .81 and .78, and maternal and paternal reports correlated significantly, $r = .61$, $p < .01$. Cronbach's α for combined maternal and paternal internalizing scale was .85 and externalizing scale .88.

Children's social developmental problems were measured at T4 by a scale from Social Skills Rating System (SSRS) (Gresham & Elliot, 1990) and another from Child Behavior Scale (CBS) (Ladd & Profilet, 1996). *Assertion*-subscale of the SSRS (10 items) describes a child's initiatives and ability to bond with peers, and *peer exclusion* -subscale of the CBS (seven items) measures a child's popularity versus rejection among peers. Parents estimated how well the descriptions fit their child on a 4-point response scale, ranging from 1 (never) to 4 (almost always). Cronbach's α values for mean response scores ranged between .78 and .80. Maternal and paternal reports were significantly correlated for both dimensions, $r = .56 - .57$, $p < .01$. For the analyses, we constructed a mean score of combined maternal and paternal evaluation of social developmental problems, which had a Cronbach's α of .81.

Children's cognitive developmental problems were assessed at T4 by the Five to Fifteen (FTF, Kadesjö et al., 2004) questionnaire for childhood neuropsychological symptoms, consisting in total of eight domains (181 items). Four domains were chosen for this study based on developmental considerations: *executive functions* (subdomain planning and organizing, seven items), *perception* (subdomains time concepts, body perception and visual perception, 13 items), *memory* (subdomains semantic and episodic memory and recall, 11 items) and *language* (subdomains expressive language skills and communication, 16 items). Parents rated the child's behavior on a 3-point response scale, ranging from 1 (does not describe my child at all) to 3 (describes my child well). Maternal and paternal Cronbach's α values for mean response scores ranged between .70 and .90. Maternal and paternal reports were significantly correlated for all domains, r range: .52 - .71, $p < .01$. Cronbach's α values for combined parental mean scores ranged between .77 and .89.

Children's psychophysiological-hormonal stress regulation was assessed at T5 by saliva cortisol samples. A research assistant visited families' homes to train the parents and children to collect the samples. They collected five samples (C1-C5) during a regular school-day: immediately after awakening (C1), 30 minutes after awakening (C2), one hour after awakening (C3), after returning from school in late afternoon (C4), and before going to sleep in the evening (C5). The sampling tube consisted of a plastic sampling vessel with a suspended insert containing sterile neutral cotton wool swab. The children were instructed to chew the swab for about a minute and then to return it to the insert. The families made structured notes about the exact time of saliva collection and stored the samples in their refrigerator. At the following day, a research assistant took the samples to Helsinki University Central Hospital laboratory, where cortisol was analyzed by a relatively novel and sensitive method of liquid chromatography-tandem mass spectrometry (LC-MS/MS), operating in the negative mode electrospray ionization (ESI) after separation on a reversed-phase column (Turpeinen, Välimäki, & Hämäläinen, 2009). For the analyzes, we constructed a sum variable of cortisol secretion throughout the day (C1-C5).

6.3 Statistical analyses

6.3.1 Research question 1 (Articles I and II)

To answer our first research question, i.e. to identify trajectories of maternal and paternal mental health symptoms from pregnancy (T1) through two months (T2) and twelve months (T3) postpartum, we used mixture modeling in Mplus version 5.2 (Muthén & Muthén, 1998–2007). Robust standard errors (MLR) with maximum likelihood estimation were used, which also handles missing data by using all the information available. Mixture modeling identifies subpopulations from the observed data, and those are in the longitudinal setting called latent trajectory groups. Figure 2 presents the factor mixture model of the present study. To increase validity of parental mental health measure, we based the identification of groups on two mental health indicators, psychological distress (GHQ-36) and depressive symptoms (BDI-13), both assessed at T1, T2 and T3. Individual variation in the level of mental health symptoms was modeled by including a level factor and fixing its loadings to one, ensuring that the number of latent groups was not due to the correlations between the variables, but instead was caused by real variation in the level of symptoms (Lubke & Neale, 2006).

The optimal number of latent groups was evaluated by using seven statistical criteria: a) three information criteria fit indices, including Akaike's information criterion (AIC), Bayesian information criterion (BIC) and the sample-size-adjusted Bayesian information criterion; (b) three likelihood ratio tests, including Vuong-Lo-Mendell-Rubin likelihood ratio test (VLMR), Lo-Mendell-Rubin adjusted likelihood ratio test (LMR) and the bootstrap likelihood ratio test (BLRT) for k versus k-1 groups; and c) Entropy. Our decision was based particularly on the BIC and the

BLRT, as suggested by Tolvanen (2007) and Nylund, Asparouhov, and Muthén (2007). The quality of classifications was evaluated using the estimated posterior probabilities of group membership for each individual and the average posterior probabilities for each group. Each subject was assigned to one specific trajectory group based on the highest estimated posterior probability, and this classification was used in the subsequent analyzes conducted by Statistical Package for the Social Sciences (SPSS, version 23). Finally, to investigate the role of ART in early parental mental health trajectories, we used Pearson's chi-square test.

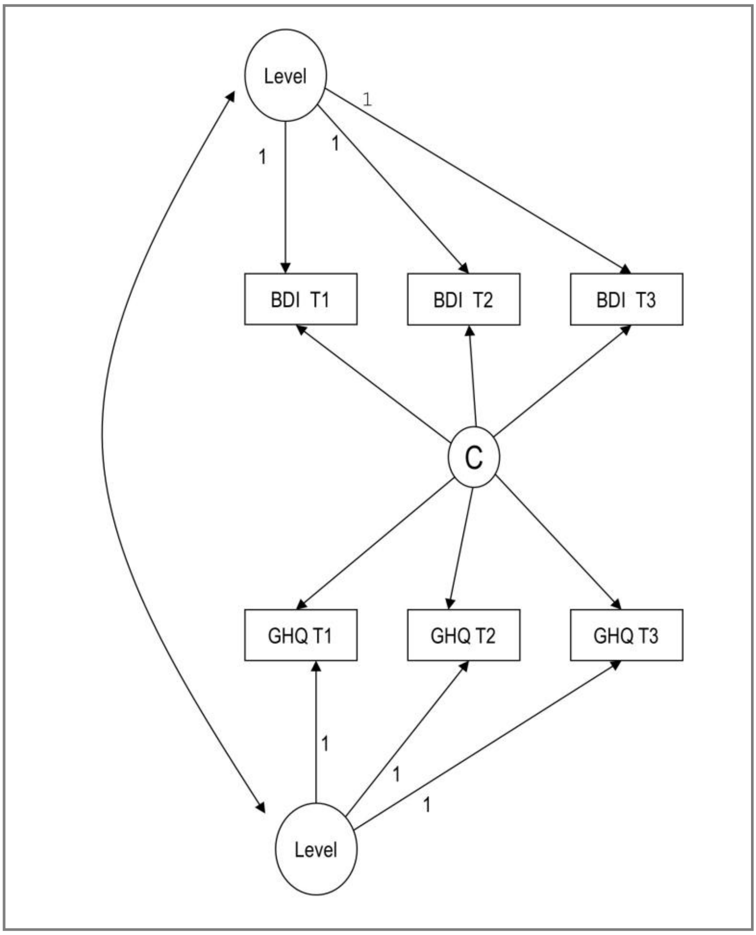

Figure 2. Factor mixture analysis design of mothers' and fathers' mental health across the pre- and postpartum period. BDI = Beck's Depression Inventory (13-item); GHQ = General Health Questionnaire (36-item); T1 = Pregnancy; T2 = Child two months old; T3 = Child twelve months old; C = Mental health latent variable; Level = Level factor.

6.3.2 Research question 2 (Article IV)

To identify intrafamilial dynamics, i.e. co-occurrence and/or compensation in parental mental health, we used SPSS cross tabulation. The χ^2-test determined whether there were significant associations between maternal and paternal symptoms at specific time points (T1-T3), and standardized adjusted residuals ($> |1.96|$) specified their location. By using the information in the cross tabulation, we constructed an intrafamilial early parental mental health variable, representing parental overlap in symptoms throughout the transition to parenthood. The variable had four categories: healthy parents, solely maternal and solely paternal problems, and both maternal and paternal problems.

6.3.3 Research question 3 (Article II)

Associations between paternal mental health trajectory groups and early fathering experiences were examined by repeated-measures MANOVAs on parent, interaction and child domains of Parenting Stress Index from T2 to T3. In addition to univariate analyzes, Tukey's Honest Significant Difference (HSD) post-hoc analyzes were conducted to compare the general level (average of T2 and T3) and the change (from T2 to T3) of fathering experience between the trajectory groups. The use of covariates (paternal education and age, marital status, duration of the partnership, parity, child's gender and birthweight) was decided based on their differences across paternal trajectory groups. To analyze whether early paternal mental health predicted early fathering experience differently in ART compared to NC-group, we included a 5 (trajectory group) * 2 (fertility history) -interaction term into the MANOVA analysis.

6.3.4 Research question 4 (Articles I and III)

To analyze the predictive value of the identified maternal mental health trajectories on child mental health and development at the age of 7-8 years, we conducted 5 (maternal mental health trajectory group) x 2 (fertility history: ART vs. NC) x 2 (gender) main effect ANCOVAs on internalizing (sum variable of anxiety, depression, and somatization) and externalizing (sum variable of aggression and attention problems) symptoms, social developmental problems (sum variable of assertion and peer exclusion) and cognitive developmental problems (separate variables for executive functions, perception, memory, and language). To analyze whether early maternal mental health predicted child's mental health and development differently a) among boys and girls and b) in the ART versus NC-group, we included the corresponding two-way interaction terms into these analyzes. Significance was set at $p < .05$, and Tukey correction was used to specify the significant differences between all the trajectory groups in child outcomes. We used the current (T4) maternal GHQ-psychological distress as a covariate, and decided on the use of other covariates (maternal education and age, marital status, duration of the partnership, parity, child's gender and birthweight) based on their differences across trajectory groups. The missing data in covariates was imputed using the Expectation Maximization (EM) algorithm implemented in SPSS.

We analyzed child psychophysiological-hormonal stress regulation among a subgroup of families (n = 102) at child's age of 10-11 years. To the best of our knowledge, no previous study had directly compared the impact of prenatal versus postpartum maternal symptoms on children, thus making it impossible to weigh the relative importance of both timings. Therefore, we compared the effects of prenatal only versus early postpartum only psychological distress and depression on children's cortisol levels and diurnal patterns. All cortisol variables (C1 – C5) were highly skewed, and a satisfactory normal distribution was not reached even with logarithmic transformations, which is why we decided to use non-parametric tests with non-transformed values. First, we used median test to examine, whether children from different maternal mental health trajectory groups differed either in their average daily cortisol level or in cortisol levels measured at each individual time point (C1 – C5). Mann-Whitney's U-tests were used as post-hoc tests to determine which pairs of the groups differed from each other in cortisol level. Second, diurnal cortisol patterns were first analyzed separately within each group of children. Friedman's tests were used as omnibus tests to examine whether cortisol values fluctuated across the daily time points within each group. Wilcoxon's signed-rank tests were used as post-hoc tests to examine the differences between each pair of consecutive daily time points (C1 vs. C2, C2 vs. C3, C3 vs. C4 and C4 vs. C5). Third, to examine the diurnal patterns further, we used the median test to compare children's cortisol value difference scores between each group of children. Cortisol value difference scores were computed between pairs of consecutive time points (i.e., C2 – C1, C3 – C2, C4 – C3). Further, to compare the overall change within the cortisol awakening response, we computed a CAR difference score from awakening to one hour after awakening (C3 – C1), and to compare the change in the diurnal cortisol decline, we computed a DCD difference score from afternoon to evening

(C5 – C4). Mann-Whitney's U-tests were used as post-hoc tests to determine which groups of children differed from each other in difference scores. The missing cortisol data was imputed using the EM algorithm implemented in SPSS.

6.3.5 Research question 5 (Article IV)

To analyze the early joint parental mental health as a predictor of child mental health and development, we conducted main effect ANCOVAs of intrafamilial early parental mental health on children's internalizing and externalizing symptoms and cognitive and social developmental problems. Child's gender was included as a covariate, as it was found to correlate with both the predictor and outcome variables. The use of other covariates (parental education and age, marital status, duration of the partnership, parity, child's gender and birthweight) was decided based on their differences across early parental mental health groups. Furthermore, due to similarities between participants and T4 drop-outs, imputation was not conducted.

We tested five possible contrast models: separate mother and separate father as well as joint additive, joint hierarchical and joint buffering models, by using post-hoc tests with custom (L-Matrix) contrasts. If more than one contrast estimate turned out to be significant in predicting child outcome, hierarchical regression analysis was conducted to decide the most valid and parsimonious model. For the hierarchical regression analysis, we recoded the intrafamilial early parental mental health variable into five new categorical variables, according to the five contrast models. The changes in the R^2- and F-statistics allowed us to assess the unique contribution of joint models over and above the more simple separate models.

6.4 Ethical considerations

The fieldwork was conducted as defined in the ethical standards of the American Psychological Association (APA, 2009). The Ethics Commitees of the participating clinics approved the study purpose, methods and data collection procedures separately concerning the transition to parenthood (T1-T3) and the two study waves in middle childhood (T4 and T5 separately). The mothers, fathers and children with clinically significant mental health problems were contacted to offer consultation by a family therapist or a child psychiatrist. The authors had no conflicting interests.

7 Overview of the results

The original publications (Articles I – IV) display the exact results, including statistics, regarding each research question. An overview of the results is presented here. Please, see the original publications (attached) for more detailed information.

7.1 Descriptive results

Maternal and paternal mental health symptoms in the transition to parenthood were relatively low in our sample. The proportion of parents with clinically significant levels of GHQ-psychological distress at each pre- and postnatal time point (T1-T3) ranged between 12% and 15% for mothers, and between 5% and 7% for fathers. The proportion of parents with clinically significant levels of BDI-depressive symptoms at each time point (T1-T3) ranged between 6% and 10% for mothers, and between 3% and 6% for fathers. When the child was 7-8 years old (T4), 14% of mothers and 10% of fathers reported clinically significant levels of GHQ-psychological distress. BDI-depressive symptoms were not assessed at that point.

Children were also quite low in mental health symptoms in middle childhood (T4). In each BASC-mental health scale, the proportion of children *at risk* of problems ranged between 1% and 8% and with clinically significant problems between 0.4% and 3%. The at risk of problems refer to 1-2 *SD*'s above the norm mean and clinically significant problems to over 2 *SD*'s above the norm mean (Reynolds & Kamphaus, 1992). Children's social developmental problems were somewhat more typical. In each social developmental problem scale (SSRS, CBS) the proportion of children at risk of problems ranged between 19% and 21% and with clinically significant problems between 3% and 9%. Finally, in each FTF-cognitive developmental problem scale the proportion of children at risk of problems ranged between 7% and 18% and with clinically significant problems between 3% and 7%.

7.2 Early parental mental health trajectories

Our first aim was to identify distinct early maternal and paternal mental health subgroups (i.e. latent developmental trajectory groups) according to timing and course of depression and psychological distress symptoms across the transition to parenthood.

7.2.1 Maternal trajectories (Article I)

Different information criteria and likelihood ratio tests of maternal mental health were giving somewhat different results. Based on theoretical meaningfulness and BIC as a highly reliable criteria (Nylund et al., 2007; Tolvanen, 2007), we selected the eight-group solution. The average predicted posterior probabilities for group membership in that solution were acceptable, ranging from .81 to 1.0. However, only four trajectory groups had distinct timing and course of mental health problems. These groups were also theoretically and conceptually meaningful, and represented 96% of the data. The remaining four groups consisted each of only few subjects and were highly heterogeneous in the course of the maternal mental health: mothers in these groups reported high levels of problems in more than one assessment points, and their symptom courses did not fit any of the four larger groups. Although perhaps representing meaningful subpopulations of mothers, our sample was not large enough to make statistical inferences. However, we did not want to leave them out of the subsequent analyzes, which is why we combined them into one new trajectory group, named as Heterogeneous high levels of mental health problems.

Therefore, five maternal mental health trajectory groups were identified that differed systematically in the timing and course of symptoms across the pre- and postnatal period, revealing distinct peaks in pregnancy, early postpartum or late postpartum. The mean levels of maternal GHQ-psychological distress and BDI-depressive symptoms are illustrated in Figure 3 according to the identified trajectories at T1 pregnancy, T2 two months postpartum, and T3 twelve months postpartum.

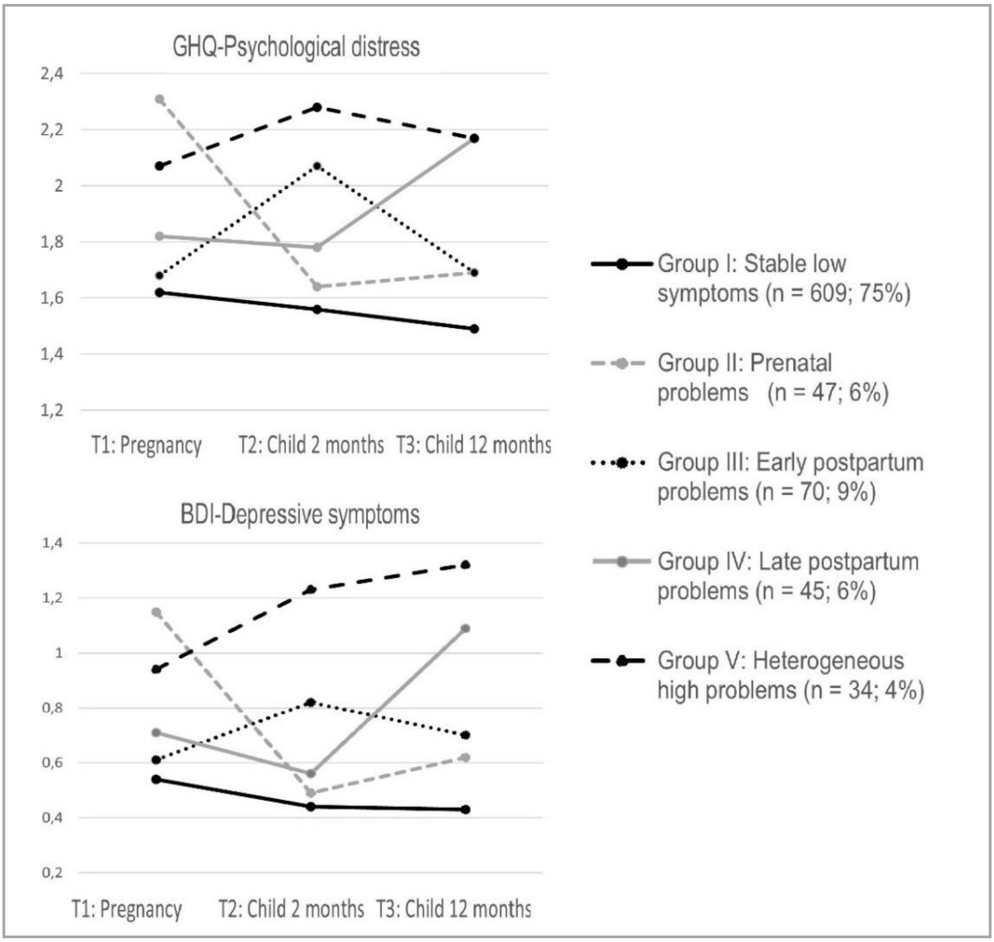

Figure 3. Means of reported GHQ-psychological distress and BDI-depressive symptoms according to ***mothers'*** early mental health trajectory group. GHQ = General Health Questionnaire (36-item); BDI = Beck's Depression Inventory (13-item). *N* = 763.

The contents of the five trajectories were the following: *I Stable low levels of mental health symptoms* was the largest trajectory group, comprising 75% of the data. Characteristic to mothers in this group were low symptom levels of psychological distress and depression throughout the pre- and postnatal period. The trajectory (average) did not exceed the clinically significant cut-off points for GHQ-psychological distress and BDI-depressive symptoms at any time point. *II Prenatal* *mental health problems* –trajectory group involved 6% of the mothers in our sample. They reported high level of mental health problems in pregnancy that then decreased to low or moderate levels in the early postpartum and remained fairly stable until the late postpartum. In pregnancy the trajectory crossed the clinically significant cut-off points for both GHQ-psychological distress and BDI-depressive symptoms (mild depression). *III Early postpartum mental health problems* –group involved 9% of the mothers in our sample. Their symptom levels were high in early postpartum, when the child was two months old, but relatively low in pregnancy and late postpartum. In the early postpartum, the trajectory exceeded the clinically significant cut-off point for GHQ-psychological distress, but not for BDI-depressive symptoms. *IV Late postpartum mental health problems* –trajectory group comprised 6% of mothers in our sample. They showed a high level of symptoms in the late postpartum, when the child was twelve months old, but low or moderate level of symptoms in pregnancy and the early postpartum. At twelve months the trajectory exceeded the clinically significant cut-off points for both GHQ-psychological distress and BDI-depressive symptoms (mild depression). *V Heterogeneous high levels of mental health problems* -post-hoc trajectory group combined four small trajectories, comprising in total 4% of the mothers in our data. They showed either chronically high levels of mental health problems or had a highly variable profile. The trajectory exceeded the clinically significant cut-off points for GHQ-psychological distress and BDI-depressive symptoms at every time point (T1-T3).

7.2.2 Paternal trajectories (Article II)

The information criteria and statistical tests of the paternal analysis gave somewhat conflicting results. Based on the highest reliability of BIC and BLRT as statistical criteria (Nylund et al., 2007), the 9-group solution appeared to be the best. Importantly, however, log-likelihoods of the solutions with nine and ten groups could be only rarely replicated even with as many as 1000 starting values, indicating instability for these solutions. BIC and BLRT suggested the eight-group solution to be the best of stable solutions. When visually comparing the mean courses and group sizes in the 8- vs. 9-group solutions, we found only minor differences: one small trajectory group was split into two, and rest of the groups remained fairly stable. Therefore, we selected the 8-group solution. The average posterior probabilities for group membership were acceptable, ranging from .81 to 1.00. The solution involved four trajectory groups that were representative of the sample, covering 96% of the data, and theoretically meaningful. The remaining four groups comprised each only a few fathers, and were highly heterogeneous in the timing and course of paternal mental health. Consequently, they could neither be combined into one group nor included in any of the larger groups. Similarly to maternal trajectory groups we combined them into one new trajectory group, named as Heterogeneous high levels of mental health problems.

Figure 4 displays the courses of fathers' GHQ-psychological distress and BDI-depressive symptoms in each mental health trajectory group from pregnancy (T1) to child being two months (T2) and twelve months (T3) old.

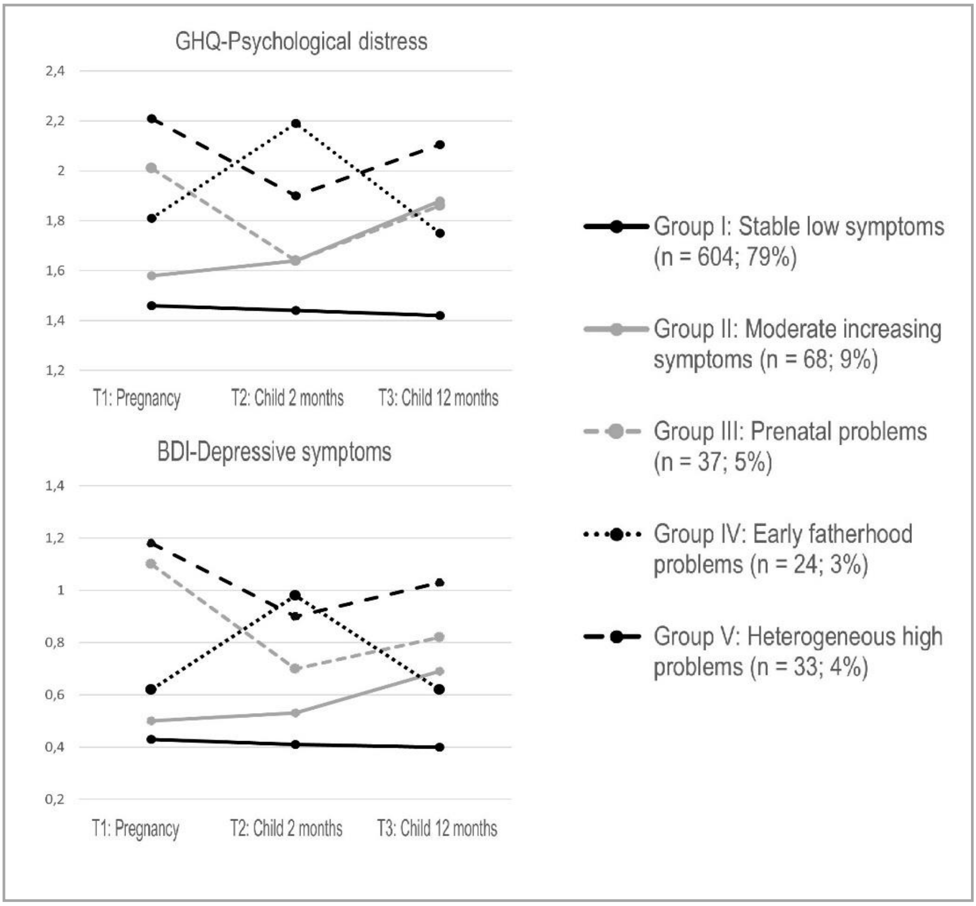

Figure 4. Means of reported GHQ-psychological distress and BDI-depressive symptoms according to ***fathers'*** early mental health trajectory group. GHQ = General Health Questionnaire (36-item; Goldberg & Hiller, 1979); BDI = Beck's Depression Inventory (13-item; Beck et al., 1961). *N* = 763.

The identified five trajectory groups were as follows: *I Stable low levels of mental health symptoms* -group was the largest, involving 79% of fathers in our sample. They showed low levels of psychological distress and depressive symptoms throughout the pre- and postnatal period. The trajectory (average) did not exceed the clinically significant cut-off point for GHQ-psychological distress or BDI-depressive symptoms at any time point. *II Moderate increasing levels of mental health symptoms* –group involved 9% of fathers in our sample. Their symptom levels started out low during pregnancy, but gradually increased towards early and late postpartum. The trajectory did not exceed the clinically significant cut-off point for GHQ-psychological distress or BDI-depressive symptoms at any time point. *III Prenatal mental health problems* –group involved 5% of fathers in our sample. They reported a relatively high level of mental health problems during pregnancy, but the symptoms then decreased to low or moderate levels towards the postpartum period. The trajectory crossed the clinically significant cut-off points for GHQ-psychological distress and BDI-depressive symptoms in pregnancy, but not during the postpartum period. *IV Mental health problems in early fatherhood* –group comprised 3% of fathers in our sample. They showed a peak in mental health problems when the child was two months old, whereas in pregnancy and at twelve months the symptom levels were relatively low. The trajectory exceeded the clinically significant cut-off point for GHQ-psychological distress, but not for BDI-depressive symptoms, at the child's age of two months. V *Heterogeneous high levels of mental health problems* –post-hoc group involved 4% of fathers in our sample. Some of them showed high and increasing course of problems; others had extremely high levels of problems during the pregnancy and early postpartum, but not anymore in the late postpartum; yet others suffered chronically high levels of problems. The trajectory exceeded the clinically significant cut-off points for both GHQ-psychological distress and BDI-depressive symptoms in pregnancy and at twelve months, and for GHQ-psychological distress only at two months.

7.2.3 Impact of former infertility

Results showed similar distribution of early mental health problems between ART and NC-groups among both mothers and fathers. This indicated that infertility history and fertility treatments had no effect on the timing and course of parental pre- and postnatal mental health symptoms.

7.3 Intrafamilial dynamics in early parental mental health (Article IV)

Our second task was to identify intrafamilial early parental mental health dynamics by examining how the mothers' and fathers' trajectory groups overlapped in families. Significant χ^2-test and standardized residuals showed co-occurrence between specific pre- and postnatal time points. First, strong co-occurrence was found between maternal and paternal stable and low levels of mental health symptoms -groups (I). Moderate co-occurrence was found between maternal (II) and paternal (III) prenatal mental health problems –groups and between maternal late postpartum mental health problems (IV) and paternal moderate increasing levels of mental health symptoms (II) -groups. Instead, there was no association between maternal and paternal trajectories with early postpartum (III, IV) and heterogeneous high levels of (V, V) mental health problems.

The four intrafamilial early parental mental health groups comprised the following: 1) *Healthy parents* (68.4%, *n* = 522), comprising families with both mothers and fathers belonging to trajectory groups without clinically significant levels of mental health problems at any point of the transition (mother I; father I or II). 2) *Solely maternal problems* -group (19.4%, *n* = 148) consisted of families with mothers who belonged to groups with clinically significant levels of problems at least at one point of the transition and fathers belonging to groups without clinically significant levels of problems (mother II, III, IV or V; father I or II), thus reflecting possible paternal compensation for maternal problems. 3) *Solely paternal problems* -group (7.6%, *n* = 58) comprised families with fathers who belonged to groups with mental health problems and mothers to that without problems (mothers I; fathers III, IV or V), thus reflecting possible maternal compensation for paternal problems. 4) *Both maternal and paternal problems* -group (4.6%, *n* = 35) consisted of families, in which both parents belonged to groups with clinically significant levels of problems (mother II, III, IV or V; father III, IV or V), thus reflecting co-occurrence of parental mental health problems.

7.4 Paternal mental health and early fathering experience (Article II)

Our third task was to examine how the identified paternal mental health trajectory groups were associated with early fathering experiences (T2-T3) and whether family's former infertility moderated the effect. Figure 5 displays the estimated marginal means of the parent, interaction and child domains of fathering experience across the fathers' mental health trajectory groups.

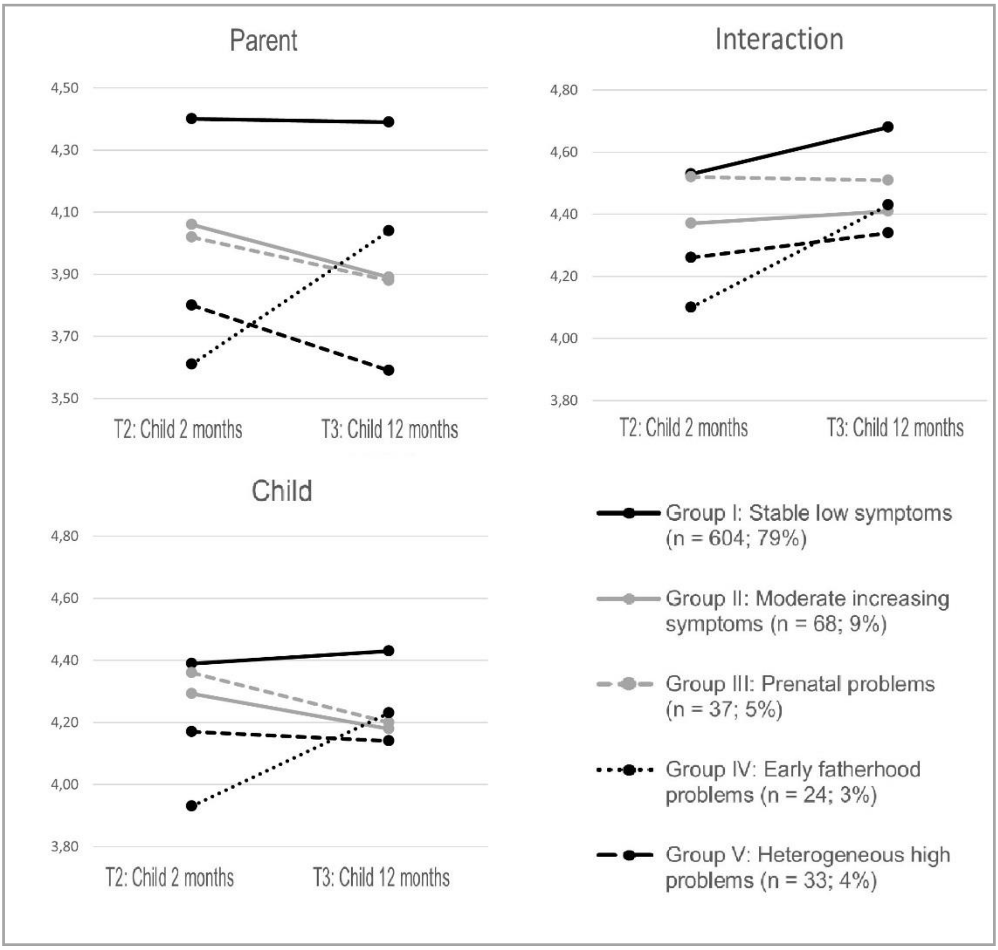

Figure 5. Estimated marginal means of parent, interaction, and child domains of fathering experience (Parenting Stress Index-36; Abidin, 1995) from child being two months (T2) to twelve months (T3) across the fathers' mental health trajectory groups. *N* = 763.

MANOVAs showed that the trajectory groups were associated with both the general level (average of T2 and T3) and the change (from T2 to T3) of fathering experience. Univariate results further revealed that differences between the trajectory groups in the general level of fathering experience were significant in the parent, interaction and child domains. First, fathers in the stable low –group (I) reported an especially positive fathering experience. In the parent domain, their experience was more positive than that of any other group (II-V), and in the interaction and child domains, it was more positive than among fathers in the moderate increasing (II), early fatherhood (IV) and heterogeneous high (V) –groups. Second, in line with our hypothesis, the fathers in the heterogeneous high –group (V) reported an especially negative fathering experience. They differed from the fathers in the stable low –group (I) in all three domains, and from the fathers in the moderate increasing (II) and prenatal -groups (III) in the parent domain. Third, also in line with our hypothesis, the early fatherhood –group (IV) reported more negative fathering experience than the stable low (I) –group in the parent domain, and the stable low (I) and prenatal (III) –groups in the interaction domain.

Differences between the trajectory groups in the change of fathering experience were significant in the parent, interaction and child domains. Typical to fathers in the early fatherhood –group (IV) was negative fathering experience when the child was two months old that then sharply improved towards twelve months. In the parent domain, their change from T2 to T3 differed from all other groups, and in the interaction and child domains, it differed from the moderate increasing (II), prenatal (III) and heterogeneous high (V) –groups. Finally, fertility history did not moderate the association between paternal mental health trajectory and fathering experience. Instead, the impact of father's trajectory group on the general level and the change of fathering experience from T2 to T3 was similar among ART and NC families.

7.5 Maternal mental health impacting children

Our fourth task was to examine how the five identified maternal mental health trajectory groups predicted children's mental health and cognitive and social development at the age of 7-8 years. Among a subsample ($N = 102$), we also analyzed differences in children's physiological-hormonal stress regulation, measured by cortisol levels and diurnal patterns at the age of 10-11 years. This analysis included children from three maternal trajectory groups: stable low levels of mental health symptoms ($n = 72$) and prenatal ($n = 15$) and early postpartum ($n = 15$) mental health problems.

7.5.1 Child mental health and development at 7-8 years (Article I)

Maternal mental health trajectory group predicted child internalizing symptoms (partial $\eta^2 = .03$), but not externalizing symptoms. Pair-wise comparisons specified that the children of mothers with early postpartum (III) or heterogeneous high levels of (V) mental health problems showed more internalizing symptoms than the children of mothers with stable low levels of symptoms (I). Parity and current T4 maternal GHQ-psychological distress were significant covariates for both internalizing and externalizing symptoms. Maternal mental health trajectory group predicted also children's cognitive developmental executive functions (partial $\eta^2 = .02$) and memory (partial $\eta^2 = .03$). Pair-wise comparisons specified that the children of mothers with heterogeneous high levels of problems (V) showed more problems in executive functions than the children of mothers with stable low levels of symptoms (I) or late postpartum mental health problems (IV). They also showed more memory problems than children of mothers in any other group. Both parity and current T4 maternal GHQ-psychological distress were non-significant covariates for child cognitive development. Children's social development was not predicted by maternal mental health trajectory group. The current T4 maternal GHQ-psychological distress was a significant, but parity a non-significant covariate for child social development. Furthermore, neither child's gender nor family's fertility history moderated the effect between maternal mental health trajectory group and children's mental health or social or cognitive development. In other words, mothers' mental health similarly predicted child internalizing and externalizing symptoms and cognitive and social developmental problems a) among boys and girls, and b) in normative families and in those with former infertility.

In line with our hypotheses, children of mothers with chronic and severe course of symptoms displayed the highest level of mental health symptoms and developmental problems at the age of 7-8 years. However, the results did not support our second hypothesis. We had assumed that children of mothers with prenatal problems would display a higher level of mental health symptoms and developmental problems compared to children of mothers with postpartum problems or those without mental health problems. Our results showed instead that children of mothers with early postpartum mental health problems had an increased vulnerability to internalizing mental health problems.

7.5.2 Child stress regulation at 10-11 years (Article III)

Results showed no differences between the three groups of children in the average daily cortisol levels. Cortisol levels differed, however, in some single point measures: at awakening (C1) and at 30 minutes after awakening (C2). Pair-wise comparisons specified that children of mothers with prenatal mental health problems (II) had at awakening (C1) lower cortisol levels than children of mothers with stable low levels of symptoms (I), whereas at 30 minutes after awakening (C2) they had higher cortisol levels than children of mothers with early postpartum mental health problems (III), suggesting a steeper increase of cortisol from awakening to 30 minutes after awakening among children of mothers with prenatal mental health problems (II) as compared to other children.

Figure 6 presents diurnal cortisol patterns in the three groups of children. Results showed fluctuation across day within each group: children of mothers with stable low levels of symptoms (I), children of mothers with prenatal mental health problems (II) and children of mothers with early postpartum mental health problems (III). Pair-wise analyzes showed that among children of mothers with stable low levels of symptoms (I), cortisol increased from awakening (C1) to 30 minutes after awakening (C2) and decreased thereafter towards one hour after awakening (C3), late afternoon (C4) and evening (C5). A similar diurnal pattern was found among children of mothers with prenatal mental health problems (II). In contrast, children of mothers with early postpartum mental health problems (III) showed no change in cortisol from awakening (C1) to 30 minutes after awakening (C2) or from 30 minutes after awakening (C2) to one hour after awakening (C3). There was however a decrease of cortisol from one hour after awakening towards late afternoon (C4) and evening (C5) in the early postpartum trajectory group, suggesting a reduced CAR among the children of mothers with early postpartum mental health problems (III).

Cortisol difference scores of the pairs of consecutive time points (C2 – C1, C3 – C2, C4 – C3), including the DCD difference score (C5 – C4), did not differ between the three groups of children. The CAR difference score from awakening to one hour after awakening (C3 – C1) differed however between the groups. Pair-wise comparisons revealed that the difference occurred between the children of mothers with prenatal mental health problems (II) and the children of mothers with stable low levels of symptoms (I): the children of mothers with prenatal mental health problems showed increase in CAR from C1 to C3, whereas the children of mothers with stable low symptoms showed decrease in CAR from C1 to C3. This suggested a steeper increase in CAR among children of mothers with prenatal problems compared to other children.

To sum it up, our hypothesis concerning a more adverse effect of maternal prenatal compared to postpartum problems on children's cortisol was not supported. Instead, we found that both maternal prenatal and early postpartum mental health problems impacted children's diurnal cortisol pattern at the age of 10-11 years, but in different directions. Whereas prenatal problems seemed to shape it towards an intensified CAR, early postpartum problems were associated with a reduced CAR.

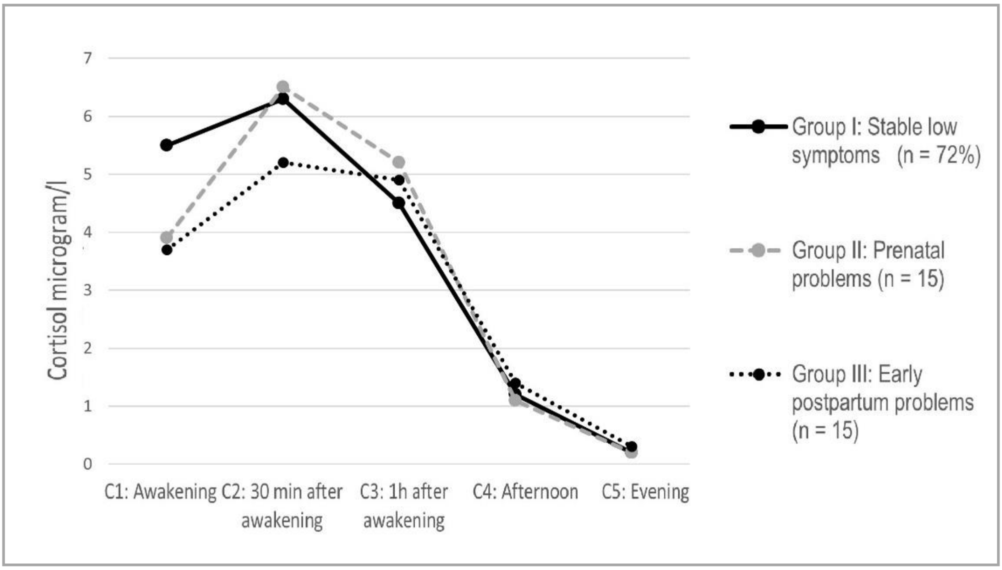

Figure 6. Children's cortisol value medians (microgram/l) according to early maternal mental health trajectory group. N = 102

7.6 Joint parental mental health impacting children (Article IV)

Concerning children's mental health at the age of 7-8 years, intrafamilial early parental mental health predicted internalizing symptoms (partial $\eta^2 = .03$), but not externalizing symptoms. Post-hoc tests with contrasts revealed that separate mother- and joint parental additive- theoretical models predicted children´s internalizing symptoms. According to the hierarchical regression analysis, separate mother variable was as significant as joint parental additive variable in predicting internalizing symptoms. Thus, it was concluded that maternal mental health alone was sufficient in predicting child internalizing symptoms. Child's gender was a significant covariate on externalizing symptoms, indicating that boys showed more problems than girls.

Concerning child development at the age of 7-8 years, intrafamilial early parental mental health predicted cognitive developmental problems of executive function (partial $\eta^2 = .02$), but not social developmental problems. Post-hoc tests with contrasts revealed that the joint parental additive model was the only significant predictor of executive function. Thus, it was concluded that both maternal and paternal symptoms contributed independently to executive function, above and beyond the contribution of the other parent's symptoms. Child's gender was a significant covariate on all cognitive variables, indicating that boys showed more cognitive developmental problems than girls. Child's gender was a non-significant covariate on child social developmental problems.

7.7 Summary of the main results

1) We first identified distinct early maternal and paternal mental health trajectories regarding the timing and course of depression and psychological distress symptoms across the transition to parenthood. According to our study:

    - Approximately three quarters of mothers (75%) and fathers (79%) show stable and low symptom course throughout their transition to parenthood, without elevated levels of depression or psychological distress at any time point.
    - Early maternal and paternal mental health problems are typically heterogeneous, dynamic and timing-specific by nature, involving groups with mental health problems at specific time points only: during the pregnancy or in the early or late postpartum.
    - Small groups of mothers and fathers suffer chronic or high sporadic problems throughout their transition to parenthood.
    - Infertility and ART do not alter the timing and course of maternal and paternal mental health symptoms in the transition to parenthood.

2) Second, we analyzed intrafamilial dynamics, i.e. co-occurrence and compensation of symptoms, between mothers' and fathers' early mental health. According to our results:

    - Strong co-occurrence exists between maternal and paternal stable and low levels of early mental health symptoms. Moderate co-occurrence exists between maternal and paternal mental health problems in the pregnancy and the late postpartum, and no co-occurrence exists between maternal and paternal early postpartum or chronic high mental health problems.
    - When analyzed throughout the transition, our results suggest more compensation of partner's mental health problems than co-occurrence of problems.

3) Third, we investigated how the timing and course of early paternal mental health symptoms were associated with early fathering experience. According to our study:

    - Fathers with stable low levels of mental health symptoms experience early fathering most positively across the child's first year.
    - Fathers with chronic or high sporadic mental health problems are at an increased risk for negative fathering experience across the child's first year.
    - Short-lived mental health problems in the early fatherhood are associated with coincidental negative fathering experience that becomes more positive hand-in-hand with the relief of mental health problems.
    - Infertility and ART do not alter the association between paternal mental health and early fathering experience.

4) Fourth, we examined how the timing and course of early maternal mental health problems predicted children's internalizing and externalizing symptoms, social and cognitive developmental problems and psychophysiological-hormonal stress regulation in the middle childhood. According to our study:

- Chronic or high sporadic early maternal mental health problems increase children's vulnerability to internalizing symptoms and cognitive developmental executive dysfunction and memory problems.
- Maternal mental health problems in the early postpartum only are a risk factor for child internalizing symptoms.
- Maternal mental health problems in the pregnancy or the late postpartum only do not indicate risk for child mental health or developmental problems.
- Both maternal prenatal and early postpartum mental health problems predict less than optimal child stress regulation, particularly alterations in CAR, but to opposite directions: prenatal problems increase likelihood of an intensified and early postpartum problems of a reduced CAR.
- Infertility and ART do not alter the association between early maternal mental health and later child mental health and development.

5) Fifth, we tested the importance of five theoretical models of separate and joint early parental mental health in predicting child mental health and development. According to our results:

- Early maternal mental health alone, independent of paternal mental health, increases risk for later child internalizing symptoms.
- Maternal and paternal mental health problems have additive effects in predicting child executive functions.

8 Discussion

This dissertation aimed to increase understanding in the fields of early family mental health and developmental psychopathology. First, previous research has been scarce regarding variability between individuals in the longitudinal course of mental health symptoms in the transition to parenthood. Using a person-oriented approach, this study demonstrated a heterogeneous, dynamic and timing-specific nature of early parental mental health problems, with specific groups of mothers and fathers showing clinical levels of problems at specific time points. Second, knowledge of early sensitive periods is important, in order to better understand child developmental origins. This study suggests a possible developmental sensitive period for mental health during the early infancy, by providing evidence of a specific timing effect of maternal mental health problems at two months postpartum on child internalizing symptoms and psychophysiological stress regulation. Importantly, however, the effect was very small, thus also emphasizing the importance of multiple other risk and protecting factors in children's lives. Third, to understand child development in context, a wider family perspective needed to be adopted. We investigated mothers' and fathers' early mental health problems together as risk factors for child mental health and developmental problems. Results showed that both maternal and paternal problems increased children's vulnerability to problems in executive function, whereas maternal problems alone formed risk for internalizing symptoms. Finally, to shed light on potential unique characteristics of families with early risks, our study included a medically non-normative group of formerly infertile families. Our results support the argument of minor specific mental health and child developmental characteristics among families with former infertility.

8.1 Timing and course of early parental mental health symptoms

A majority, about three quarters of the mothers (75%) and fathers (79%) in this study reported relatively low level and stable course of mental health symptoms across the transition to parenthood. This finding is consistent with previous studies (Guyon-

Harris et al., 2016; Luoma et al., 2015; Mora et al., 2009), as well as everyday perceptions, showing that for most parents the experience of the transition to parenthood is predominantly positive. Parenthood can provide them for instance with a clearer purpose of life, a deeper sense of satisfaction as well as enhanced social roles (Cohen & Slade, 2000; Cowan & Cowan, 2000; Nelson, Kushlev, & Lyubomirsky, 2014).

In line with previous studies, this study also reminded us that mental health problems among expecting and new parents are not at all uncommon. A quarter of the mothers (25%) and more than a tenth of the fathers (12%) showed clinically significant levels of depression and psychological distress in at least one time point during the transition to parenthood. A variety of risk factors can induce mental health problems in the transition to parenthood, including genetic and biological vulnerabilities, negative early-life experiences, previous mental health problems, and multilevel demands of adaptation during the transition. As we did not analyze these parental mental health predictors, we do not know which of them were important in explaining the mental health of mothers and fathers in this study. One can speculate that these external and internal factors have played a dynamic interactive role in the process.

Previous research has been controversial regarding the timing and course of mental health problems in the transition to parenthood, with some studies suggesting stability (e.g. Paulson et al., 2016) and others variability (e.g. Luoma et al., 2001; Matthey et al., 2000). More research is needed on *subclinical* mental health problems as well as *individual variation* in the longitudinal course of symptoms (Goodman & Tully, 2009; Mora et al., 2009), as most traditional variable-oriented research has failed to analyze them. Using a person-oriented method, we were able to detect subtle variability in the longitudinal course of maternal and paternal symptoms. Our results suggest stability of good parental mental health, but disqualify the argument that mental health problems are likely to continue throughout the pre- and postpartum period. Instead, mental health problems in our study were highly heterogeneous, dynamic and timing-specific by nature. Mothers and fathers with early mental health problems suffered the disorder typically only at a specific time point, being symptomatic either only during the pregnancy (mothers 6%, fathers 5%), only when the child was two months old (mothers 9%, fathers 3%) or only when the child was twelve months old (mothers 6%). Interestingly, our analysis also identified a group of fathers (9%) who reported low levels of symptoms during the pregnancy that then gradually increased towards the child being two and especially twelve months old, yet, not reaching clinical significance. Although not being clinically relevant, such mild symptoms can reflect impairment in daily parental functioning and coping (Goodman & Tully, 2009; Weinberg et al., 2001), thus making their recognition important.

The finding of considerable variability in the timing and course of mental health symptoms can increase understanding of the nature of problems. In particular, maternal postpartum depression has often been considered as a uniform clinical condition that starts soon after the child's birth and is likely to continue throughout the first year (for instance, Beeghly et al., 2002; Moss, Skouteris, Wertheim, Paxton, & Milgrom, 2009). Our results revealed, however, two distinct trajectories of maternal mental health problems in the postpartum period, one occurring very early, when the child was two months old and the other when the child was twelve months old. These two trajectories differed also in their level and content of symptoms. Mothers with early postpartum problems displayed clinical levels of psychological distress, but only subclinical levels of depression, whereas mothers with late postpartum problems displayed clinically significant levels of both psychological distress and depression. Importantly, the result of two unique postpartum trajectories may reflect that the early and the late postpartum periods demand different adaptive qualities from the mothers. During the early postpartum months, mothers undergo marked bodily changes, such as rehabilitating from the labor and getting familiar with the experience of breastfeeding, both demanding psychological flexibility and ability to accept alteration in body figure (Aber et al., 2013). In turn, social and functional characteristics may become more important in the late postpartum. At that point, mothers can, for instance, be dissatisfied with division of work within the family or worry over financial and practical issues, such as the conflict of whether to return to work or to stay at home with the child. In our study, maternal mental health problems in the early postpartum, compared to the late postpartum, predicted somewhat differing effects on the child's future mental health, thus proposing that they may represent at least partially separate phenomena.

Different from previous studies (Campbell et al., 2007; Luoma et al., 2015; Mora et al., 2009), our trajectory analyzes did not reveal unified groups of mothers and fathers suffering from chronic mental health problems. Instead, 4% of both mothers and fathers belonged to a heterogeneous and dynamic group with more severe mental health problems, suffering either chronic or high sporadic problems across the pre- and postpartum period. Both the distinct timings and the heterogeneousness of severe mental health problems speak for the importance of active recognition of parental mental health problems at multiple times during the transition to parenthood. Exhaustion and despair can peak rapidly during reorganizational periods such as the transition to parenthood, and psychological support, combined with practical help if needed, should be easily available to parents throughout this period.

8.2 Intrafamilial dynamics in early parental mental health

Family systems perspective suggests an ongoing interplay of emotions and symptoms between family members (Cox & Paley, 1997; Minuchin, 1985). We attempted to get a grasp of such dynamics, by analysing associations between maternal and paternal symptoms at specific pre- and postnatal time points as well as throughout the transition. We found that about two thirds (68%) of the families had two healthy parents without clinical levels of symptoms at any time point during their transition to parenthood. Instead, about a third (32%) of the families had either one or both parents with mental health problems at least in some point of the transition. Importantly, one third is a significant proportion of families having to deal with the extra burden of parental psychological distress and depression during this challenging transitional phase. It is of utmost importance that families with early parental problems are not left alone.

We found both co-occurrence and possible compensation between mothers' and fathers' symptoms. Co-occurrence of parental problems can reflect spillover of emotions from one parent to the other (Paulson et al., 2006). As an example, depression in one parent could transmit to the other through increased negative communication and marital conflict. The co-occurrence in our study was evident at two time points: during the pregnancy and in the late postpartum, when the child was twelve months old. Interestingly, however, there was no co-occurrence of symptoms in the early postpartum, when the child was two months old. This lack of early postpartum symptom co-occurrence may reflect a fundamental gender discrepancy in adjusting to parenthood. Among mothers, biological and hormonal changes underlie a temporary psychological reorganization that involves full concentration on the baby during the first few weeks and months after the birth (Stern, 1985). At this point, mothers typically dedicate themselves to caring for young infants, who often need frequent bodily contact, feeding, soothing, and help with sleep. Fathers, instead, may remain more independent during this period (Escribà-Agüir & Artazcoz, 2011). For instance, Finnish fathers typically return to work at few weeks after the child's birth. These different experiences and roles during the first few postnatal months may partly explain why maternal and paternal mental health problems did not co-occur in the early postpartum period as they did during the pregnancy and in the late postpartum period.

Possible compensation was evident in about a quarter (27%) of the families, where one parent suffered mental health problems in at least one time point during the pre- and postpartum period, but the other parent did not. Previous studies have suggested that fathers can compensate for the possible negative impact of maternal depression on children, by establishing a particularly sensitive and supportive relationship with the child (Edhborg, et al., 2003; Nelson et al., 2009). As we did not measure parent-child relationship, we don't know, whether this kind of compensation took place in our sample. However, to get a hint of such potential parenting-related dynamic, we ran an additional analysis to test whether spouses of mothers and fathers with mental health problems compensated by having especially positive early parenting experiences. Results showed that mothers in families with paternal mental health problems reported more positive experience of themselves as parents at both the early and the late postpartum, whereas fathers' parenting experience in families with maternal problems did not differ from that of other fathers'. The result thus suggests a potential maternal compensation of paternal problems in the postpartum period.

It is an encouraging finding that in many families one parent can remain healthy despite spouse's problems. Interparental compensation is important in early parenthood to ensure that the developing infant receives all the available family resources. Beyond the obvious benefits of having one parent maintain psychological health while the other experiences problems, compensation may also be a crucial family resource for therapeutic interventions intended to address the problems.

8.3 Mental health and early fathering experience

Although exciting and delightful, early parenting often involves stress. New fathers typically face challenges in balancing their time between work and family, managing the changes in family economy, and accepting decreased time and intimacy with the partner (Chin et al., 2011; Genesoni & Tallandini, 2009). This study investigated the importance of specific timing and course of fathers' mental health problems, depicted in mental health trajectories, for the early fathering experience.

Understandably, the fathers with stable and low levels of symptoms throughout the transition to parenthood experienced their early fathering most positively. They were most comfortable with themselves as fathers, their interaction with the baby, as well as the infant's early characteristics. In contrast, and in line with our hypothesis, the most negative fathering experience was found among the small group of fathers with chronic or high sporadic mental health problems. These fathers felt themselves as less than competent parents, faced difficulties in adapting to the demands of parenthood, experienced interaction with the infant as relatively non-rewarding, and reported most temperamental irritability and negativity in their babies.

Furthermore, our results highlight the importance of early postnatal months for the development of fathering experience, as the fathers with mental health problems at child's age of two months (but not during the pregnancy or the end of the child's first year) showed more negative fathering experience than other fathers at two months. Once the child was one year old, these fathers no longer suffered from mental health problems and their fathering experience was more positive. This rehabilitating course may reflect an intensive early postnatal adjustment period among these fathers. They might have been unprepared for parental responsibilities, and some early difficulty, for instance a temperamentally demanding baby, was able to shake their overall balance, leading to negativity and exhaustion that was evident in both mental health and early experience of fathering.

However, because the observed association between early fatherhood mental health problems and negative early fathering experience was cross-sectional, we cannot draw conclusions about the direction of causality. It may as well be that early negative feelings about parenting led to symptoms, or that symptoms interfered with early fathering tasks. Importantly, with increasing adjustment to fatherhood during the child's first year, both mental health and fathering experience of these fathers improved. This emphasizes the potential benefit of psychological support for the early father-infant relationship. As it appears that the relief of either mental health problems or negative fathering experience can positively affect the other, supporting the early relationship may well reduce the effects of early negative experiences on later family and child functioning.

8.4 Maternal mental health impacting children

Developmental periods during which children are particularly responsive to environmental influences are called sensitive periods (Knudsen, 2004). Those represent heightened epochs of brain plasticity, through which early experiences can shape structural and functional aspects of the brain and behavior, with a long-term impact on development. Importantly, these programming effects on the central nervous system can produce either risk or resilience to later mental health and developmental problems (Roth & Sweatt, 2011). This study attempted to identify potential early sensitive periods in child development, by comparing the outcomes of children whose mothers displayed mental health problems at different time points of the transition to parenthood.

In line with our hypothesis, we found that the children of mothers with chronic or high sporadic problems were at highest risk of developing mental health symptoms and cognitive developmental problems in middle childhood. Compared to other children, these children showed more internalizing symptoms, consisting of anxiety, depression and somatization, as well as problems in executive functions and memory. Previous research has emphasized the chronicity of maternal depression to be harmful for child development (Grace et al., 2003; Hammen & Brennan, 2003; Weissman et al., 2016). From the perspective of the child, chronic maternal depression and anxiety can mean prolonged negative mother-child interactions, including more criticism and less playfulness and stimulation (Apter-Levi et al., 2016). They can also increase the likelihood of marital conflict and other adversities in the family environment (Klier et al., 2008), thus increasing the risk for child problems (Hanington et al., 2012). Importantly, however, some studies suggest *unpredictability* of adversities in early developmental environment to be even more detrimental to children than chronicity of problems (e.g. Simpson, Griskevicius, I-Chun Kuo, Sung, & Collins, 2012). In our study, maternal high sporadic mental health problems may have represented marked unpredictability in early parental care and sensitivity, thus predisposing children to later developmental problems.

Importantly, in our study, both prenatal biological and postnatal psychosocial mechanisms are likely to be responsible for the effect of chronic maternal mental health problems. During the pregnancy, maternal depression and anxiety can be harmful to fetal development via epigenetic changes and through less than optimal calibration of the HPA-axis (Beijers et al., 2014; Kapoor et al., 2006; Singh et al., 2012). In the postpartum period, the early mother–infant relationship can be at risk due to maternal problems (Edhborg et al., 2003; Feldman et al., 2009; Seymour et al., 2015). In the case of chronic maternal problems, these mechanisms can further accumulate each other's impact. As an example, early heightened negativity, possibly induced by HPA-axis and other physiological modifications during the pregnancy, can make the child more vulnerable to early difficulties in mother-infant dyadic interaction (Thomas, Letoumeau, Campbell, Tomfohr-Madsen, & Giesbrecht, 2017).

Our findings provided further evidence of a potential sensitive period of the early infancy for the development of child mental health and psychophysiological-hormonal stress regulation. The children of mothers with mental health problems at two months postpartum displayed in middle childhood more internalizing symptoms and HPA-axis dysregulation, compared to children of mothers without early mental health problems. It is an intriguing finding that maternal postpartum symptoms that appeared to be *short-term* and *minor* - being even below clinical relevance on the depression measure - were significant predictors of child functioning nearly a decade later. In line with some previous research (Behrendt et al., 2016), our study thus suggests that even subclinical levels of maternal problems during developmental periods of increased sensitivity may be able to interfere with important child developmental processes and tasks. During the early infancy, those can be suggested to include the psychophysiological-hormonal protecting and fine-attuning processes that develop through sensitive and responsive early care-giving interactions.

During the first few postnatal months, patterns of interaction are established between the mother and the infant, mainly through maternal touch and voice, as well as her gestures and gaze towards the baby (Calkins & Hill, 2007; Crockenberg & Leerkes, 2000; Feldman et al., 2009). In optimal interaction, the mother reinforces the infant's positive affect, and actively soothes and relieves its distress (Calkins & Hill, 2007), thus producing adaptive behavioral and endocrine synchrony with the infant (Feldman, 2012). However, maternal mental health problems can compromise her ability to form such synchronized interaction. In line with this, anxious and depressed mothers can show intrusive or withdrawing behaviors that do not match the infant's emotional state and regulatory needs (Edhborg et al., 2003; Feldman, 2007; Feldman et al., 2009; Murray et al., 2007; Seymor et al., 2015). Such interaction can leave the infant alone to struggle with arousal that exceeds its emotional capacity, with possible adverse effects on both emotion and stress regulation development (Feldman et al., 2009). Thus, one possible mechanism explaining children's internalizing symptoms and cortisol dysregulation in middle childhood, may relate to the timing of maternal mental health problems into the early months, when infants are fully dependent on their caregivers for soothing and regulation.

Interestingly, maternal problems both during the pregnancy and in the early postpartum period were associated with children's later physiological stress regulation, but in different ways. Mother's prenatal problems seemed to shape the child's diurnal cortisol pattern toward an intensified awakening response (CAR), whereas maternal problems in the early postpartum period were associated with a reduced CAR. The purpose of the CAR is to mobilize resources to meet the perceived demands of the upcoming day (Fries, Dettenborn, & Kirschbaum, 2009). Whereas an intensified CAR appears to be associated with current stress and bodily over-activation, a reduced CAR is more often found in states of burnout and exhaustion (Chida & Steptoe, 2009). Researchers emphasize the nature and intensity of the distress, suggesting that intensified awakening response is typical in milder and more transient experiences of distress, whereas the reduced CAR underlies more chronic stress resulting in exhaustion (Fries et al., 2005). In relation to our results, this suggests that the alterations in CAR among children of mothers with early postpartum mental health problems would perhaps be more chronic and severe in nature, as compared to the alterations among children of mothers with prenatal problems.

Unexpectedly, our study did not find association between prenatal maternal mental health and later child mental health or social or cognitive development. Importantly, research suggests that the impact of maternal prenatal anxiety and depression on the fetus and child may differ between periods of gestation, depending on the developmental stage of the fetal nervous system (Graignic-Philippe, Dayan, Chokron, Jacquet, & Tordjman, 2014). Most prior studies have evidenced particular fetal vulnerability during the second trimester, possibly due to intensive organization of cortical circuits in the fetal brain (Graignic-Philippe et al., 2014; Van den Bergh et al., 2005). However, results have been mixed, and it may well be that our results would have been different if another or multiple prenatal measurement points had been used. The lack of impact of prenatal maternal problems in our study may also, at least partially, reflect that the mothers in our trajectory of prenatal problems had resolved their problems by the time the child was two months old. One may speculate that even clinically significant prenatal anxiety and depression can leave children’s emotional and cognitive development intact, if maternal condition is more optimal during the crucial first year. In such a case, postnatal sensitive mother-infant interaction may be able to neutralize effects of prenatal maternal problems on child development (Bergman, Sarkar, Glover, &O'Connor, 2008; Grant, McMahon, Reilly, & Austin, 2010). Yet, the intensified CAR, evidenced in children of mothers with prenatal problems, suggests a psychobiological vulnerability to mental health and developmental problems that may become more evident at some later point of development.

Finally, researchers argue that the development of boys compared to girls is more affected by maternal mental health (e.g., Brand & Brennan, 2009). However, our study did not find any gender specificity among school-aged children, but concurs with studies that have suggested similarity in the maternal effects between boys and girls in this age (for example, Van den Bergh & Marcoen, 2004). One possible explanation of gender similarity is suggested by Hay et al. (2001), who argue that whereas boys might react to maternal distress earlier than girls, the differences are likely to get smaller towards adolescence.

8.5 Joint parental mental health impacting children

We analyzed the role of intrafamilial parental mental health in predicting child development, by testing two separate (mother and father) and three joint parental (additive, hierarchical and buffering) theoretical models. Both the separate and joint models were valid in predicting child mental health and cognitive development, but the results were domain-specific. Maternal problems alone, independent of possible paternal problems, formed risk for children's internalizing symptoms, whereas additive effects of both maternal and paternal problems predicted problems in executive function.

The result of maternal early mental health alone being important for child mental health may reflect a gender-typical difference in parental roles and behaviors. The mother-child relationship can be described as *soothing relationship*, with its primary purpose in calming and comforting children's distress (Paquette, 2004). Mothers with early depression and anxiety face difficulties in calming their own emotions and stress reactions as well as the child's early somatic and affective states, which can have negative long-term impact on child emotional and self-regulatory development (Feldman et al., 2009). The father-child relationship in turn has been described as the *activation relationship*, developed mainly through physical play and aimed at exciting, surprising and momentarily destabilizing children (Paquette, 2004). However, according to our results, these typical father-child relational characteristics may not play a significant role in children's early emotional development, although they may become more salient during the course of child development.

Fathers' early mental health was, however, important for children's cognitive development, as the additive model of joint parental mental health predicted children's executive function. Thus, according to our results, both maternal and paternal early symptoms have distinct contribution to children's cognitive development, yet perhaps through different underlying mechanisms. Dysregulation in maternal HPA and other hormonal systems during the pregnancy can negatively affect development of brain regions vital for cognitive operations (Frodl & O'Keane, 2013; Singh et al., 2012). Furthermore, both maternal pre- and postnatal mental health problems can adversely affect child HPA and autonomic nervous system development, inducing physiological over-arousal in the child (Beijers et al., 2014; Sohr-Preston & Scaramella, 2006). The over-arousal, in turn, can negatively impact many cognitive operations, including the executive function (Blair, Granger, & Peters Razza, 2005).

The paternal impact may find its way to children's cognitive development through more physical activities, such as early father-child rough-and-tumble play (Diamond, 2012; Flanders, Leo, Paquette, Pihl, & Séguin, 2009). Research on father-child interaction shows that depressed fathers spend less time with their children, and when they do, they are more passive in playing with them (Wilson & Durbin, 2010). In the postpartum period, depressed fathers appear to be particularly passive in touching and reading to their infants (Davis et al., 2011; McElwain & Volling, 1999; Sethna et al., 2015). Based on our results, one can speculate that fathers with early mental health problems may not activate enough infants' gross and fine motor skills, leading to children's lack of courage, self-efficacy and self-regulatory skills, and thus vulnerability to problems in executive function.

8.6 Impact of former infertility

Half of the families in our study had experienced infertility and achieved parenthood via assisted reproductive treatment (ART). Infertility is considered as a major life crisis, making couples vulnerable to feelings of shame, guilt and isolation; problems in sexual and marital relationship; and mental health symptoms such as depression and anxiety (Verhaak et al., 2007). Stressful life events can increase risk of mental health symptoms among infertile couples, whereas acceptance of fertility problems and support from the family, friends and the spouse can serve as protective factors (Verhaak, Smeenk, van Minnen, Kremer, & Kraimaat, 2005).

Conflicting views exist on mental health and parenting after successful fertility treatments. Some studies suggest that the stress, burden and fear related to infertility and its treatment continue to interfere with early family life. ART parents have reported to be at increased risk of early depression, anxiety and parenting difficulties (Fisher et al., 2005; Monti et al., 2015). Our results did not provide evidence of increased risks of mental health problems among ART parents. Instead, they correspond with those arguing for normative transition to parenthood (Hammarberg et al., 2008), as we found similar trajectories to reflect the timing and course of mental health symptoms among both ART and naturally conceiving (NC) parents.

These results are encouraging, as they suggest that parental distress and negative emotions related to infertility are relieved and balanced to normative levels once the treatment is successful and the pregnancy proceeds.

Furthermore, former infertility and ART had no impact on the association between fathers' mental health and early fathering experience, including their self-image as fathers, their interaction with the baby, as well as their experience of the infant's early characteristics. Similarly, former infertility and ART did not affect the way, how maternal pre- and postnatal mental health symptoms predicted children's mental health and development. Earlier research has mainly focused on the direct associations between ART and child well-being and development (e.g. Barnes et al., 2004; Carson et al., 2011; Wagenaar et al. 2008). Our study was the first to find similar links between maternal mental health and child well-being among ART and NC families. These findings substantiate the argument of minor specific mental health characteristics among ART families (Hammarberg et al., 2008).

Some earlier research has suggested more fetal- and child-related worry and higher parenting stress among ART compared to NC parents (e.g. Dunnington & Glazer, 1991; Fisher et al., 2005; McMahon et al., 1997; McMahon & Gibson, 2002). Our study partly concurs, as ART fathers reported a more negative fathering experience on one dimension, reflecting perceived lack of parenting resources and competences. In contrast, ART fathers' experiences of the early dyadic interaction and the infant characteristics were similar to NC fathers'. The result may reflect that it takes longer to find self-assurance and parental competence after painful and frustrating experience of infertility (Dunnington & Glazer, 1991).

8.7 Strengths, limitations, and implications for future studies

This study had a relatively large sample that included both mothers and fathers. The data setting was longitudinal and included multiple measurement points across the pre- and postpartum period, which made it possible for us to regard the transition to parenthood as a reorganizational process with both stability and change. Having similar data on both mothers and fathers enabled us to analyze intrafamilial mental health dynamics and their joint impact on children. Those have only rarely been considered in prior research. Furthermore, our study was able to identify and analyze the impact of maternal and paternal subclinical mental health problems. Those have been disregarded in most previous studies, despite their suggested negative impact on early parent-infant relationship (Behrendt et al., 2016). Furthermore, a half of our sample comprised couples with infertility history, which provides valuable insight into mental health and child developmental processes in these families. However, this also restrains generalizability of the findings into normative populations. The mothers in our sample were older than average mothers in Finland. This is due to the fact that for some ART mothers it had taken years to achieve pregnancy, which also led us to exclude mothers under the age of 25 from the NC sample. Our sample included low levels of families with severe psychosocial risks. Therefore, some caution is warranted in generalizing our results.

Attrition was substantial, particularly among fathers. Challenges of including and maintaining fathers as respondents in developmental research are well-known, often raising concerns about possible biases (West, 2007). In this study, nearly 35% of the fathers missed at least one of the three pre- and postnatal measurement points, and drop-out rate was higher among NC fathers and fathers whose spouses suffered from early mental health problems. The latter may have caused a bias towards optimal paternal mental health in our results, by leaving more potentially symptomatic fathers out. Paternal attrition in the first school year measurement was particularly high (62%), which interferes with interpretation of the child mental health and developmental findings. Luckily, there was no statistical difference in maternal or paternal drop-out rates between the trajectory groups, but attrition resulted in small cell sizes in ANCOVA analyzes. Furthermore, the participating mothers and fathers were older and the fathers also had higher education level than the ones who had dropped out. This may have caused bias into our results towards more economically wealthy families.

Methodologically, we had to rely on mere self-reports when assessing early maternal and paternal mental health. Particularly the General health questionnaire (GHQ-36), which we used to measure parental psychological distress, might have been less than accurate in detecting problems. First, as respondents are instructed to evaluate their well-being during the past few weeks, compared with that of before, the measure may fail to detect chronic or recurrent problems (Mäkikangas, Feldt, Kinnunen, Tolvanen, Kinnunen, & Pulkkinen, 2006). Second, severe nausea and vomiting during the pregnancy (Swallow, Lindow, Masson, & Hay, 2004) as well as infant's frequent need of night-time care taking might have been reflected in early maternal psychological distress. We tried to deal with these issues by using two independent mental health measures (GHQ and BDI), but it is obvious that clinical interviews would have guaranteed a more accurate detection of severity and nature of mental health problems (Pawlby, Sharp, Hay, & O'Keane, 2008).

Children's mental health and development in the first school year was reported by parents, which makes the assessment sensitive to biases. Distressed parents, for example, may be prone to negative appraisals and pessimistic evaluations of child functioning (Raskin, Fosse, & Easterbrooks, 2015). Standardized tests for cognitive development, for instance the Wechsler Intelligence Scale for Children (WISC) or the Developmental NEuroPSYchological Assessment (NEPSY), would have provided more reliable assessments of children's functioning. Similarly, using more informants, for instance combining parental, child and teacher accounts, would have provided more reliable assessments of children's mental health and social relationships.

Statistically, as our primary interest in the latent group analyses was in detecting unique courses of mothers' and fathers' mental health (Articles I and II), some variation in the level of symptoms was accepted within each group. Therefore, in line with reality, we were unable to identify completely homogenous mental health problems -groups that would have included only mothers and fathers with clinically significant levels of symptoms at particular time points. Yet, as the mean levels of symptoms in mental health problems- trajectories (mothers: groups II – V, fathers: groups III –V) crossed the cut-off points for clinical significance, it is clear that the groups were generally high in symptoms.

With regard to our analyses of child physiological stress regulation, specific limitations arise. First, in predicting child cortisol patterns, early maternal mental health problem -groups were both very small (each n = 15), leading to only modest statistical power. Further research with larger samples and more advanced modeling of the diurnal cortisol patterns is thus needed. Second, seasonal change in the amount of daily light in Finland is substantial, which can impact cortisol secretion at different times of the year (Persson et al., 2008). We tried to control the effect of seasonal change by collecting all saliva samples during the dark winter months (late October – early March) and by testing that the time of the year in saliva sampling was independent of maternal trajectory group. Third, although we measured children's cortisol at five time points throughout one day, collecting samples across several days would have been more reliable. Studies show that day-to-day variation in children's cortisol levels can be marked (Hruschka, Kohrt, & Worthman, 2005), particularly in children with developmental risks (Halligan et al., 2007). Our results need to be interpreted with caution, as they depict only one day diurnal levels of children's cortisol excretion.

Several possible parent-, child- and family-related confounders were not included in this dissertation. First, when examining parental mental health in the transition to parenthood, we did not have information on their *pre-pregnancy* well-being. It is possible that some parental problems that we interpreted as prenatal-only were actually reflecting more chronic difficulties, potentially even unrelated with the pregnancy itself. Second, when analyzing children's mental health and development, we were able to control for current maternal mental health, but not for symptoms during child's toddlerhood and preschool years. Elevated levels of maternal and paternal symptoms are likely to have occurred more frequently in families with mental health problems in the transition to parenthood. Together with the pre- and postnatal symptoms, these recurrent symptoms are likely to have negatively impacted children's mental health and development in the middle childhood. Importantly, we did analyze mental health differences between maternal trajectory groups in middle childhood (T4), and found that mothers with chronic or high sporadic problems in the transition to parenthood (group V) were higher in symptoms also in middle childhood, compared to mothers without pre- and postnatal mental health problems (group I). In contrast, mothers with prenatal (II) or early postpartum (III) mental health problems did not differ in middle childhood from mothers without early problems (I), thus providing some evidence of these early increased symptoms not being chronic in nature. However, not being able to control for parental symptoms throughout the early childhood is a considerable limitation of the study, which cannot be ruled out. Third, we did not examine children's early development or stress regulation, although both could have provided us with important information concerning the link between early parental mental health and later child development. Similarly, also parent-infant interaction and marital relationship should have been analyzed, as both are likely to have played a role in the association.

This study proposes suggestions for future studies. First, the transition to parenthood involves several reorganizational stages, with different parents likely to show unique mental health responses to them. Therefore, future studies should include more measurement points across the transition, particularly during the pregnancy. Several prenatal measurement points could increase understanding of the fetal HPA-axis and brain development as well as the prenatal development of mother-fetus emotional bonding. Second, involving measurement points of child well-being throughout the development would enable a more sophisticated modeling of child developmental paths from the fetal period to later childhood. The modeling could include potential early mediating and moderating mechanisms, including parent-infant interactions and the infant and child HPA-axis development. Finally, children's basic developmental unit is the family. Future research should therefore aim at adopting even more systemic approaches to studying development, with emphasis on the importance of different family subsystems such as the marital and sibling relationships.

8.8 Conclusions and implications for clinical practice

Importance of this dissertation lies in its ability to shed light on the unique individual characteristics of the longitudinal course of pre- and postnatal parental mental health symptoms. The diversity of early parental problems encompasses experiences from mild, transient episodes of distress to severe and chronic conditions. Subtle differences between individuals can be difficult to reach by the means of traditional variable-oriented methods. Therefore, we utilized a person-oriented approach to detect more unique experiences of mothers and fathers in their transition to parenthood. Our study emphasizes a heterogeneous, dynamic and timing-specific nature of early maternal and paternal mental health problems.

Also, we found two separate pathways of child developmental problems from the fetal period and the infancy to middle childhood. The *biological pathway* derives from a less than optimal fetal environment, and leads to an increased psychophysiological vulnerability to problems in middle childhood. The *interactional pathway* in turn draws from the early mother-child dyadic relationship, and leads to increased vulnerability to both later child mental health symptoms and less than optimal psychophysiological stress regulation. Furthermore, difficulties in a small proportion of children evolve through *both the biological and interactional pathways*, leading to more severe developmental problems on multiple domains of mental health and cognitive development.

Importantly, this dissertation raises a number of aspects that can benefit clinical practice. First, it draws a clear picture of a great majority of Finnish families having two psychologically healthy and well-functioning parents across the transition to parenthood. At the same time, however, this study reminds us that depression and psychological distress are not at all uncommon among expecting and new mothers and fathers. Despite increasing awareness of fathers' mental health in family well-being, fathers are not usually screened in maternity clinics and child health centers. Our findings emphasize the importance of *screening and directly asking about problems from both mothers and fathers*. Second, our study provided evidence that parental well-being at one point of the transition to parenthood does not necessarily imply the same for other times, thus making it crucial to recognize symptoms actively at *multiple time points across the transition*. Third, our results were supportive of the view that not only the clinical but also *the subclinical* mental health symptoms can be relevant in directing family functioning and child well-being. Thus, instead of strictly following clinical cut-off scores, the parent's experience of increased stress and worry as well as compromised daily functioning may be better indicators of problems. Providing information, practical help, compassion, and psychological support can be extremely important for expecting and new couples with mental health problems. When symptomatic, the mere knowledge of one's experiences not being uncommon can itself relief some of the shame and guilt involved, and thus release energy into things that need to be changed or worked through.

Our study also pointed a possibility of *positive compensation* in symptoms between the spouses. This means that in many families with one symptomatic parent the other parent remains healthy, and may thus be able to provide significant security and support for the child as well as the symptomatic parent. Professionals should acknowledge this valuable parental share of work in enhancing family well-being. They could support the healthy parent to remain well-functioning, and to courage him or her to take a more active role in taking care and raising the child. Importantly, however, not all families possess such protective resources. In contrast, a small proportion of families (5% in our study) have two symptomatic parents, who both need active help and support in their early parenting. According to our study, such families have the highest risk of child mental health and developmental problems, thus making their recognition particularly important.

Our study points out the *critical nature of the early months* of a child's life, as maternal problems during that period increased children's vulnerability to mental health symptoms and psychophysiological-hormonal dysregulation. The result brings forth the importance of psychological treatment on the mother-child dyadic relationship in the postpartum period, possibly even already during the pregnancy. In line with this, psychoanalytic psychotherapy, interpersonal psychotherapy and cognitive-behavioral therapy have shown to be effective in treating maternal prenatal depression and anxiety (Anderson & Lieser, 2015). Also bodily treatments such as massage therapy can be useful in symptom reduction (Field, Diego, & Hernandez-Reif, 2010). Similarly, in the postpartum period, a number of interventions have shown to be effective, including psychoanalytic parent-infant psychotherapy (Fonagy, Sleed, & Baradon, 2016), cognitive-behavioral therapy (Milgrom et al., 2015), and home-based psychological interventions (Leis, Mendelson, Tandon, & Perry, 2009). Even peer support (Leger & Letourneau, 2015) and web-based interventions (Lee, Denison, Hor, & Reynolds, 2016) have been conducted with positive results. Importantly, however, to help both mothers and children, interventions should not focus on maternal symptom reduction only, but could instead aim also at supporting the early mother-infant interaction and maternal capacity to mentalizing and reflective function (Fonagy & Sleed, 2016). During the pregnancy, important targets of the intervention could be maternal representations of the fetus and the formation of prenatal mother-fetus attachment (Flykt, 2014).

Treatment of fathers' pre- and postnatal mental health problems have been much less conducted and studied, even though suggestions for interventions have been made (Habib, 2012). Our study speaks for the importance of providing early psychological help to fathers as well as to mothers. Furthermore, according to our results, early mental health problems can spillover from one parent to the other, which emphasizes the importance of *including both parents in the intervention programs*. In line with this, treatments with an emphasis on co-parenting have proven to be particularly successful in enhancing well-being of the entire family (Frank, Keown, & Sanders, 2015; Doss, Cicila, Morrison, Hsueh, & Carhart, 2014).

In Finland, projects such as the 'European early promotion project', including home visitations by primary health care professionals across the transition to parenthood (Puura et al., 2005), and 'Baby Magic' (Vauvan taika), a structured group intervention program for expecting and new mothers (Salo et al., 2016), have done pioneering work in developing interventions for families with early mental health problems. Yet, sufficient treatment is not available to all symptomatic parents. Particularly families with mild or moderate parental problems, who would be likely to benefit from psychological treatments, are often left without access to them (Marcus, 2009). On societal level, an important purpose of this dissertation was to increase decision makers' knowledge of the significance of early psychological treatment for families with mental health problems.

From the perspective of a symptomatic parent, it can be difficult to hear about the possible long-term negative impact of early symptoms. Parents want what is best for their children, and if not being able to provide that, feelings of guilt and shame can be devastating. Making things even more complicated for some expecting mothers, child developmental risks of prenatal use of antidepressant and other psychopharmacologic medications have been documented (for instance, El Marroun, White, Verhulst, & Tiemeier, 2014). Therefore, a thorough weighing of potential benefits of the medication against risks for both the mother and the unborn child need to be made by the treating psychiatrist and the mother herself (Walton et al., 2014). However, nobody can know what the exact consequences of symptoms against medication would be for a particular fetus and child, and whatever decision is made, it always leaves room for doubt. Support by a therapist or other health care professional can be tremendously important in helping the mother to 'carry' the mental burden of not being able to know the consequences of the choices made.

Finally, an important psychoeducational issue relates to a need of professionals to remind symptomatic parents of the diverse nature of child development. The impact of any single risk factor, such as early parental mental health problems, on later child well-being and development is modest. All families possess both risks and protective factors, and the course of child development is ultimately shaped by their complicated interactions. Positive family interactional characteristics, such as use of humor and acceptance of humane weaknesses in both parents and children, can be important in fostering adaptive child development. Similarly, supportive relationships outside the family, for instance with teachers, grandparents and friends can act as protective factors against the negative impact of potential risks. Furthermore, some children have remarkable resilience factors, such as innate positivity, self-esteem and intelligence, and can thus show optimal development despite serious risks in their lives (Southwick, Bonanno, Masten, Panter-Brick, & Yehuda, 2014). Therefore, an important task of professionals is to help families find their unique strengths and positive characteristics, so that with help and support, mothers and fathers with mental health problems are able to be *good enough parents* for their children, despite of difficulties.

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Maternal pre- and postnatal mental health trajectories and child mental health and development: Prospective study in a normative and formerly infertile sample

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Abstract

Pregnancy and early motherhood involve uncertainty and change, which can evoke mental health problems. We identified maternal mental health trajectories in pre- and postnatal period, and examined their association with later child mental health and development. Finnish mothers reported psychological distress (General Health Questionnaire [GHQ-36]) and depressive (Beck Depression Inventory [BDI-13]) symptoms in pregnancy (T1; $N = 788$) and two months (T2; $N = 657$) and 12 months (T3; $N = 545$) postpartum. Both parents accounted their child's mental health (Behavior Assessment System for Children [BASC]) and social (Social Skills Rating System [SSRS], Child Behavior Scale [CBS]) and cognitive development (Five to Fifteen [FTF]) when the child was 7–8 years old (T4; $N = 485$). We identified five trajectories depicting unique timing and course of maternal mental health from pregnancy into 1 year of mothering: Stable low levels of mental health symptoms (75%) and prenatal (6%), early postpartum (9%) and late postpartum (6%) mental health problems. The fifth trajectory, heterogeneous high levels of mental health problems (4%) was an unclassified post hoc class, combining mothers with chronic high or highly variable mental health profiles. Results show some trajectory-related timing effects on children's mental health and cognitive development. The trajectories of early postpartum and heterogeneous high levels of mental health problems predicted higher level of internalizing symptoms as compared to stable low-levels trajectory. The heterogeneous high-levels trajectory predicted higher levels of problems in executive functions than the stable low and late postpartum trajectories, and in memory tasks than children in other trajectories. We discuss the timing and course of maternal mental health from the viewpoint of infant and child development.

Keywords

child development, child mental health, depression, infertility, maternal mental health

Although exciting and delightful, expecting and caring for a baby is characterized by uncertainty and stress, as future mothers are forced to reorganize and reconstruct their lives (Lorensen, Wilson, & White, 2004). In some mothers the new demands give rise to depression, anxiety, and other mental health symptoms (Hock, Schirtzinger, Lutz, & Widaman, 1995; Keeton, Perry-Jenkins, & Sayer, 2008). Maternal postpartum depression is extensively studied (O'Hara, 2009; Wisner, Chambers, & Sit, 2006), whereas less research is available on other mental health problems in the postpartum period and on maternal mental health during pregnancy. Some studies have documented a continuation between symptoms during pregnancy and the postpartum period (Grant, McMahon, & Austin, 2008; Robertson, Grace, Wallington, & Stewart, 2004), while others emphasize the changes and variability in maternal mental health across the transition (Lee et al., 2007; Matthey, Barnett, Ungerer, & Waters, 2000; Perren, von Wyl, Burgin, Simoni, & von Klitzing, 2005). We suggest that the timing and course of maternal mental health in the pre- and postnatal periods may constitute different phenomena due to their unique impacts on child development. We utilize a person-oriented approach to identify maternal mental health trajectories, for example, distinct subgroups of mothers in terms of the timing and persistence of mental health symptoms. We further examine the relation between maternal mental health trajectories and child's later mental health and social and cognitive development. The trajectories and their impacts on children are studied among normative mothers and those with infertility history.

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Maternal mental health in the pre- and postnatal period

Prenatal depression affects approximately 10–20% of mothers (Einarson, Taddio, Koren, Einarson, & Bennett, 2004; Evans, Heron, Francomb, Oke, & Golding, 2001), and is more evident at the first and third trimesters compared to the second (Heron, O'Connor, Evans, Golding, & Glover, 2004; Lee et al., 2007). Postpartum depression is found in approximately 7–13% of mothers (Matthey et al., 2000; O'Hara, 2009; O'Hara & Swain, 1996). Depression in pregnancy is agreed to predict postpartum depression (C. T. Beck, 1996; O'Hara & Swain, 1996; Robertson et al., 2004), and symptoms appear generally to be more severe prenatally than in the postpartum period (Evans et al., 2001). However, most findings supporting the continuation of depression from pregnancy to postpartum are based on variable-oriented methods such as mean levels, correlations, and beta coefficients. Transition to motherhood involves intensive biological, social, and psychological changes, and therefore a more dynamic, person-oriented approach can detect relevant differences in the timing and course of maternal mental health (Bergman & Magnusson, 1997).

A trajectory method enables us to capture the individual variability in the longitudinal course of maternal mental health from pregnancy to postpartum. We could locate two prior studies that used trajectories to analyze the timing of changes in maternal depressive symptoms. Mora et al. (2009) studied the course of depression from pregnancy into 2 years of mothering and Campbell, Matestic, von Stauffenberg, Mohan, and Kirchner (2007) from postpartum into 7 years. The majority of mothers belonged to trajectories of stable low or moderate levels of depressive symptoms (Mora et al. 71% and Campbell et al. 82%), and a minority suffered from chronic depression (respectively 7% and 3%). More dynamic trajectories involved mothers with postpartum depression that decreased mildly during the child's early years (9% and 6%) and those whose postnatal depression gradually increased (7% and 6%). Mora et al. also found a group of mothers who were depressive only in pregnancy (6%).

Although inadequately recognized, maternal mental health problems in the pre- and postnatal periods often include distress symptoms other than depression such as anxiety, sleeping difficulties, and social dysfunction. Anxiety during pregnancy and in the postpartum period is known to be at least as common as depression (Giakoumaki, Vasilaki, Lili, Skouroliakou, & Liosis, 2009; Heron et al., 2004) and their comorbidity is high (Lee et al., 2007; Reck et al., 2008). Prenatal anxiety has unique contribution to maternal postpartum mental health (Grant et al., 2008; Skouteris, Wertheim, Rallis, Milgrom, & Paxton, 2009) as well as to later child development (O'Connor, Heron, & Glover, 2002). Therefore screening for both anxiety and depression would be recommendable in expectant and new mothers (Matthey, Barnett, Howie, & Kavanagh, 2003; Miller, Pallant, & Negri, 2006). Sleeping difficulties in pregnancy have been found to predict later depressive symptoms as well (Okun, Hanusa, Hall, & Wisner, 2009; Skouteris, Germano, Wertheim, Paxton, & Milgrom, 2008). Social dysfunction, in turn, tends to persist even after the remission of depression (Kennedy, Foy, Sherazi, McDonough, & McKeon, 2007), and can thus continue to interfere with mother's and child's psychosocial well-being. Accordingly, the present study extends maternal mental health to include also anxiety, sleeping difficulties, and social dysfunction in addition to depression, as we identify trajectories from pregnancy through the first year of mothering.

Timing of maternal mental health and child mental health and development

The importance of distinguishing between prenatal and postpartum mental health problems may lie in their specific impacts on child development and in their potential specific underlying mechanisms. Generally, prenatal maternal anxiety and depression are hypothesized to form a risk for children through biological routes (van den Bergh, Mulder, Mennes, & Glover, 2005) and postpartum depression through problematic mother–child relationship (Murray & Cooper, 1997).

There is some evidence that *maternal prenatal mental health problems* have a lasting negative effect on child's mental health and development, independently of maternal postnatal mental health (O'Connor et al., 2002; van den Bergh & Marcoen, 2004), thus providing support to the unique, biologically based contribution of the pregnancy period (Sarkar, Bergman, O'Connor, & Glover, 2008; van den Bergh et al., 2005). Anxiety and depression during pregnancy have been found to associate with adverse fetal outcome such as increased activity and heart rate and growth delays (Field, Diego, & Hernandez-Reif, 2006; Field et al., 2003) and preterm delivery (Copper et al., 1996; Wadhwa, 2005). The newborns of anxious or depressive mothers show atypical biochemical patterns such as high cortisol and low dopamine and serotonin levels (Field et al., 2004), and their early behaviors are less than optimal (Field et al., 2006). In infancy the children of mothers with prenatal anxiety or depression show a negative behavioral reactivity to novelty (Davis et al., 2004). Maternal prenatal anxiety further predicts problems in children's cognitive development, including intellectual abilities (Mennes, Stiers, Lagae, & van den Bergh, 2006; Sohr-Preston & Scaramella, 2006; Talge, Neal, & Glover, 2007), and maternal prenatal anxiety and depression form a heightened risk for attention deficit hyperactivity disorder (ADHD) (Rodriguez & Bohlin, 2005; van den Bergh & Marcoen, 2004), anxiety, and negative emotionality (Martin, Noyes, Wisenbaker, & Huttunen, 1999; O'Connor et al., 2002).

Ample evidence shows that *maternal postpartum mental health problems*, especially depression, are associated with problematic mother–infant interaction (Bettes, 1988; Campbell, Cohn, & Meyers, 1995; Herrera, Reissland, & Shepherd, 2004). Infancy is a crucial time for the development of emotional regulation and attachment (Crittenden, 2004; Crockenberg & Leerkes, 2000; Stern, 1985), and maternal depression may impair them both (Maughan, Cicchetti, Toth, & Rogosch, 2007). Infants of mothers with postpartum depression appear to be more tense and deteriorate more quickly under stress than infants of nondepressed mothers (McGrath, Records, & Rice, 2008; Whiffen & Gotlib, 1989), and they show higher than average rates of insecure attachment (Cicchetti, Rogosch, & Toth, 1998). Similarly to prenatal anxiety, maternal postpartum depression has been found to predict cognitive impairments, such as low intelligence, attention problems, and difficulties in mathematic reasoning (Hay et al., 2001; Hay, Pawlby, Waters, & Sharp, 2008). Children of mothers with postpartum depression show increased internalizing symptoms (Essex, Klein, Miech, & Smider, 2001) and problems in social development (Sinclair & Murray, 1998).

Researchers are not unanimous about the unique effects of maternal postpartum depression on child development. Some studies indicate that maternal postpartum depression permanently impairs child's mental health and development, regardless of possible subsequent positive changes in maternal mental health (Alpern

& Lyons-Ruth, 1993; Bureau, Easterbrooks, & Lyons-Ruth, 2009; Essex et al., 2001). By contrast, others suggest that it is the chronicity and/or severity, and not the timing, of the maternal depression that predicts later adverse effects on children (Grace, Evindar, & Stewart, 2003; Hammen & Brennan, 2003). Furthermore, some studies suggest that maternal postpartum depression can have a direct effect on child's cognitive development but not on mental health (Hay et al., 2008) or that the effect may be direct on some but not all mental health disorders (Halligan, Murray, Martins, & Cooper, 2007). Finally, there are methodological problems to draw conclusions. Most of the studies of maternal postpartum mental health and child well-being have not taken the prenatal symptoms into account, and therefore these effects cannot be separated for certain from the prenatal biological ones.

Empirical evidence is scarce about the specific timing effects of early maternal mental health problems on children's mental health and development. Identifying mental health trajectories across the pre- and postnatal periods can present an effective way of comparing the unique timing effects of elevated symptom levels on children. We could detect three studies that examined the relation between maternal postnatal depressive trajectories and child's mental health or development (Ashman, Dawson, & Panagiotides, 2008; Campbell et al., 2007; Gump et al., 2009). They all support the argument that the chronicity rather than the timing of maternal depression is critical for child mental health. In addition, Ashman et al. (2008) provide also evidence of a specific timing effect by showing that the early postnatal maternal depression predicted children's externalizing problems also when the maternal depression subsequently decreased. The present study extends these trajectory findings by including both pregnancy and postpartum, and by examining whether the timing of elevated maternal mental health problems differently predicts child's mental health and social and cognitive development in the first school year.

Former infertility, treatment and mental health

Previous studies on early maternal mental health effects on children have mostly included normative samples or social risk groups. Our study extends the focus into a medically non-normative group of formerly infertile mothers, who have achieved pregnancy through successful assisted reproductive treatment (ART). Infertility and its treatment are considered highly stressful and found to be associated with psychological distress (Burns, 2007) that can continue to influence negatively maternal mental health even if the treatment is successful (Hjelmstedt, Widström, Wramsby, & Collins, 2004). Some studies do suggest ART mothers to be at risk of depression and anxiety symptoms (Fisher, Hammarberg, & Baker, 2005; Monti et al., 2008), while others have not found differences between ART and normative control mothers in their mental health during pregnancy or in the postpartum period (Greenfeld & Klock, 2001; Klock & Greenfeld, 2000; McMahon, Ungerer, Tennant, & Saunders, 1997; Repokari et al., 2005).

We could not detect earlier studies exploring the associations between fertility history (ART vs. normative) and maternal mental health trajectories in the pre- and postnatal periods. ART parents have sometimes been described to idealize their future parenthood and the long-awaited child (Hammarberg, Fisher, & Wynter, 2008). It can possibly lead to disappointments and mental health problems that emerge only later on in the postpartum, while in pregnancy, the joy of the successful treatment overwhelms the worries of medical vulnerabilities found in ART pregnancies. On the other hand, former infertility can make parents anxious about losing the child (Hjelmstedt, Widström, Wramsby, & Collins, 2003), and thus prenatal mental health symptoms might actually be elevated as compared to normative mothers.

ART pregnancies involve more premature birth and low birth weight (Jackson, Gibson, Wu, & Croughan, 2004; Poikkeus, Gissler, Unkila-Kallio, Hyden-Granskog, & Tiitinen, 2007; Schieve et al., 2002) that can have negative impacts on child development (van Baar, Ultee, Gunning, Soepatmi, & de Leeuw, 2006). However, research suggests that the psychosocial and cognitive development of ART children is similar to those spontaneously conceived (Gibson & McMahon, 2004; Middelburg, Heineman, Bos, & Hadders-Algra, 2008; Wagenaar, Huisman, Cohen-Kettenis, & Delemarre-van de Waal, 2008). To our knowledge, this is the first study to compare mental health trajectories from pregnancy to postpartum between ART and normative mothers and to examine whether the trajectories differently predict child's later mental health and development in ART families.

The role of child's gender

Several studies suggest that early maternal mental health problems more strongly affect the mental health and development of boys than of girls (Brand & Brennan, 2009; Hay et al., 2008; Martin et al., 1999; Rodriguez & Bohlin, 2005; Sinclair & Murray, 1998). Yet, others have not found the gender effect (Cornish et al., 2005; Murray et al., 1999; van den Bergh & Marcoen, 2004). The possible gender differences can be explained by biological factors, by early mother–infant interaction and/or by gender-specific psychological symptoms. Compared to females, male fetuses are biologically more vulnerable to adversity (Cieslik & Waszak, 2001; Mueller & Bale, 2008), and the development of boys is more susceptible to a variety of neurophysiological problems (Bauermeister et al., 2007; Wadsworth, DeFries, Stevenson, Gilger, & Pennington, 1992). Studies on the quality of mother–infant interaction suggest that mothers with depressive symptoms communicate less with their sons than with their daughters (Murray, Kempton, Woolgar, & Hooper, 1993). Finally, boys are found to show more externalizing symptoms such as aggression both in early childhood (Hammarberg & Hagekull, 2006; Winsler & Wallace, 2002) and adolescence (Card, Stucky, Sawalani, & Little, 2008). From early adolescence on, girls typically show more internalizing symptoms of depression and anxiety (Crawford, Cohen, Midlarsky, & Brook, 2001; Kistner, 2009). The present study examines whether the timing of maternal pre- and postnatal mental health problems differently affects the mental health and development among boys and girls.

The current study

Our study had three main goals. First, to identify distinct subgroups of mothers according to their mental health during the pre- and postnatal periods. The maternal mental health trajectories were identified by the timing and course of psychological distress (symptoms of depression, anxiety, social dysfunction, and sleeping difficulties) and depressiveness from pregnancy (T1) through 2 months (T2) and 12 months (T3) postpartum. We also explored, whether the fertility history (ART vs. normative group) was associated with the trajectories. Second, we examined whether and how the maternal mental health trajectories (i.e., specific timing and course of mental health problems in the pre- and postnatal periods) predict children's mental health and social and cognitive development in the first school year. Third, we wanted to find out, whether the fertility history and child's gender moderated the effect between maternal mental health trajectory class and later child outcomes.

Methods

Participants and procedure

The original sample was 805 Finnish women with singleton pregnancies, recruited to participate during the second trimester of pregnancy (T1, 18–20 weeks of gestation). Fifty-two percent had undergone a successful infertility treatment with their own gametes (ART group; $N = 417$) and 48% were normative mothers ($N = 388$). All the mothers entering the infertility clinics in Finland were asked to participate in the study (ART group), and the normative group consisted of mothers participating in a routine ultrasound examination offered by community maternal-care clinics. The mean age of mothers was similar in both groups (33.1 $\pm$ 4.4 for ART and 33.2 $\pm$ 3.0 for normative mothers), but ART mothers had less children than normative mothers (primiparous 67.4% vs. 34.0%, multiparous 32.6% vs. 66.2%, $\chi^2 = 87.96$, $p < .001$). The families were further contacted when the child was 2 months (T2), 12 months (T3) and 7–8 years (T4) old, and asked to fill in questionnaires. Detailed information about the research setting from pregnancy to 1 year of mothering is presented in Repokari et al. (2005).

At the time of T4 assessment, the families were approached by mail and telephone. Both mothers and fathers answered questions concerning child's mental health and development. The mothers also filled in a questionnaire concerning their own mental health. The ethical committees in participating clinics approved the study separately concerning the pre- and postnatal period (T1–T3) and the assessment at T4.

At T1 788 (97.9%), at T2 657 (81.6%) and at T3 545 (67.7%) mothers participated in the study. Five hundred and twenty-nine (65.7%) mothers participated in all assessments during T1–T3. At T4 485 (60.2%) mothers and 290 (36.0%) fathers took part. Maternal attrition at T1–T3 was independent of the fertility history (ART vs. normative), maternal education, age, length of marriage, number of children, and child's birth weight. It was also independent of maternal mental health (GHQ psychological distress and BDI depressive symptoms) measured at earlier stages. Also at T4 the participation rate was similar in ART and in normative groups for both mothers and fathers. The identified trajectories did not differ from each other in the dropouts at T4. However, the parents who participated in T4 were somewhat older than the ones who had dropped out (age of fathers at T1: 36.3 $\pm$ 5.0 vs. 34.8 $\pm$ 5.6, $t = 2.60$, $p < .05$, age of mothers at T1: 33.6 $\pm$ 3.8 vs. 32.8 $\pm$ 3.6, $t = 3.01$, $p < .01$). The participating fathers, but not mothers, were also more educated compared to the ones who had dropped out ($\chi^2 = 11.10$, $p < .01$). However, both paternal and maternal attrition at T4 was independent of the length of the marriage, the number of the children, and child's birth weight. It was also independent of paternal and maternal mental health (GHQ psychological distress and BDI depressive symptoms) measured at previous stages. Paternal mental health was assessed with the same tools as mothers' but the data is not presented in this study.

Measures

Maternal psychological distress was measured by using the 36-item General Health Questionnaire (GHQ-36) (Goldberg & Hiller, 1979) that gives an effective measure of psychiatric disorders in the general population (Ferdinand & Verhulst, 1994) and has been validated also in Finland (Rantakallio, 1988). The questions cover symptoms of depression (feelings of hopelessness and suicidal ideation), anxiety (feelings of being under constant pressure and panicking), sleeping difficulties (waking up at night and difficulties in falling asleep) and social dysfunction (feelings of inability to perform everyday tasks and social activities). Subjects estimated how the symptom descriptions matched their present state over the past weeks on a 4-point scale, ranging from 1 (not at all) to 4 (much more than usually). The mean score was calculated for time points T1–T4 and the reliabilities (Cronbach's α) were .91 at T1, .91 at T2, .94 at T3, and .95 at T4. We also formed dichotomic variables of clinical significance based on the clinical criterion of the cut-off point in Finnish samples (Holi, Marttunen, & Aalberg, 2003). The cut-off point is 9 and above after recoding the original values ranging between 1 and 4 into dichotomous (0 or 1) values (the original values 1 and 2 = 0 and original values 3 and 4 = 1).

Maternal depressive symptoms were assessed by a shortened version of Beck Depression Inventory (BDI-13) (Beck, Ward, Mendelsohn, Mock, & Erlaugh, 1961). It consists of 13 descriptions of low mood, hopelessness, and somatic signs of depression. Each item consists of five sentences of which participants were instructed to select the one that best describes how they have been feeling during the last week. Each sentence is rated from 0 to 4 indicating the increased severity of depression. The mean score was calculated for time points T1–T3, reliabilities (α) being .75 at T1, .77 at T2, and .83 at T3. In addition, dichotomic variables of clinical significance were formed based on the clinical criterion of the cut-off point in Finnish samples (Kaltiala-Heino, Rimpelä, Rantanen, & Laippala, 1999). The cut-off point for mild depression is 5 and above, after recoding the original values (the original values 0 and 1 = 0, the original value 2 = 1, 3 = 2, and 4 = 3).

Both parents reported the child's mental health and social and cognitive development at T4, and the mean of their assessments was calculated. In families where only one parental report was available ($N = 209$), the scales include only this report.

Child's mental health problems were measured by four scales of the Parent Rating scales for children (PRS-C) component of the Behavior Assessment System for Children (BASC) (Reynolds & Kamphaus, 1992). The BASC PRS-C consists of 12 scales (138 items) and our choice of four scales was based on conceptual and practical issues. Anxiety, depression, and somatization scales depict internalizing, and aggression scale externalizing symptoms that are relevant for the studied age group. Furthermore, we found it unwise to apply highly pathological scales in the questionnaires sent to the families and tried not to burden the parents unnecessarily, so excessive scales were omitted accordingly. *Anxiety* scale (11 items) measures the child's tendency to be nervous, fearful, or worried about real or imagined problems, *depression* (12 items) represents the child's feelings of sadness and stress that may result in an inability to carry out everyday activities or may bring out thoughts of suicide, and *somatization* (13 items) reflects the child's tendency to be overly sensitive and complain about relatively minor physical discomforts. *Aggression* (13 items) represents the child's tendency to act in a hostile manner (either verbal or physical) that is threatening to others. Both parents rated the child's behavior on a

4-point response scale, ranging from 1 (never) to 4 (almost always). The mean scores were calculated for each scale and the reliabilities (α) were .76 (mothers) and .82 (fathers) for anxiety, .61 and .80 for depression, .70 and .74 for somatization, and .83 and .85 for aggression. Maternal and paternal reports were significantly correlated for all scales: Anxiety $r = .33$, $p < .01$; depression $r = .44$, $p <. 01$; somatization $r = .46$, $p < .01$; and aggression $r = .53$, $p < .01$. For this analysis, we constructed mean score sum variables for internalizing symptoms (anxiety, depression and somatization scales) and externalizing symptoms (aggression scale and five items of attentional problems from executive functions domain of cognitive developmental problems, attentional problems reliabilities (α) .81 and .78 and $r = .61$, $p < .01$).

Child's social developmental problems were measured by scales from parent versions of Social Skills Rating System (SSRS) (Gresham & Elliot, 1990) and Child Behavior Scale (CBS) (Ladd & Profilet, 1996). *Assertion* subscale of the SSRS (10 items) measures the child's initiatives and ability to bond with peers. *Excluded by peers* subscale of the CBS (seven items) measures the child's popularity versus rejection among peers. Both parents estimated how well the descriptions fit their child on a 4-point response scale, ranging from 1 (never) to 4 (almost always). The items that were measuring positive peer and friendship relations were recoded to measure social developmental problems. The mean score was calculated for both scales and the reliabilities (α) were .79 (mothers) and .78 (fathers) for SSRS assertion and .78 and .80 for CBS excluded by peers. Maternal and paternal reports correlated significantly for both dimensions: SSRS assertion $r = .57$, $p < .01$ and CBS excluded by peers $r = .56$, $p < .01$. For the analysis, combined-sum variable of social developmental problems was further constructed by averaging both sum scores.

Child's cognitive developmental problems were assessed by the parental questionnaire Five to Fifteen (FTF), which is a developmental screening questionnaire for early childhood onset of neuropsychological disorders such as ADHD (Kadesjö et al., 2004). FTF consists of eight domains (181 items), most of which can be further divided into subdomains. In this study our choice of scales was guided by developmental considerations, and the following four domains were used: *Executive functions* (subdomain for planning and organizing, seven items), *perception* (subdomains for time concepts, body perception, and visual perception, 13 items), *memory* (subdomains for semantic and episodic memory and recall, 11 items) and *language* (subdomains for expressive language skills and communication, 16 items). Both parents rated the child's behavior on a 3-point response scale, ranging from 1 (does not describe my child at all) to 3 (describes my child well). The mean score was calculated for each scale and the reliabilities (α) were .81 (mothers) and .81 (fathers) for executive fuctions, .70 and .76 for perception, .79 and .83 for memory, and .64 and .90 for language. Maternal and paternal reports correlated significantly for all domains: Executive functions $r = .55$, $p < .01$; perception $r = .52$, $p < .01$; memory $r = .54$, $p < .01$; and language $r = .71$, $p < .01$.

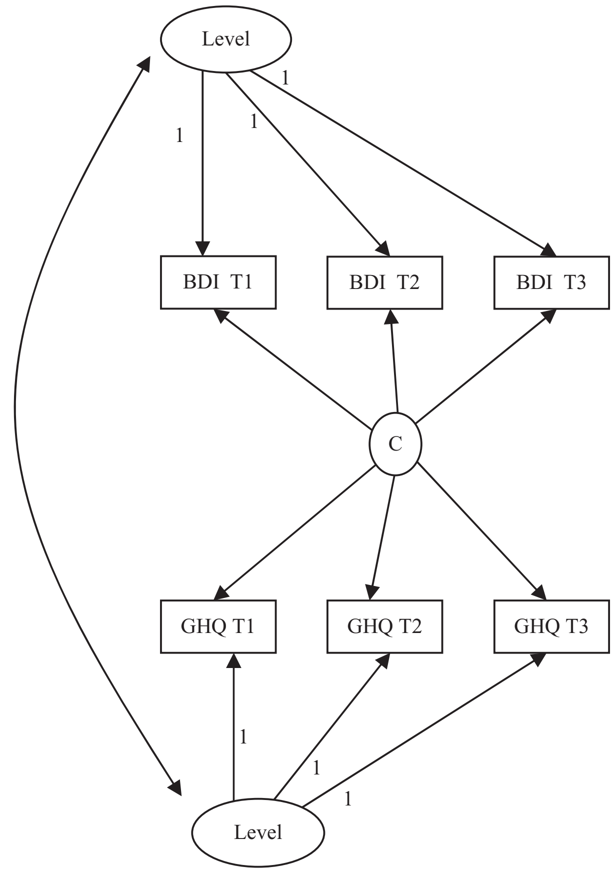

Figure 1. Factor mixture analysis design of maternal mental health in transition to parenthood.
BDI = Beck Depression Inventory (13-item); GHQ = General Health Questionnaire (36-item); T1 = pregnancy; T2 = 2 months postpartum; T3 = 12 months postpartum; C = maternal mental health latent variable; Level = level factor.

Statistical analyses

We used mixture modeling in Mplus 5 (Muthén & Muthén, 1998–2007) to identify trajectories of maternal mental health symptoms from pregnancy (T1) through 2 months (T2) and 12 months (T3) postpartum. Mixture modeling identifies latent classes of subpopulations from the observed data and provides statistical tests to aid in the evaluation of the existence and the number of classes (Muthén, 1998–2004, 2001). In order to form comprehensive trajectories of maternal mental health we used two indicators, the psychological distress (GHQ-36) and depressive symptoms (BDI-13) as the dependent variables. Figure 1 presents the factor mixture analysis design based on these two separate indicators of maternal mental health. The missing-data method implemented in Mplus was used, which allowed us to use all the observations in the data set to estimate the parameters in the models.

The identification of trajectories was based on differences in mean values of observed variables in latent classes. Individual variation in the level of symptoms was modeled by adding a level factor and fixing the loadings to 1 in the model. This ensured that the number of latent classes was not due to the correlations between the variables, but was based on real variation in the level of symptoms (Lubke & Neale, 2006).

The selection of optimal number of classes was based on the following statistical criteria and tests: (a) information criteria fit indices: Akaike's information criterion (AIC), Bayesian information criterion (BIC) and the sample-size-adjusted Bayesian information criterion; (b) likelihood ratio tests: Vuong-Lo-Mendell-Rubin likelihood ratio test (VLMR), Lo-Mendell-Rubin adjusted likelihood ratio test (LMR) and the bootstrap likelihood ratio test (BLRT) for *k* versus *k-1* classes, and (c) reliability of classifications via the estimated posterior probabilities of class membership for each individual and the average posterior probabilities for each class. The smaller the values of information criteria are, the better the class solution fits the data. The LMR, BLRT and VLMR tests compare solutions with different numbers of latent classes: a low p-value ($p < .05$) indicates that the k- model is needed to be rejected in favor of a model with at least $k+1$ classes. The BIC and BLRT tests were chosen as the most reliably functioning criteria when deciding the number of latent classes, as recommended by Nylund, Asparauhov and Muthén (2007) and Tolvanen (2007). Each subject was assigned to one specific trajectory class based on the highest estimated posterior probability, and this classification was used in the subsequent analyses conducted by Statistical Package for the Social Sciences (SPSS, 2007).

To examine how the identified maternal mental health trajectories predict children's mental health and social and cognitive development, we conducted 5 (maternal mental health trajectory class) $\times$ 2 (fertility history: ART vs. normative) $\times$ 2 (gender) main effect ANCOVAs on internalizing (sum variable of anxiety, depression, and somatization) and externalizing (sum variable of aggression and attention problems) symptoms, social developmental problems (sum variable of assertion and excluded by peers) and cognitive developmental problems (separate variables for executive functions, perception, memory, and language). To analyze whether maternal mental health trajectory class predicts child's mental health and development differently in ART versus normative groups and among boys and girls, we included the corresponding two-way interaction terms in these analyses. Significance was set at $p < .05$ for both main and interaction analyses. As our timing hypothesis suggests all pair-wise comparisons to be of interest, we chose Tukey as to specify the significant differences between all the trajectory classes in child outcomes. The current (T4) maternal psychological distress (GHQ-36) and parity (at T1) were used as covariates. The missing data in the current (T4) maternal psychological distress covariate scores ($n = 6$) was imputed using the estimated marginal (EM) means imputation method in SPSS and the missing data in parity scores ($n = 20$) was coded from medical data.

Table 1. Means, standard deviations and ranges of maternal psychological distress, maternal depressiveness and child mental health, social, and cognitive development

	M	*SD*	Range
Maternal mental health			
Psychological distress (GHQ-36)			
T1 ($N = 788$)	1.70	0.32	1.11–3.78
T2 ($N = 657$)	1.63	0.32	1.06–3.47
T3 ($N = 545$)	1.60	0.34	1.06–3.56
T4 ($N = 491$)	1.65	0.36	1.05–3.78
Depressiveness (BDI-13)[a]			
T1 ($N = 788$)	0.61	0.32	0.00–2.23
T2 ($N = 657$)	0.53	0.30	0.00–2.23
T3 ($N = 545$)	0.56	0.36	0.00–2.54
Child mental health and development at T4[b]			
Internalizing symptoms			
Anxiety (BASC)	1.63	0.29	1.00–3.55
Depression (BASC)	1.46	0.26	1.00–2.42
Somatization (BASC)	1.29	0.21	1.00–2.31
Externalizing symptoms			
Aggression (BASC)	1.64	0.30	1.00–2.61
Attention (FTF)[c]	1.49	0.42	1.00–3.00
Social development[c]			
Assertion (SSRS)	1.90	0.39	1.00–3.30
Excluded by peers (CBS)	1.44	0.35	1.00–2.61
Cognitive development[c]			
Executive functions (planning and organizing) (FTF)	1.47	0.37	1.00–2.71
Perception (FTF)	1.26	0.20	1.00–2.35
Memory (FTF)	1.29	0.25	1.00–2.41
Language (FTF)	1.16	0.26	1.00–2.31

Note: [a] BDI depressiveness was not measured at T4. [b] $N = 491$. The values are for combined mothers' and fathers' scores on child mental health and social and cognitive development at T4. [c] In the scales of social and cognitive development high values indicate problematic development.

Results

Identifying maternal mental health trajectories

Table 1 presents the sample means, standard deviations and ranges of maternal mental health scales from pregnancy to postpartum and child mental health and social and cognitive developmental scales at 7–8 years.

Our first goal was to identify distinct classes of mothers with different mental health trajectories during the pre- and postnatal periods. The information criteria and the likelihood ratio tests of the mixture modeling are displayed in Table 2. The results show that as the number of the trajectory classes increased, the information criteria (AIC, BIC, adjusted BIC) became smaller, which indicates that the solutions with more classes fitted the data better than the solutions with fewer classes. Different information criteria gave somewhat different results concerning the number of trajectory classes. According to BIC, the best fitting solution to the data was that of eight classes, while AIC and adjusted BIC favored the 10-class solution. The statistical tests of VLMR and LMR showed that two classes fitted the data better than one class, three classes better than two classes, and seven classes better than six classes. Although BLRT showed that the solution improved with the increase of the class number from one to 10, the test functioned most reliably in the solutions with six classes or less. In the solutions with seven to 10 classes the best log-likelihood value was replicated only with few starting values. This was due to suspect p-values, even though as much as 500 starting values were used.

Based on theoretical meaningfulness and BIC as the most reliable criteria (Nylund et al., 2007; Tolvanen, 2007), we selected the eight-class solution. The average predicted posterior probabilities for class membership in the eight-class solution were acceptable, ranging from .81 to 1.0. However, the result showed that only four trajectory classes clearly had distinct courses of timing of mental health problems, were theoretically and conceptually meaningful, and represented 96% of the data. The remaining four trajectories consisted each of few subjects (total $N = 34$, representing 4% of the data) and were highly heterogeneous in the course of the maternal mental health. Consequently the statistical solution could neither combine them to represent one trajectory class nor fit to any of the larger main trajectory classes. Nearly a half of mothers ($n = 16$) in these four small classes were chronically suffering from mental health problems indicated by clinically significant severity at every time point either in GHQ psychological distress or in BDI depressive symptoms (but only four of them in both). The rest of the cases in the small classes were highly heterogeneous in timing and severity. We combined

Table 2. The goodness-of-fit indices and the likelihood ratio tests of the mixture modelling identifying maternal mental health trajectory classes during transition to parenthood

Number of groups	AIC	BIC	Adjusted BIC	VLMR	LMR	BLRT	Class sizes based on estimated model
1	602.971	673.408	625.755	–	–	–	$N = 809$
2	237.257	340.565	270.702	.0001	.0001	<.0001	69/739
3	25.977	162.155	70.063	.0381	.0409	<.0001	68/53/688
4	−110.170	58.879	−55.442	.6537	.6574	<.0001	692/51/48/18
5	−186.277	15.642	−120.908	0.1949	0.1974	<.0001	17/79/636/23/53
6	−260.345	−25.555	−184.334	0.3837	0.3873	<.0001	13/34/18/616/46/81
7	−315.450	−47.789	−228.797	0.0203	0.0212	<.0001	46/569/18/85/72/13/6
8	−372.924	−72.392	−275.630	0.0996	0.1025	<.0001	568/17/6/46/3/88/67/13
9	−400.464	−67.062	−292.529	0.1010	0.1029	<.0001	564/67/15/6/89/2/17/44/3
10	−413.628	−47.356	−295.052	0.4372	0.4394	<.0001	44/542/87/16/4/14/68/15/13/6

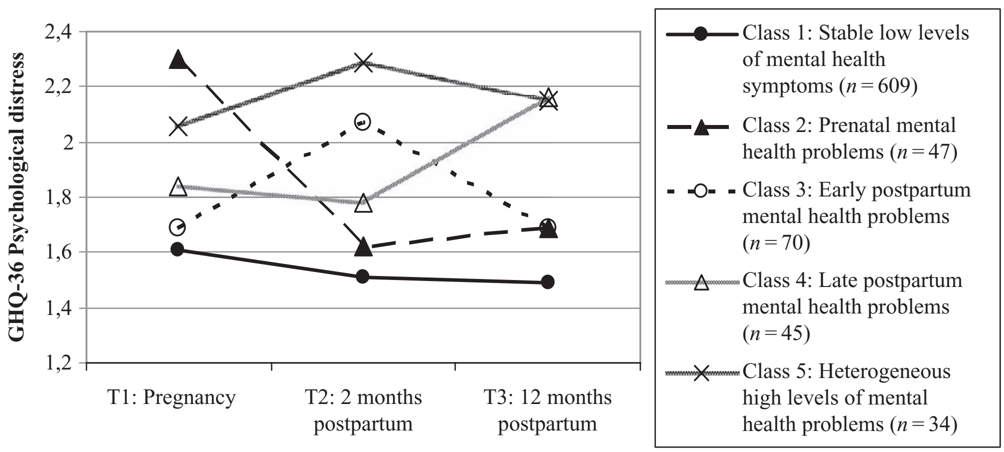

Figure 2. Means of reported GHQ-36 psychological distress at T1–T3 according to maternal mental health trajectory class. Standard deviations: Class 1: 0.18–0.22; Class 2: 0.25–0.29; Class 3: 0.22–0.26; Class 4: 0.29–0.31; Class 5: 0.41–0.58.

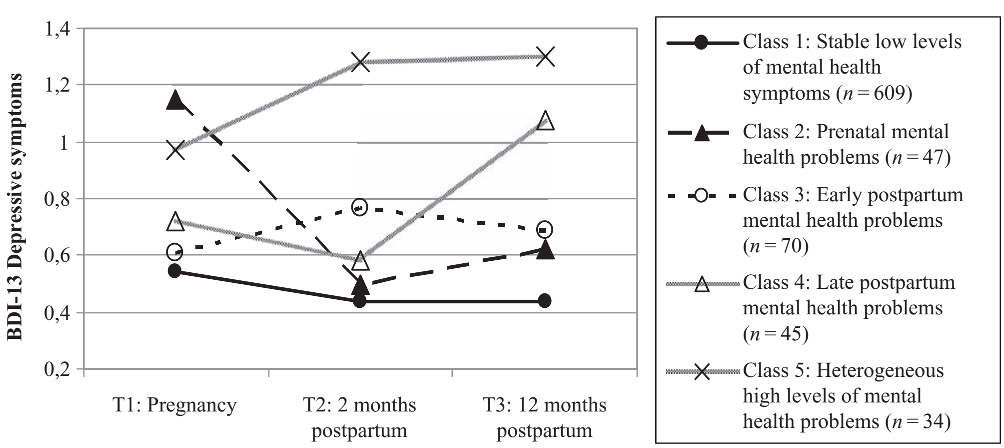

Figure 3. Means of reported BDI-13 depressive symptoms according to maternal mental health trajectory class. Standard deviations: Class 1: 0.22–0.23; Class 2: 0.23–0.29; Class 3: 0.61–0.77; Class 4: 0.27–0.72; Class 5: 0.59–0.97.

the mothers in these small trajectories into one class named as "heterogeneous high levels of mental health problems." The decision of this kind of post hoc combining the unclassifiable and residue cases is based on Bergman (1988).

Thus, five trajectory classes were identified that differed systematically in the timing of maternal mental health problems during the pre- and postnatal period, revealing distinct peaks in pregnancy, early postpartum and late postpartum. The levels of GHQ-36 psychological distress (Figure 2) and BDI-13 depressive symptoms (Figure 3) are illustrated according to the identified trajectories at T1 pregnancy, T2 2 months, and T3 12 months postpartum. The figures are drawn based on the original mean scores of GHQ and BDI, thus not revealing cases exceeding the clinical significance. The contents of the five trajectories were the following:

I Stable low levels of mental health symptoms. Trajectory class was the largest (70.6% of the data $N = 568$ based on the estimated model; 75.7% $N = 609$ based on the actual classification of subjects). Characteristic to mothers in this trajectory class were low levels of symptoms of depression, anxiety, social dysfunction, and sleeping difficulties in pregnancy, as well as in the early and late postpartum. The trajectory did not exceed the clinically significant cut-off points for GHQ psychological distress and BDI depressive symptoms at any time point. However, 7.9% of the mothers reported clinically significant level of GHQ psychological distress and 3.3% clinically significant level of BDI depressive symptoms at some time point (T1–T3). None of the mothers reported chronic clinical significance in GHQ psychological distress or BDI depressive symptoms, chronicity referring to mothers whose scores exceed the clinically significant level of symptoms at every time point of T1, T2, and T3.

II Prenatal mental health problems. Trajectory (5.7% $N = 46$ based on the estimated model; 5.8% $N = 47$ based on the actual classification of subjects) involved women showing a high level of mental health problems in pregnancy that then decreased to low or moderate levels in the early postpartum and remained fairly stable until the late postpartum. In pregnancy the trajectory crossed the clinically significant cut-off points for both GHQ psychological distress and BDI depressive symptoms (mild depression). At this point 91.5% of the mothers reported clinically significant level of GHQ psychological distress and 61.7% clinical level of BDI depressive symptoms. However, 17.0% of the mothers had clinical significance in the GHQ psychological distress and 4.3% in the BDI depressive symptoms at some other time point (T2 or T3).

III Early postpartum mental health problems. Trajectory (10.9% $N = 88$ based on the estimated model, 8.7% $N = 70$ based on the actual classification of subjects) consisted of mothers with a peak in mental health symptoms in the early postpartum, when the child was 2 months old. On the contrary, in pregnancy as well as in the late postpartum their symptom levels were relatively low. The trajectory exceeded the clinically significant cut-off point for GHQ psychological distress in the early postpartum, but BDI depressive symptoms did not reach clinical severity. In the early postpartum 79.7% of the mothers reported clinically significant level of GHQ psychological distress and 18.6% of BDI depressive symptoms. However, 15.7% of the mothers had clinical significance in the GHQ psychological distress and 10.0% in the BDI depressive symptoms at some other time point (T1 or T3).

IV Late postpartum mental health problems. Trajectory (8.3% $N = 67$ based on the estimated model; 5.6% $N = 45$ based on the actual classification of subjects) consisted of mothers who showed a high level of mental health symptoms in the late postpartum, when the child was 12 months old. On the contrary they had low or moderate levels of symptoms in pregnancy and in the early postpartum. At 12 months the trajectory exceeded the clinically significant cut-off points for both GHQ psychological distress and BDI depressive symptoms (mild depression), and at this point 75.5% of the mothers reported clinically significant level of GHQ psychological distress and 40.0% of BDI depressive symptoms. However, 37.8% of the mothers had clinical significance in the GHQ psychological distress and 22.2% in the BDI depressive symptoms at some other time point (T1 or T2).

V Heterogeneous high levels of mental health problems. Post hoc trajectory class combined four small trajectories (4.5% of the data $N = 36$ based on the estimated model; 4.2% $N = 34$ based on the actual classification of subjects). The mothers in this class were chronically high in either GHQ psychological distress or BDI depressive symptoms (or both) or had a highly variable profile. The trajectory exceeded the clinically significant cut-off points for both GHQ psychological distress and BDI depressive symptoms at every time point of T1, T2, and T3. Ninety-four point one percent of the mothers reported clinically significant level of GHQ psychological distress and 94.1% of BDI depressive symptoms at least at two time points. Twenty-six point five percent of the mothers had chronic clinical significance in the GHQ psychological distress and 20.6% in the BDI depressive symptoms.

Infertility history and demographic factors associating with the trajectories

Table 3 shows whether the distribution of the maternal mental health trajectories differed between ART and normative families. Results show no group differences, indicating that the level and timing of mental health problems were similar in ART and normative mothers in the pre- and postnatal periods.

Of demographic factors, only parity was significantly associated with the maternal mental health trajectories. In the prenatal mental health problems trajectory, almost two thirds (63%) were multiparous women (one or more children), whereas in the early postpartum mental health problems trajectory 67% were primaparous (first-time mothers). In other trajectories, there were about equal shares of multiparous and primaparous mothers. The trajectories did not differ in mother's education, marital status, number of previous marriages or cohabiting partnerships, or in gender of the child. Also the age of the mother, $F(4,756) = 0.15$, $p = ns$, duration of the partnership, $F(4,737) = 0.77$, $p = ns$, and child's birth weight, $F(4,644) = 1.89$, $p = ns$, did not significantly differ between the trajectory classes.

Current T4 maternal GHQ psychological distress differed significantly between the trajectory classes, $F(4,481) = 10.92$, $p < .001$, and pair-wise comparisons indicated that the mothers in the stable low levels of mental health symptoms class showed significantly lower level of T4 symptoms than the mothers in the late postpartum ($p < .01$) and the heterogeneous high levels of ($p < .001$) mental health problems classes. Mothers in the early postpartum mental health problems class reported lower level of T4 symptoms than mothers in the heterogeneous high levels of mental health problems class ($p < .01$). The heterogeneous high levels of mental health problems class was the only class reporting clinically significant level of current T4 maternal GHQ psychological distress.

Table 3. Demographic variables according to maternal mental health trajectory classes

	I Stable low levels of mental health symptoms ($n = 609$)		II Prenatal mental health problems ($n = 47$)		III Early postpartum mental health problems ($n = 70$)		IV Late postpartum mental health problems ($n = 45$)		V Heterogeneous high mental health problems ($n = 34$)		
	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	$\chi^{2,a}$
Fertility history											2.82 (4,799)
ART	52.3	316	52.2	24	57.1	40	42.2	19	47.1	16	
Normative	47.7	288	47.8	22	42.9	30	57.8	26	52.9	18	
Socioeconomic status											21.86 (16,783)
High professional	31.1	185	23.4	11	34.3	23	25.0	11	19.4	6	
Low professional	41.2	245	42.6	20	49.3	33	52.3	23	32.3	10	
Skilled worker	16.3	97	14.9	7	9.0	6	18.2	8	19.4	6	
Unskilled worker	9.3	55	14.9	7	6.0	4	2.3	1	19.4	6	
Other	2.0	12	4.3	2	1.5	1	2.3	1	9.7	3	
Marital status											2.49 (4,745)
Married	71.7	412	60.0	24	68.3	41	62.5	25	60.0	18	
Cohabitant	28.3	163	40.0	16	31.7	19	37.5	15	40.0	12	
Previous partnerships											6.64 (8,747)
None	67.0	388	65.0	26	75.0	45	69.2	27	58.6	17	
One	25.7	149	25.0	10	25.0	15	23.1	9	31.0	9	
Two or more	7.3	42	10.0	4	–	–	7.7	3	10.3	3	
Child's gender											4.29 (4,791)
Boy	50.3	300	47.8	22	47.1	33	64.4	29	55.9	19	
Girl	49.7	296	52.2	24	52.9	37	35.6	16	44.1	15	
Parity											10.24* (4,726)
Primiparous	53.4	299	36.6	15	66.7	40	47.4	18	44.4	12	
Multiparous	46.6	261	63.4	26	33.3	20	52.6	20	55.6	15	

Note: [a]The difference in the sample size of individual variables is due to missing data.
$*p < .05$.

Maternal mental health trajectories predicting child mental health and development

Results show a significant ANCOVA main effect of the maternal mental health trajectory class on internalizing symptoms, but non-significant effects on externalizing symptoms (Table 4). Pair-wise comparisons specified that the children of mothers belonging to the early postpartum ($p < .05$) or to the heterogeneous high levels of ($p < .05$) mental health problems trajectories exhibited higher levels of internalizing symptoms than the children of mothers in the stable low levels of mental health symptoms class.

Both covariates were significant for both internalizing and externalizing symptoms (parity: $F(1{,}474) = 6.29$, $p < .05$, partial $\eta^2 = .01$ for internalizing, and $F(1{,}474) = 6.54$, $p < .05$, partial $\eta^2 = .01$ for externalizing. Current T4 maternal GHQ psychological distress: $F(1{,}474) = 13.45$, $p < .001$, partial $\eta^2 = .03$, for internalizing, and $F(1{,}474) = 8.27$, $p < .01$, partial $\eta^2 = .02$ for externalizing).

The maternal mental health trajectory classes did not differently predict children's social development, as was indicated by non-significant ANCOVA. The current T4 maternal GHQ psychological distress turned out to be a significant covariate, $F(1{,}474) = 6.12$, $p < .05$, partial $\eta^2 = .01$.

Concerning cognitive development, significant ANCOVA main effects with pair-wise comparisons reveal that the maternal mental health trajectory classes significantly predicted children's executive functions and memory. The results in Table 4 show that the children of mothers belonging to the heterogeneous high levels of mental health problems class exhibited more problems in executive functions than the children in the stable low levels mental health symptoms class ($p < .01$) or in the late postpartum mental health symptoms class ($p < .05$). Further, the children of mothers belonging to the heterogeneous high levels of mental health problems class exhibited more memory problems as compared to the children of mothers in any other trajectory class ([$p < .01$] and [$p < .05$]). Parity and current T4 maternal GHQ psychological distress were non-significant covariates.

Infertility history and child gender in maternal mental health trajectories predicting child social and cognitive development

Our results show that neither family's fertility history nor child gender moderated the effect between maternal mental health trajectory class and children's internalizing or externalizing symptoms. In other words, mothers' mental health similarly predicted child mental health in both normative families and in those with former infertility problems, and also among boys and girls. The main effect ANCOVA of fertility history was significant on internalizing symptoms, $F(1{,}474) = 4.11$, $p < .05$, partial $\eta^2 = .01$, revealing a lower symptom level among the ART group children.

Similarly, the interaction effects ANCOVAs were nonsignificant between the fertility history and maternal trajectory class, and between the child gender and maternal trajectory class on social development and cognitive development. Also the main effects of fertility history and child gender were both nonsignificant.

Table 4. Means and standard errors of child mental health symptoms and social and cognitive developmental problems according to maternal mental health trajectory class, and ANCOVA statistics

	Maternal mental health trajectory class												
	I Stable low levels of mental health symptoms		II Prenatal mental health problems		III Early postpartum mental health problems		IV Late postpartum mental health problems		V Heterogeneous high mental health problems		ANOVA [a] statistics	Partial η^2	Pair-wise group comparisons
Child mental health and development	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*F* (4,474)		
Mental health symptoms													
Internalizing	1.44	.01	1.49	.04	1.52	.03	1.50	.04	1.54	.05	3.33*	.03	III,V > I *
Externalizing	1.57	.02	1.61	.06	1.57	.04	1.54	.05	1.72	.07	1.36	.01	
Social development	2.70	.01	2.72	.06	2.63	.04	2.69	.05	2.70	.06	0.58	.01	
Cognitive development													
Executive functions	1.47	.02	1.54	.08	1.47	.05	1.41	.07	1.70	.08	2.37*	.02	V > I** V > IV*
Perception	1.25	.01	1.27	.04	1.29	.03	1.25	.04	1.31	.05	0.74	.01	
Memory	1.28	.01	1.27	.05	1.31	.04	1.28	.05	1.51	.06	3.67**	.03	V > I** V > II,III,IV*
Language	1.16	.01	1.19	.06	1.13	.04	1.14	.05	1.28	.06	1.24	.01	

Note: In all scales high values indicate problems in adjustment. [a]ANCOVA analysis, in which parity (at T1) and current T4 maternal GHQ psychological distress were used as covariates. **p* < .05; ***p* < .01.

Discussion

Our results revealed five distinct trajectories of maternal mental health symptoms from pregnancy to child's first year: Stable low levels of mental health symptoms and prenatal, early postpartum, and late postpartum mental health problems. Fifth trajectory, heterogeneous high levels of mental health problems was an unclassified post hoc class, combining mothers with chronic high or highly variable mental health profiles. Each trajectory had its unique timing and course of psychological distress and depressive symptoms, and the trajectories predicted, to some extent, uniquely child's later mental health and cognitive development. Our results suggest that the timing and course of maternal mental health problems during pregnancy and in the early and late postpartum constitute separate phenomena.

Severity, course and timing of maternal mental health

A majority, three quarters, of the mothers reported relatively low and stable levels of mental health symptoms across the pre- and postnatal periods. This finding is consistent with previous studies suggesting that over 70% of mothers do not experience elevated levels of depressive or anxiety symptoms at any point from pregnancy to postpartum (Heron et al., 2004; Matthey et al., 2000; Mora et al., 2009). Also in line with previous research, a quarter of the mothers showed course and timing of mental health symptoms that exceeded the clinically significant severity at some time during the pre- and postnatal periods.

Some studies have suggested a high continuation in mental health problems across the pre- and postnatal periods (Grant et al., 2008; Robertson et al., 2004). Our results support the continuation argument concerning good maternal mental health, but disqualify the argument that mental health problems are likely to continue from pregnancy to early and late postpartum. Instead, our finding of the considerable variability in the timing and course of psychological distress and depressive symptoms is consistent with Matthey et al.'s (2000), who found that most mothers with postpartum depression showed clinically significant condition only at one point, that is, either at early postpartum (6 weeks), midpostpartum (4 months) or late postpartum (12 months).

Different from previous studies (Ashman et al., 2008; Campbell et al., 2007; Mora et al., 2009), our trajectory analysis did not reveal one stable unified class of mothers suffering from chronic mental health symptoms. We found instead a highly heterogeneous and unstable group of mothers who showed chronic and clinically significant mental health problems during the pre- and postnatal periods. Both the phenomena of clear distinctive timing and heterogeneousness of severe maternal mental health problems make demands to the services of maternity clinics and child health centers. It would be wise to screen for maternal mental health at multiple time periods, and mothers should be provided with tailored help to match with the specific maternal tasks at different stages in transition to parenthood.

The proportion of mothers who had mental health problems only in pregnancy, but not in the early or late postpartum was 6%, and it corresponds exactly with the share of the prenatal mental health trajectory found by Mora et al. (2009) in a North American sample. Studies based on variable-oriented approaches report higher levels of mental health problems in pregnancy (10–20%) (Einarson et al., 2004; Heron et al., 2004), with the highest peaks occurring in the first and third trimesters (Lee et al., 2007). Our study focused solely on the second trimester, which may partly explain the smaller proportion of women with mental health problems. The other reason may relate to the more dynamic trajectory method that identified a unique subgroup of women suffering predominantly from prenatal mental health problems that were resolved when the child was born.

Maternal postpartum depression is generally considered a uniform clinical condition that starts soon after the child's birth and is likely to continue throughout the first year (Beeghly et al., 2002). Our results revealed, however, two distinct trajectories of maternal mental health problems in the postpartum period, one occurring very early, when the child was 2 months old and the other when the child was 12 months. These trajectories had somewhat differing impacts on the child's future mental health, thus supporting the argument that early and late postpartum maternal mental health problems may represent separate phenomena. Earlier research is scarce on distinct postpartum mental health typologies. Perren et al. (2005) suggest that depressive symptoms that increase towards the end of child's first year are typical among mothers with psychopathology, while a decrease would reflect fluctuations of mood in a more normal range.

Pre- and postnatal maternal mental health impacting children

Becoming a parent involves great biological and social changes for the mother, but even more so for the child and infant to be. From the perspective of the child it is of great difference, whether the mother suffers from mental health problems prenatally or when he or she is 2 or 12 months old. Researchers suggest that if the mother suffers anxiety and depression in pregnancy, the impact may be more biochemical and happens through the fetus development (Field et al., 2004), while during the first year of life the mother–infant relationship is at risk due to maternal problems (Bettes, 1988; Campbell et al., 1995; Herrera et al., 2004).

Our findings contribute to the argument that the very early months are important for later child mental health. The children who experienced maternal mental health problems at 2 months showed more internalizing symptoms such as anxiety, depression, and somatization in the first school year, as compared to the children of mothers without mental health problems. At 2 to 3 months the infant development goes through a substantial qualitative leap due to more direct eye-to-eye contacts and more focused and frequent smiles. Subsequently the infant's ability to pay attention and participate in dyadic and family interactions increases markedly (Crockenberg & Leerkes, 2000). Yet, infants need their parent for balancing between their emerging capacity and environmental stimuli. At the early age infant's emotions are strongly connected to bodily sensations, and during that period, the most crucial task for the caregiver is to maintain adequate emotion regulation, for example by responding appropriately to physiological needs of hunger and discomfort (Crittenden, 2004). An adequately regulated infant is able to remain in a state of alert inactivity long enough to make mutual interaction possible for increasing periods of time. When the mother suffers from depression and other mental health symptoms the infant may be left alone to struggle with overwhelming bodily distress and overarousal, exceeding his/her emotional capacity (Stern, 1985). Thus, one possible mechanism explaining child's internalizing mental health symptoms at school age may relate to the timing of maternal mental health problems into the early months, which has interfered with the earliest form of child emotion regulation.

Our results also accord with studies showing that the chronicity and severity of maternal mental health problems are critical to child mental health (Ashman et al., 2008; Hammen & Brennan, 2003) and cognitive development (Grace et al., 2003). Mother's clinically severe mental health problems, although heterogeneously timed across the pre- and postnatal periods, formed risk for children's internalizing symptoms and cognitive developmental problems. Children of mother's with early severe and/or chronic mental health problems showed relatively more problems in executive functioning and memory. The abilities to plan, solve problems, organize school work, and work effectively with episodic and semantic memory are all important for successful academic performance. It is thus vital to consider also the family mental health, here maternal problems, as a possible contributor to learning difficulties in the first school year. One suggested reason for children's cognitive vulnerability relates to the increased stress during the first year of life if the child has to cope with a depressed and anxious mother. According to Sohr-Preston and Scaramella (2006), both pre- and postnatal maternal mental health problems can negatively affect the developing children's stress reactivity, making them more easily overaroused in a variety of situations, including learning situations. Frequent stress reactions may interfere with child's executive functioning and memory consolidation (Blair, Granger, & Peters Razza, 2005) and the ability to retrieve previously encoded information (Quas, Bauer, & Boyce, 2004).

Our results do not concur with studies showing that especially the prenatal maternal anxiety or depression has far-reaching negative effects in increasing child's mental health (O'Connor et al., 2002; van den Bergh & Marcoen, 2004) and cognitive developmental (Mennes et al., 2006; Talge et al., 2007) problems. The lack of association between prenatal maternal mental health and child well-being may be due to the fact that mothers in our trajectory of prenatal mental health problems have resolved their problems when the child was 2 months. We may suggest that even clinically significant prenatal anxiety and depression can leave children's emotional and cognitive development intact, if maternal condition is more optimal during the crucial first year. The trajectory class of prenatal mental health was, however, small originally, and the nonsignificant associations must be interpreted with caution due to substantial dropout of families in the assessment when the child was in school age.

Half of the mothers in our study had experienced infertility and became pregnant via assisted reproductive treatment (ART). Mothering after an intensively yearned child is considered challenging and mentally burdening (Burns, 2007; Fisher et al., 2005). Yet, according to our results maternal infertility history did neither compromise early maternal mental health nor affect the ways how the trajectories predicted child's mental health and development. Earlier research has mainly focused on the direct associations between ART and child well-being and development (Wagenaar et al., 2008). Our study was the first to find out similar links between maternal mental health trajectories and child well-being in ART and normative mothers. The findings substantiate the argument for minor specific characteristics linking ART mothering and mental health problems (Hammarberg et al., 2008).

Researchers argue that the development of boys compared to girls is more affected by maternal mental health (e.g., Brand & Brennan, 2009; Rodriguez & Bohlin, 2005). However, our study did not find any gender specificity among school-aged children, but concurs with the studies that have suggested a similarity in the maternal effects among boys and girls in this age (e.g., van den Bergh & Marcoen, 2004). One possible explanation of gender similarity is suggested by Hay et al. (2001), who argue that whereas boys might react to maternal distress earlier than girls, later in the school age the differences tend to become smaller.

Research comparing pre- and postpartum maternal mental health effects on children is still scarce and, to our knowledge, this was the first trajectory study focusing on the issue. Consistent with Miller et al. (2006), our study suggests that it is useful to assess for multiple mental health symptoms in this maternal transition period characterized by intensive multilevel changes. We extended the concept of maternal mental health to anxiety, social dysfunction, and sleeping difficulties in addition to depression. The child outcomes covered social and cognitive development and mental health, thus providing possibility to a more comprehensive view and testing specific predictors of early maternal mental health.

Limitations

Despite the large sample and the longitudinal data setting, the limitations of the study are numerous. We relied on self-reports to determine the level of maternal mental health symptoms, although face-to-face clinical interviews would have guaranteed a more accurate detection of severity and nature of mental health problems (Pawlby, Sharp, Hay, & O'Keane, 2008). The information concerning child's mental health and development was based on parents' reports, and distressed parents can report negatively biased child outcomes. To balance that we controlled the current maternal mental health and used a multi-informant method by combining mother's and father's records on child mental health and development. Although the inclusion of fathers' reports could reduce reporter bias and increase the validity of the results, their smaller sample size is of concern. We therefore replicated the analyses of maternal mental health trajectories predicting child outcomes using only father's data ($N = 290$). The results were similar to those based on multi-informant data on main effects. Yet, small cell sizes in two-way ANCOVA analyses did not allow us to make conclusions concerning the gender or infertility effects.

The attrition was substantial in the final assessment in the first school years (39.8%), which interferes with the interpretation of the role of early maternal mental health predicting children's well-being. Although there was not statistical difference in dropout rates between the trajectory classes, the attrition resulted in small cell sizes in ANCOVA analyses. As our primary interest in the trajectory analysis was in detecting the unique shapes and courses of maternal symptoms, some variation in the level of symptoms was accepted within each class. Therefore, although detecting well the unique timings and courses of problems, we were not able to take fully into account the severity and chronicity of symptoms in our analyses concerning child adjustment. Also in line with reality, we could not detect trajectory classes where the clinically significant mental health problems would have occurred solely at certain time point.

The present study sample is not nationally representative. The participants were older than the average age of new mothers in Finland. The sample included low levels of risk families and the mothers were generally low in distress during the pre- and postnatal period. Therefore, our results can be generalized only to relatively stable and low-risk populations. Several possible confounding factors were not included. In particular, when examining child's mental health and development, we were able to control for current maternal mental health, but not for symptoms during child's toddler and preschool years. Elevated levels of symptoms are likely to have occurred more frequently in mothers with mental health problems during the pre- and postnatal periods. Also, we did not measure for maternal lifetime depression status, although the history of depression prior to pregnancy is known to be a significant predictor of high postpartum symptoms (O'Hara, 2009). The role of paternal mental health in child development is well acknowledged (Goodman & Gotlib, 1999; Ramchandani et al., 2008) and our study can be criticized for not considering the paternal mental health in the pre- and postnatal period.

In summary, we found evidence that maternal mental health problems in the pre- and postnatal periods are heterogeneous in their timing and course. In some mothers the distress and depression reaches its peak during pregnancy, in some at early months of postpartum and in others only towards the end of child's first year. Therefore, it is essential that the mental health screenings in maternal care include the entire transition to motherhood. Our findings emphasize the critical nature of the early months of child's life for internalizing mental health problems, and negative impact of chronic and severe maternal problems on child mental health and cognitive development. Screening and treatment of maternal mental health can ease the severity and prevent the chronicity of symptoms, which is crucial for optimal child development.

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Paternal mental health trajectory classes and early fathering experiences: Prospective study on a normative and formerly infertile sample

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Abstract

A father's mental health is important for family well-being, but research is scarce on paternal symptoms during the transition to fatherhood. This study identified fathers' latent mental health trajectory classes from the pre- to postnatal period and examined their associations with early fathering experiences. It further analysed, whether a family's infertility history was associated with mental health trajectory classes and moderated their effects on fathering experiences. Finnish fathers ($N = 773$) reported psychological distress (General Health Questionnaire; GHQ-36) and depressive symptoms (Beck Depression Inventory; BDI-13) in pregnancy (T1), and at 2 months (T2) and 12 months (T3) postpartum. They further reported their fathering experience (Parenting Stress Index; PSI-36) at T2 and T3. Results revealed five paternal mental health trajectory classes, differing in timing and course of symptoms across the pre- and postpartum: stable low (79%) and moderate increasing (9%) levels of symptoms, and prenatal (5%), early fatherhood (3%) and heterogeneous high levels of (4%) problems. The trajectory classes were associated with fathering experiences within parental, interactive and child domains, across the child's first year. The stable low levels of symptoms-class showed the most positive experiences and the heterogeneous high levels of problems-class the most negative ones; mental health problems in the early fatherhood-class reported negative fathering experience, but only when the child was 2 months old. A family's infertility history neither showed any significant association with trajectory classes nor moderated their impact on early fathering, supporting the growing evidence that infertility treatments do not place an additional burden on early fatherhood.

Keywords

Paternal mental health, paternal depression, infertility, fathering experience, parenting stress

Introduction

Traditionally, considering fathers predominantly as breadwinners has undermined their contribution to family well-being. Yet, a shift has occurred in Western families, and the paternal role today is characterized by increasing involvement and responsibility for children (di Torella, 2014). Research confirms the importance of paternal mental health for family well-being and child development (Ramchandani, Stein, O'Connor, Heron, Murray, & Evans, 2008; Ramchandani et al., 2011). However, little is known about the variability in timing, course and effects of paternal mental health symptoms during the transition to fatherhood. This study applied a person-oriented approach to identify fathers' longitudinal latent mental health classes from pregnancy to the end of the child's first year, and analysed how the classes associated with early fathering experiences.

Paternal Pre- and Postpartum Mental Health

Mental health problems affect approximately 10% of fathers in the pre- and postpartum period (Paulson & Bazemore, 2010), but conflicting views exist concerning the timing and course of symptoms. Regarding *timing*, that is, the occurrence of mental health problems at a particular time point, a meta-analysis by Paulson and Bazemore (2010) reported that depression was most common in early fatherhood when the child was three to six months old. Other studies have instead found fathers' depression to be more common in the late, rather than early postpartum (Areias, Kumar, Barros, & Figueiredo, 1996), or suggested it to be most common during pregnancy. For instance, one study ($N = 157$) found that over 5% of fathers were depressed prenatally, but less than 3% during the early postpartum

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(Matthey, Barnett, Ungerer, & Waters, 2000). Furthermore, some research shows no timing differences: in an extensive epidemiological study ($N = 13\ 228$) (Ramchandani et al., 2008), paternal depression was almost as common (3.5%) during the second trimester of pregnancy as during early postpartum (3.3%).

Regarding the *course* of paternal mental health problems, research suggests both stability and change in symptoms. Two studies have showed that fathers' symptoms were highly stable throughout the transition (Ballard, Davis, Cullen, Mohan, & Dean, 1994; Zelkowitz & Milet, 2001). Ballard et al. (1994) revealed, for example, that among fathers who were depressed when their child was 6 weeks old, more than a half still suffered the disorder at six months. However, other studies show considerable variability in the course of symptoms. Matthey et al. (2000) reported that a majority of the fathers who were depressed during the pre- and postpartum period showed clinically significant depression only at one point in time. For instance, 70% of those who were depressed at late postpartum had been depressed neither prenatally nor during the early postpartum.

These conflicting views concerning the timing and course of symptoms might reflect the existence of unique subgroups of fathers in transition to parenthood. Some fathers with mental health problems may, for instance, be symptomatic only during pregnancy, others only in early fatherhood and yet others may suffer more chronic problems. We could not, however, find any prior research concerning fathers' mental health trajectories that could reveal these patterns and subgroups. Furthermore, most research concerning early paternal mental health has focused solely on depression. Our latent trajectory class analysis extends this by also including psychological distress (encompassing symptoms of anxiety, sleeping difficulties and social dysfunction) in addition to depression, as we identify paternal trajectory classes from pregnancy through the child's first year.

Early Fathering Experience

Transition to fatherhood involves major psychological reorganization. Much of the change is usually experienced positively, including a new sense of life purpose and responsibility (Chin, Hall, & Daiches, 2011). New fathers explore parental roles actively, often identifying themselves more as emotional supporters, playmates and caregivers, and less as traditional breadwinners or simple maternal helpers (Habib & Lancaster, 2006). During this transition, fathers redefine their relationship with the partner, which can lead to increased unity and companionship (Chin et al., 2011).

However, if the partners do not share beliefs about parental roles and responsibilities, marital well-being is likely to decrease from pre- to postpartum (Adamsons, 2013). The first year of parenthood has sometimes been described as a time of mismatch between expectations and child-care realities, with negative changes for fathers in, for example, the sexual relationship and the amount of time spent with the partner (Gensoni & Tallandini, 2009). Furthermore, some babies are temperamentally demanding, showing negative emotionality and a constant need for parental regulation; consequently, new parents may feel that these demands exceed their resources (Oddi, Murdock, Vadnais, Bridgett, & Gartstein, 2013).

Hand-in-hand with positive emotions, new parents are thus prone to negative experiences that have also been conceptualized as parenting stress (Abidin, 1995). Mothers and fathers with negative parenting experience are prone to adverse parenting behaviours such as decreased sensitivity and warmth, and increased negative feelings, hostility and rejection towards the child (Rodgers, 1998). Early negative parenting experience also increases the risk for concurrent and later emotional, social and cognitive problems in the children (Guajardo, Snyder, & Petersen, 2009).

Research is scarce concerning the link between fathers' early mental health and parenting experience, and completely lacking on specific timings of mental health problems. We can hypothesize that mental health problems during pregnancy are especially harmful for early fathering, because they interfere with intensive prenatal preparation to fatherhood. Research suggests that paternal attachment to the child begins in early pregnancy (Habib & Lancaster, 2006) and remains fairly similar until the late postpartum (Vreeswijk, Maas, Rijk, Braeken, & van Bakel, 2014). Furthermore, men undergo physiological and hormonal changes, such as a decline in testosterone, during the pregnancy, allowing a biological basis for prenatal child-care preparation (Gray & Campbell, 2009). Some evidence confirms that fathers' prenatal mental health predicts early fathering experience. For instance, a study by Saisto, Salmela-Aro, Nurmi and Halmesmäki (2008) followed families ($N = 214$) from pregnancy to toddlerhood and found that fathers' prenatal depression predicted negative fathering experience at two to three years.

We can further assume paternal postpartum mental health problems to impair the early fathering experience, for example, through decreased sensitivity to a child's needs (Wilson & Durbin, 2010). To increase knowledge about the role of mental health in early fathering, the present study analyses whether problems at specific time-points play a role in the early fathering experience.

Former Infertility

Infertility, the inability to conceive or carry a pregnancy to full term, can be extremely painful for both men and women (Burns, 2007). Half of the couples in our study had a history of infertility and became parents through assisted reproductive treatment (ART). Conflicting views prevail concerning mental health and parenting after ART. Some studies suggest that identification with the label "infertile" is strong and enduring, with infertility-related distress continuing to interfere with parental life (Hjelmstedt, Widström, Wramsby, & Collins, 2004). In contrast, other studies suggest none or minor differences in mental health and parenting experience between ART and naturally conceiving (NC) parents (for review, see Hammarberg, Fisher, & Wynter, 2008).

Research concerning ART fathers is very limited. Higher prenatal levels of aggression and anxiety (Hjelmstedt et al., 2004) and lower self-esteem (McMahon & Gibson, 2002) have been reported. However, one study reported similar (Cohen, McMahon, Tennant, Saunders, & Leslie, 2001) and one even lower (Repokari et al., 2005) levels of prenatal depression among ART fathers. Concerning early fathering, two studies reported similar experiences (Colpin, De Munter, Nys, & Vandemeulebroecke, 1999; Repokari et al., 2006), but one detected more negative experience (Baor, Bar-David, & Blickstein, 2004) among ART fathers.

These conflicting findings suggest that there may be latent subgroups of ART fathers in terms of their mental health across the pre- and postpartum. Furthermore, the proportion of fathers belonging to each subgroup may differ between ART and NC groups. For instance, due to psychological burden and medical worries caused by infertility, more ART than NC fathers may be prone to mental health problems during pregnancy. Further differences may be found in associations between mental health and the fathering experience. For example, ART fathers who have waited for and invested a great deal in fatherhood may be especially well-prepared for parental responsibilities, and their possible mental health problems may thus not impair early fathering. Findings based on the current data showed that ART and NC fathers had similar prenatal expectations concerning their relationship to the future child, and that ART fathers even constructed their parental identity somewhat faster, possibly due to longer preparation (Flykt et al., 2009). To our knowledge, no prior studies among ART fathers have analysed latent mental health trajectory classes or their connection to early fathering.

Current Study

Our first aim was to identify longitudinal latent classes of fathers according to early depressive and other psychological distress symptoms (including anxiety, social dysfunction and sleeping difficulties). The trajectories depict the timing and course of paternal symptoms from pregnancy (T1) to the child's age of 2 months (T2) and 12 months (T3). Our second aim was to examine how the trajectory classes associated with early fathering experience across the child's first year (T2–T3). Finally, we examined whether a family's fertility history (ART vs. NC group) predicted membership of the trajectory classes, and whether it moderated the association between the trajectory class and fathering experience.

Methods

Participants and Procedure

The sample comprised 773 Finnish Caucasian couples, who participated in the study during the second trimester of pregnancy (T1, 18–20 weeks of gestation) and when the child was 2 (T2) and 12 months (T3) old. Fifty-three per cent of the couples had suffered from infertility (duration $M = 57$ months; $SD = 33$ months) and undergone a successful assisted reproductive treatment with their own gametes (ART group). Forty-seven per cent were NC couples. All the couples entering the infertility clinics were asked to participate in the study (ART group), and the NC group consisted of couples taking part in a routine ultrasound examination offered by community maternal care clinics. The Ethical Committees in participating clinics approved the study.

During pregnancy at T1 $N = 756$ (99.1%) fathers took part in the study. Later participation rates were $N = 615$ (80.6%) for T2 and $N = 506$ (66.3%) for T3. Approximately five hundred ($N = 497$, 65.1%) fathers participated in all three assessments. Participation at T3 was higher in the ART than in the NC group, 69.2% vs. 62.2%, $p < 0.05$. Participation was also dependent on maternal mental health: at each time-point the wives of the participating fathers reported lower levels of psychological distress and/or depressive symptoms than the wives of the fathers who did not take part, General Health Questionnaire (GHQ): T1 $t = 2.2$, $p < 0.05$; T3 $t = 2.3$, $p < 0.05$; Beck's Depression Inventory (BDI): T1 $t = 2.4$, $p < 0.05$; T2 $t = 3.2$, $p < 0.01$; T3 $t = 3.2$, $p < 0.01$. However, participation was independent of the paternal mental health measured at previous stages. It was also independent of paternal and maternal education and age, length of the partnership, child's birth weight and parity.

Measures

Psychological distress was measured at T1–T3 using the 36-item GHQ (GHQ-36; Goldberg & Hiller, 1979), covering anxiety, depression, social dysfunction and sleeping difficulties. Fathers estimated how the symptom descriptions matched their state over the previous few weeks on a Likert scale (1 = *not at all* to 4 = *much more than usual*). In this study, averaged sum variables were constructed for time points T1 (Cronbach's $\alpha = 0.92$), T2 ($\alpha = 0.92$) and T3 ($\alpha = 0.93$). The Finnish version of the GHQ has shown to be both valid and reliable in detecting symptoms of psychological distress (Holi, Marttunen, & Aalberg, 2003). To indicate clinical significance, dichotomic variables were computed based on the cut-off point in Finnish samples (Holi et al., 2003).

Depression was assessed at T1–T3 by a shortened version of the BDI (BDI-13; Beck, Ward, Mendelsohn, Mock, & Erlaugh, 1961). It consists of 13 descriptions of low mood, hopelessness and somatic signs of depression. Participants estimated how they felt on a Likert scale (0 = *symptom not present* to 4 = *symptom present most of the time*). Averaged sum variables were constructed for time points T1 ($\alpha = 0.81$), T2 ($\alpha = 0.80$) and T3 ($\alpha = 0.84$). The Finnish version of the BDI has been found valid and reliable in detecting depressive symptoms (Kaltiala-Heino, Rimpelä, & Laippala, 1999). Clinical significance was assessed using dichotomized variables with the cut-off points used in Finnish samples (Kaltiala-Heino et al., 1999).

Fathering experience was assessed at T2–T3 using the short form of Parenting Stress Index (PSI-36; Abidin, 1995). The scale conceptualizes three components of parenting experience: The *parent domain* (12 items) represents the experience of resources and limitations one posits as a parent; the *interaction domain* (12 items) represents the experience of the dyadic relationship with the child; and the *child domain* (12 items) measures the child's early characteristics contributing to his/her difficulty from the caretaker's point of view. Fathers estimated how the descriptions matched their experiences on a Likert scale (1 = *completely agree* to 5 = *completely disagree*), with higher values indicating more positive experience. All three domains correlated at both time-points (r's ranging from 0.50 to 0.60, p's < 0.01). The Finnish version of the PSI has previously been used in a large, longitudinal family study in Finland, providing validity of the measure (Saisto et al., 2008). Three averaged sum variables were constructed for time-points T2 (parent $\alpha = 0.82$, interaction $\alpha = 0.83$, and child $\alpha = 0.85$) and T3 (parent $\alpha = 0.84$, interaction $\alpha = 0.83$, and child $\alpha = 0.83$).

Statistical Analyses

To identify fathers' mental health trajectory classes from pregnancy to the child being 2 months and 12 months old, we used factor mixture modelling in Mplus 5 (Lubke & Muthén, 2005; Muthén & Muthén, 1998–2007). It identifies subpopulations from the observed data, in a longitudinal setting called latent trajectory classes. Figure 1 presents the model of the present study. The identification of latent classes was based on psychological distress (GHQ-36) and depressive symptoms (BDI-13) assessed at T1, T2 and T3. Level factors with loadings fixed at one were included into the model to indicate the overall individual level of GHQ and BDI. Variances, covariances and residual variances were set equal between classes. All mental health variables (GHQ and BDI at T1–T3) were non-normally distributed. Skewness in variables ranged from 1.22 to 1.83 and kurtosis from 2.30 to 5.76, all $p < 0.001$.

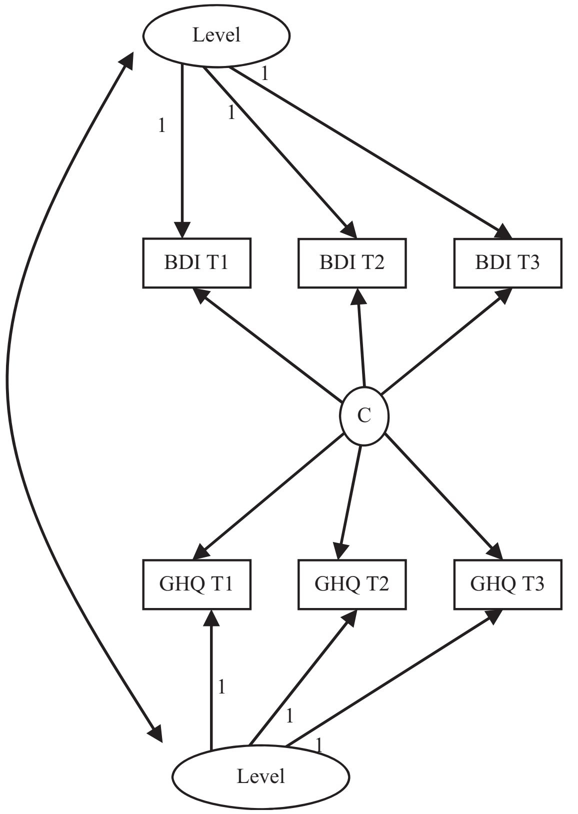

Figure 1. Factor mixture analysis design of fathers' mental health across the pre- and postpartum period.
Note. BDI = Beck's Depression Inventory (13-item); GHQ = General Health Questionnaire (36-item); T1 = pregnancy; T2 = child 2 months old; T3 = child 12 months old; C = paternal mental health latent variable; Level = level factor.

Thus, robust standard errors (MLR) with maximum likelihood estimation were used, which also handles missing data by using all the information available (Muthén & Muthén, 1998–2007).

The optimal number of latent classes was evaluated through seven statistical criteria: three information criteria, three tests and entropy (see Table 1). Our decision was based particularly on the Bayesian information criterion (BIC) and the bootstrap likelihood ratio test (BLRT) that have been found to be the most reliable criteria (Nylund, Asparouhov, & Muthén, 2007). The quality of classifications was evaluated using average posterior probabilities for each class.

To answer our second question concerning the associations between fathers' mental health trajectory classes and early fathering experiences, we applied repeated-measures multivariate analyses of variance (MANOVA) on parent, interaction and child domains of the PSI from T2 to T3. Univariate analyses as well as Tukey's honest significant difference (HSD) *post-hoc* analyses were conducted. We compared the general level (average of T2 and T3) and the change (from T2 to T3) of fathering experience between the trajectory classes. The use of covariates was decided based on differences between the classes according to demographic variables (see Descriptive Statistics).

Finally, to examine how the family's fertility history (ART vs. NC) associated with paternal mental health trajectory class, we used Pearson's chi-square test (χ^2), and to analyse whether fertility history moderated the effect of trajectory class on fathering experience, we included a 5 (trajectory class) * 2 (fertility history)-interaction term into the MANOVA.

Results

Descriptive Statistics

Table 2 shows the demographic variables according to families' fertility history. Results show that the ART and NC groups differed in marital status (ART parents being more often married), number of previous partnerships (ART parents having less earlier partnerships), parity (ART parents being more often primiparous), and maternal socioeconomic status (ART mothers being less often high professionals and more often skilled workers). Further, the partnership had endured longer in the ART group, $t(706) = 4.20, p < 0.001$. In contrast, the ART and NC groups did not differ in gender of the child or father's socioeconomic status. Likewise, maternal age, $t(724) = -0.59, p = 0.56$, and paternal age, $t(708) = 1.78, p = 0.07$, were similar between the groups.

Table 3 presents the means, standard deviations and ranges of paternal psychological distress and depressive symptoms at T1–T3. It further shows the means, standard deviations and ranges of the parent, interaction and child domains of fathering experience at T2 and T3.

Identifying Fathers' Mental Health Trajectory Classes

Our first goal was to identify fathers' mental health trajectory classes across the pre- and postpartum period. As displayed in Table 1, the information criteria (Akaike information criterion, BIC, sample-size-adjusted BIC) and statistical tests (Vuong–Lo–Mendell–Rubin likelihood ratio test (VLMR), Lo–Mendell–Rubin adjusted likelihood ratio test (LMR), BLRT) of the analysis gave somewhat conflicting results. The three information criteria as well as the BLRT test suggested that solutions with nine or ten classes would fit best to our data, whereas LMR and VLMR tests preferred solutions with two or seven classes. Entropy decreased slightly when adding classes in the model, but all values indicated proper solutions. Based on the highest reliability of BIC and BLRT as statistical criteria (Nylund et al., 2007), the 9-class-solution appeared most suitable. Importantly, however, log-likelihoods of the solutions with nine and ten classes could be only rarely replicated, even though as many as 1000 starting values were used. This indicated instability for these solutions. According to BIC and BLRT, the best stable solution was the one with eight classes. We compared visually the mean courses and class sizes in the 8- vs. 9-class-solutions, and found only minor differences. From the 8- to 9-class-solution one small trajectory was split into two, and rest of the classes remained fairly stable. Therefore, we selected the solution with eight classes.

The 8-class-solution had acceptable average posterior probabilities for class membership, ranging from 0.81 to 1.00. The solution comprised four trajectory classes that were representative of the sample (covering 96% of the data) and had courses that were theoretically meaningful. The remaining four classes comprised only a few fathers (total $N = 33$; 4.3%), who reported high levels of problems in at least one assessment, but whose symptom courses did not fit any of the four larger classes. These small classes were

Table 1. Information criteria and statistical tests of mixture modelling identifying fathers' mental health trajectory classes.

Number of groups	Information criteria			Statistical tests			Entropy	Class sizes based on estimated model
	AIC	BIC	aBIC	VLMR	LMR	BLRT		
1	−305.89	−236.13	−283.77	-	-	-	1.0	$N = 773$
2	−610.36	−508.06	−577.92	0.0322	0.0342	<0.0001	0.979	748/25
3	−829.19	−694.33	−786.42	0.4915	0.4963	<0.0001	0.919	48/23/703
4	−970.69	−803.28	−917.60	0.1192	0.1223	<0.0001	0.912	23/680/28/42
5	−1040.87	−840.90	−977.45	0.5975	0.6006	<0.0001	0.900	6/27/44/653/42
6	−1104.03	−871.51	−1030.83	0.3018	0.3041	<0.0001	0.850	593/37/28/6/96/13
7	−1158.64	−893.58	−1074.58	0.0797	0.0816	<0.0001	0.863	2/41/15/7/92/583/32
8	−1197.28	−899.66	−1102.89	0.5172	0.5199	<0.0001	0.855	567/40/14/30/97/18/5/2
9	−1231.19	−901.02	−1126.48	0.4285	0.4293	<0.0001	0.858	16/27/6/28/570/88/5/2/30
10	−1249.01	−886.29	−1139.97	0.6051	0.6056	<0.05	0.855	52/4/20/11/63/54/543/8/10/8

Notes: Lower values of the information criteria, lower p-values of the statistical tests and higher values of entropy indicate better fitting models. AIC = Akaike information criterion; BIC = Bayesian information criterion; aBIC = sample-size-adjusted BIC; VLMR = Vuong–Lo–Mendell–Rubin likelihood ratio test; LMR = Lo–Mendell–Rubin adjusted likelihood ratio test; BLRT = bootstrap likelihood ratio test.
$N = 773$.

Table 2. Demographic variables according to family's fertility history.

	Assisted reproductive treatment (ART) group ($n = 405$)			Naturally conceiving (NC) group ($n = 356$)			χ^2 *(df, n)*
	%	95% CI	n	%	95% CI	n	
Child's gender							0.08 (1, 754)
Boy	50.4	[45.5, 55.3]	201	50.7	[45.5, 55.9]	180	
Girl	49.6	[44.7, 54.5]	198	49.3	[44.1, 54.5]	175	
Marital status							8.07** (1, 700)
Married	74.9	[70.7, 79.1]	269	65.1	[60.2, 70.1]	222	
Cohabitant	25.1	[20.9, 29.3]	90	34.9	[30.0, 39.9]	119	
Previous partnerships							7.37* (2, 712)
None	72.0	[67.6, 76.4]	265	62.5	[57.5, 67.5]	215	
One	22.0	[18.0, 26.0]	81	29.9	[25.1, 34.7]	103	
Two or more	6.0	[3.7, 8.3]	22	7.6	[4.9, 10.4]	26	
Parity							75.86*** (1, 694)
Primiparous	69.9	[65.4, 74.4]	258	36.9	[31.9, 41.9]	120	
Multiparous	30.1	[25.6, 34.6]	111	63.1	[58.1, 68.1]	205	
Socioeconomic status							
Mother							14.14** (3, 702)
High professional	30.3	[25.8, 34.8]	111	38.7	[33.6, 43.8]	130	
Low professional	41.0	[36.2, 45.8]	150	40.5	[35.4, 45.6]	136	
Skilled worker	22.7	[18.6, 26.8]	83	12.8	[9.3, 16.3]	43	
Unskilled worker	6.0	[3.7, 8.3]	22	8.0	[5.2, 10.8]	27	
Father							6.52 (3, 696)
High professional	31.6	[27.1, 36.1]	112	38.9	[33.8, 44.0]	133	
Low professional	30.5	[26.0, 35.0]	108	31.0	[26.2, 35.8]	106	
Skilled worker	30.2	[25.7, 34.7]	107	22.5	[18.2, 26.8]	77	
Unskilled worker	7.6	[5.0, 10.2]	27	7.6	[4.9, 10.4]	26	

Notes: $N = 761$. ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$.

highly heterogeneous in timing and severity of symptoms. Although perhaps representing meaningful subpopulations of fathers, our sample was not large enough for statistical inferences. However, we did not want to leave them out of the subsequent analyses, which is why we combined them into one new trajectory class named as heterogeneous high levels of mental health problems.

Figure 2 displays the courses of fathers' psychological distress and depressive symptoms in each mental health trajectory class from pregnancy (T1) to child being 2 months (T2) and 12 months (T3) old. The figure is based on the original reported mean scores, and thus does not show the clinically significant cut-off points. The identified five trajectory classes were as follows:

I Stable low levels of mental health symptoms -class (78.9%, $N = 604$) was the largest. Characteristic of fathers in this class were low levels of psychological distress and depressive symptoms during pregnancy and when the child was 2 months and 12 months old. The trajectory (average) does not exceed the clinically significant cut-off point for psychological distress or depressive symptoms at any time-point.

II Moderate increasing levels of mental health symptoms -class (8.9%, $N = 68$) involved fathers who started out with low levels of

Table 3. Means, standard deviations and ranges of paternal mental health symptoms from pregnancy through child's first year (T1–T3) and fathering experience across the child's first year (T2–T3).

	M	SD	Range
Paternal mental health			
Psychological distress (GHQ-36)			
T1: Pregnancy ($N = 756$)	1.56	0.29	1.00–3.22
T2: Child 2 months ($N = 615$)	1.54	0.27	1.00–3.19
T3: Child 12 months ($N = 506$)	1.56	0.39	1.00–3.39
Depressiveness (BDI-13)			
T1: Pregnancy ($N = 756$)	0.51	0.32	0.00–2.00
T2: Child 2 months ($N = 615$)	0.48	0.30	0.00–2.15
T3: Child 12 months ($N = 506$)	0.50	0.33	0.00–2.08
Fathering experience (PSI-36) T2–T3			
Parent-domain			
T2: Child 2 months ($N = 615$)	4.27	0.49	2.42–5.00
T3: Child 12 months ($N = 504$)	4.25	0.51	2.00–5.00
Interaction-domain			
T2: Child 2 months ($N = 615$)	4.48	0.44	1.92–5.00
T3: Child 12 months ($N = 504$)	4.61	0.35	2.92–5.00
Child-domain			
T2: Child 2 months ($N = 615$)	4.33	0.47	2.42–5.00
T3: Child 12 months ($N = 504$)	4.36	0.42	2.75–5.00

Notes: GHQ-36 = General Health Questionnaire (Goldberg & Hiller, 1979); BDI-13 = Beck's Depression Inventory (Beck et al., 1961); PSI-36 = Parenting Stress Index (Abidin, 1995). Higher values of mental health symptoms indicate more problems and higher values of fathering experience indicate more positive experience. Theoretical ranges: psychological distress (GHQ-36): 1–4; depressiveness (BDI-13): 0–4; fathering experience (PSI-36): 1–5. $N = 761$.

symptoms during pregnancy, but whose symptoms gradually increased towards child's age of 2 months and especially 12 months. Similar to the stable low-class (I), this trajectory does not exceed the clinically significant cut-off point for psychological distress or depressive symptoms at any time-point.

III Prenatal mental health problems -class (4.7%, $N = 37$) involved fathers showing a relatively high level of mental health problems during pregnancy, but whose symptoms then decreased to low or moderate levels when the child was 2 months and 12 months old. The trajectory crosses the clinically significant cut-off points for psychological distress and depressive symptoms in pregnancy, but not any more during the first year of fatherhood.

IV Mental health problems in early fatherhood -class (3.1%, $N = 24$) comprised fathers with a peak in mental health problems when the child was 2 months old. In pregnancy and at 12 months the symptom levels were relatively low. The trajectory exceeds the clinically significant cut-off point for psychological distress, but not for depressive symptoms, at the child's age of 2 months.

V *Heterogeneous high levels of mental health problems* -class (4.3%, $N = 33$) combined four small classes that showed variable but severe mental health symptom profiles. Some fathers (2.3%, $N = 18$) suffered high levels of problems that increased towards the child's age of 12 months; others (1.1%, $N = 8$) showed extremely high symptom levels in pregnancy and at 2 months, that then decreased to low levels towards 12 months; others (0.6%, $N = 5$) suffered chronically high levels of problems; and yet others (0.3%, $N = 2$) reported extremely low levels in pregnancy, but extremely high scores at 12 months. The trajectory exceeds the clinically significant cut-off points for both psychological distress and depressive symptoms in pregnancy and at 2 months, and for psychological distress only at 12 months.

Table 4 shows that the fathers' trajectory classes did not differ in demographic variables of paternal education, marital status, number of previous marriages, gender of the child, or parity. Furthermore, the age of the father, $F(4,709) = 0.33$, $p = 0.86$, and the duration of the partnership, $F(4,686) = 0.41$, $p = 0.80$, did not differ between the trajectories. Based on the demographic similarity of the trajectory classes, no covariates were included in the MANOVA analysis.

Mental Health Trajectories and Fathering Experience

Our second task was to examine how the paternal trajectory classes associated with early fathering experience. Table 5 presents the means and standard deviations of the three domains of PSI from 2 months (T2) to 12 months (T3) postpartum according to the five trajectory classes. Multivariate results showed that trajectory classes were associated with both the *general level* (average of T2 and T3), $F_{\text{Wilk's } \lambda}\,(12, 1291) = 14.47$, $p < 0.001$, partial $\eta^2 = 0.11$, and the *change* (from T2 to T3), $F_{\text{Wilk's } \lambda}\,(12, 1291) = 3.78$, $p < 0.001$, partial $\eta^2 = 0.03$, of fathering experience.

Univariate results in Table 5 reveal that differences between the trajectory classes in the *general level* of fathering experience were significant in the parent, interaction and child domains. Figure 3 illustrates, first, that the fathers in the stable low-class (I) reported an especially positive fathering experience. *Post-hoc* tests specified that on the parent domain, their experience was more positive than that of any other class, and on the interaction and child domains, it was more positive than among fathers in the moderate increasing (II), early fatherhood (IV) and heterogeneous high (V)-classes. Second, the fathers in the heterogeneous high -class (V) reported an especially negative fathering experience. *Post-hoc* tests specified that they differed significantly from the fathers in the stable low-class (I) on all three domains, and from the fathers in the moderate increasing-class (II) on parent domain. Third, the fathers in the early fatherhood-class (IV) reported more negative fathering experience than fathers in the stable low (I) and prenatal (III)-classes on the parenting and interaction domains.

Univariate results in Table 5 further reveal that differences between the trajectory classes in the *change* of fathering experience were significant on the parent, interaction and child domains. As Figure 3 illustrates, typical to fathers in the early fatherhood-class (IV) was highly negative fathering experience when the child was 2 months old that then sharply improved towards 12 months. *Post-hoc* tests specified that on the parent domain, their change from T2 to T3 differed from all other classes, and on the interaction and child domains, it differed from the moderate increasing (II), prenatal (III) and heterogeneous high (V)-classes.

Role of Former Infertility

Our third task was to examine, whether a family's fertility history (ART vs. NC group) associated with the trajectory class and moderated its effect on early fathering experience. Results of the chi-square test in Table 4 showed that the trajectory classes did not associate with fertility history, suggesting similar early mental health among ART and NC fathers. Alike, fertility history did not moderate the association between mental health trajectory classes and fathering experience. The interaction between trajectory class and fertility history was non-significant on the general level

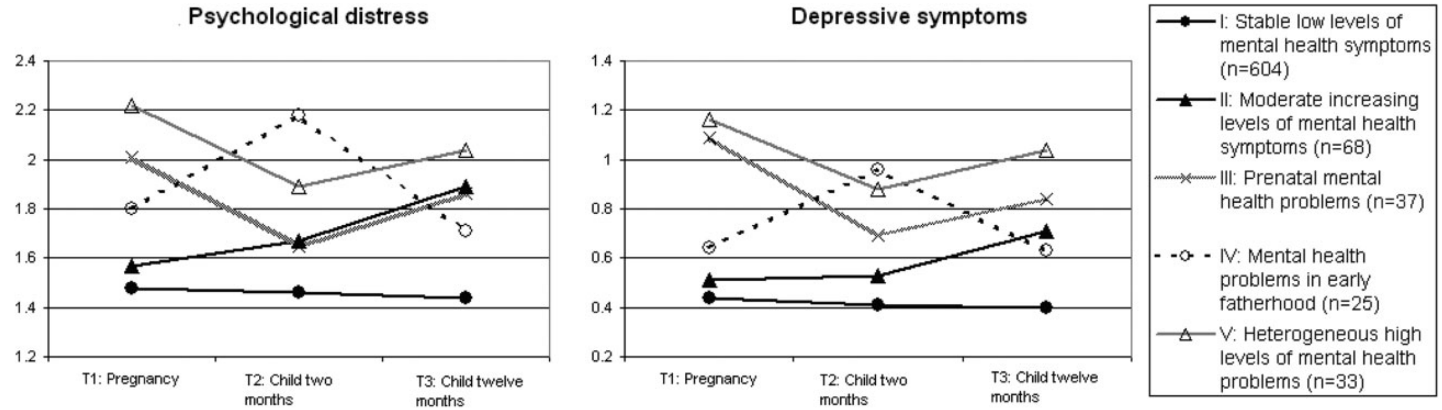

Figure 2. Means of reported mental health symptoms according to paternal mental health trajectory class.
Note: $N = 767$.

Table 4. Demographic variables and fertility history according to paternal mental health trajectory classes.

	I Stable low levels of mental health symptoms ($N = 604$)			II Moderate increasing levels of mental health symptoms ($N = 68$)			III Prenatal mental health problems ($N = 37$)			III Mental health problems in early fatherhood ($N = 25$)			V Heterogeneous high levels of mental health problems ($N = 33$)			
	%	95% CI	n	%	95% CI	n	%	95% CI	n	%	95% CI	n	%	95% CI	n	χ^2 (df, n)
Fertility history																8.26 (4, 761)
Assisted reproductive treatment	55.3	[51.3, 59.3]	332	50.0	[38.1, 61.9]	34	47.2	[31.1, 63.3]	17	29.2	[11.4, 47.0]	7	45.5	[28.5, 62.5]	15	
Naturally conceiving	44.7	[40.7, 48.7]	268	50.0	[38.1, 61.9]	34	52.8	[36.7, 68.9]	19	70.8	[53.0, 88.6]	17	54.5	[37.5, 71.5]	18	
Child's gender																0.61 (4, 754)
Boy	50.6	[46.6, 54.6]	300	51.5	[39.6, 63.4]	35	47.2	[31.1, 63.3]	17	45.8	[26.3, 65.3]	11	54.5	[37.5, 71.5]	18	
Girl	49.4	[45.4, 53.4]	293	48.5	[36.6, 60.4]	33	52.8	[36.7, 69.0]	19	54.2	[34.7, 73.7]	13	45.5	[28.5, 62.5]	15	
Marital status																0.79 (4, 710)
Married	71.5	[67.9, 75.1]	403	66.7	[55.5, 77.9]	38	67.6	[52.5, 82.7]	23	69.6	[51.6, 87.6]	16	71.9	[56.6, 87.2]	23	
Cohabitant	28.5	[24.9, 32.1]	161	33.3	[22.1, 44.5]	19	32.4	[17.3, 47.5]	11	30.4	[12.4, 48.4]	7	28.1	[12.8, 43.4]	9	
Previous partnerships																11.08 (8, 697)
None	67.9	[64.2, 71.6]	374	58.6	[46.9, 70.3]	34	52.9	[36.8, 69.0]	18	77.3	[60.9, 93.7]	17	62.5	[46.0, 79.0]	20	
One	26.1	[22.6, 29.6]	144	31.0	[20.0, 42.0]	18	44.1	[28.1, 60.1]	15	18.2	[3.1, 33.3]	4	25.0	[10.2, 39.8]	8	
Two or more	6.0	[4.1, 7.8]	33	10.3	[3.1, 17.5]	6	2.9	[0.0, 8.3]	1	4.5	[0.0, 12.6]	1	12.5	[1.2, 23.8]	4	
Parity																7.19 (4, 694)
Primiparous	56.9	[53.0, 60.9]	314	48.3	[36.4, 60.2]	28	38.7	[23.0, 54.4]	12	42.9	[23.5, 62.3]	9	46.9	[29.9, 63.9]	15	
Multiparous	43.1	[39.2, 47.1]	328	51.7	[39.8, 63.6]	30	61.3	[45.6, 78.0]	19	57.1	[37.7, 76.5]	12	53.1	[36.1, 70.1]	17	
Socioeconomic status: father																13.43 (12, 696)
High professional	37.5	[33.6, 41.4]	206	22.0	[12.2, 31.9]	13	21.2	[8.0, 34.4]	7	39.1	[20.0, 58.2]	9	31.2	[15.4, 47.0]	10	
Low professional	30.2	[26.5, 33.9]	166	32.2	[21.1, 43.3]	19	36.4	[20.9, 51.9]	12	26.1	[8.9, 43.2]	6	34.4	[18.2, 50.6]	11	
Skilled worker	25.0	[21.6, 28.5]	137	39.0	[27.4, 50.6]	23	30.3	[15.5, 45.1]	10	30.4	[12.4, 48.4]	7	21.9	[7.8, 36.0]	7	
Unskilled worker	7.3	[5.2, 9.4]	40	6.8	[0.8, 12.8]	4	12.1	[1.6, 22.6]	4	4.3	[0, 12.3]	1	12.5	[1.2, 23.8]	4	

Note: $N = 767$.

Table 5. Fathering experiences (PSI-36) in paternal mental health trajectory classes and effects of classes and time on fathering experience.

	T2: Child 2 months					T3: Child 12 months					Repeated Measures ANOVA			
	I	II	III	IV	V	I	II	III	IV	V				
PSI-36	M (SD) 95% CI	M (SD) 95% CI	M (SD) 95% CI	M (SD) 95% CI	M (SD) 95% CI	M (SD) 95% CI	M (SD) 95% CI	M (SD) 95% CI	M (SD) 95% CI	M (SD) 95% CI	Classes	N_p^2	Classes X Time	N_p^2
Parent-domain	4.40 (0.39) [4.36, 4.44]	4.06 (0.48) [3.94, 4.19]	4.02 (0.47) [3.82, 4.23]	3.61 (0.57) [3.33, 3.89]	3.80 (0.61) [3.55, 4.04]	4.39 (0.40) [4.35, 4.44]	3.89 (0.43) [3.78, 4.00]	3.88 (0.45) [3.68, 4.07]	4.04 (0.51) [3.80, 4.29]	3.59 (0.85) [3.25, 3.92]	44.98***	.27	10.56***	.08
Inter-action-domain	4.52 (0.42) [4.48, 4.57]	4.37 (0.47) [4.25, 4.49]	4.51 (0.37) [4.35, 4.67]	4.11 (0.49) [3.88, 4.34]	4.27 (0.48) [4.08, 4.47]	4.68 (0.30) [4.65, 4.70]	4.42 (0.42) [4.31, 4.52]	4.51 (0.34) [4.36, 4.65]	4.44 (0.41) [4.25, 4.64]	4.36 (0.53) [4.15, 4.56]	11.75***	.09	2.97*	.02
Child-domain	4.39 (0.42) [4.34, 4.43]	4.0 (0.48) [4.13, 4.37]	4.36 (0.47) [4.15, 4.56]	3.93 (0.59) [3.65, 4.21]	4.16 (0.46) [3.95, 4.38]	4.42 (0.39) [4.38, 4.46]	4.20 (0.47) [4.08, 4.32]	4.21 (0.42) [4.03, 4.39]	4.23 (0.38) [4.04, 4.41]	4.15 (0.55) [3.94, 4.37]	8.25***	.06	2.64*	.02

Notes: I = stable low levels of mental health symptoms ($N = 373$); II = moderate increasing levels of mental health symptoms ($N = 62$); III = prenatal mental health problems ($N = 23$); IV = mental health problems in early fatherhood ($N = 19$); V = heterogeneous high levels of mental health problems ($N = 27$). Fathering experience was measured using the Parenting Stress Index (PSI-36; Abidin, 1995). Analysis of variance degrees of freedom: $F(4, 495)$. N_p^2 = partial eta squared. $N = 504$. ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$.

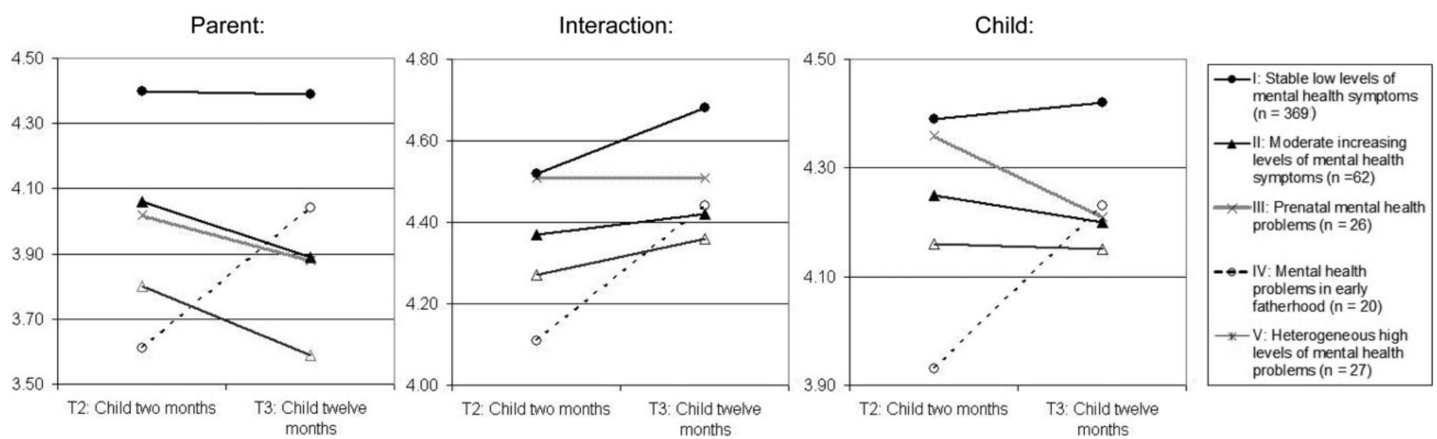

Figure 3. Estimated marginal means of parent, interaction and child domains of fathering experience (Parenting Stress Index-36; Abidin, 1995) from child being two (T2) to twelve (T3) months across the fathers' mental health trajectory classes.

Notes: Tukey (HSD) *post-hoc* tests: (1) parent domain: average (T2–T3) *level* differences: I > II, III, IV, V ($p < 0.001$), II > V ($p < 0.01$) and III > V ($p < 0.05$); differences in the *change* from T2 to T3: IV $\neq$ II, III ($p < 0.001$), IV $\neq$ V ($p < 0.01$) and IV $\neq$ I ($p < 0.05$); (2) interaction domain: average (T2–T3) *level* differences: I > II, IV, V ($p < 0.001$) and III > IV ($p < 0.05$); differences in the *change* from T2 to T3: IV $\neq$ III ($p < 0.01$) and IV $\neq$ II, V ($p < 0.05$); (3) child domain: average (T2–T3) *level* differences: I > II, IV, V ($p < 0.01$); differences in the *change* from T2 to T3: IV $\neq$ III ($p < 0.01$) and IV $\neq$ II, V ($p < 0.05$). $N = 504$.

(average of T2 and T3), $F_{\text{Wilk's } \lambda}$ (12, 1291) = 1.73, $p = 0.06$, partial $\eta^2 = 0.01$, and the change (from T2 to T3), $F_{\text{Wilk's } \lambda}$ (12, 1291) = 0.95, $p = 0.50$, partial $\eta^2 = 0.01$, in fathering experience. However, the main effect of fertility history was significant on the general level of fathering experience, $F_{\text{Wilk's } \lambda}$ (3, 488) = 3.49, $p < 0.05$, partial $\eta^2 = 0.02$, indicating that ART fathers reported more negative fathering experience on the parent domain, $F(1, 490) = 3.88$, $p < 0.05$., partial $\eta^2 = 0.01$. Concerning interaction and child domains, there were no differences between ART and NC fathers. There was no main effect of fertility history on the change of fathering experience from T2 to T3, $F_{\text{Wilk's } \lambda}$ (3,488) = 1.80, $p = 0.15$, partial $\eta^2 = 0.01$.

Discussion

In our study, the timing and course of fathers' mental health symptoms from pregnancy to the child's first year were best described by five distinct trajectory classes: stable low (79%) and moderate increasing (9%) levels of symptoms, and prenatal (5%), early fatherhood (3%) and heterogeneous high levels of (4%) mental health problems. Previous research has been controversial regarding the course of paternal mental health symptoms during the pre- and postpartum period, with some studies suggesting stability (Ballard et al., 1994; Zelkowitz & Milet, 2001) and others variability (Matthey et al., 2000). Our findings demonstrate a heterogeneous, dynamic and timing-specific nature of paternal mental health problems.

Paternal Mental Health Symptoms

In our study, nearly nine out of ten fathers belonged to trajectory classes without clinical levels of mental health problems, in line with previous research suggesting mental health problems to affect approximately 10% of new fathers (Paulson & Bazemore, 2010). Among the mentally healthy fathers we detected two distinct classes: a larger group of fathers (79% of the entire sample) showed relatively stable and low symptom courses across the pre- and postpartum; and a smaller group (9%) reported low levels of symptoms during pregnancy that then gradually increased towards the child being two and especially 12 months old, yet, not reaching clinical significance.

The substantial number of fathers with an increasing course of symptoms from pregnancy and across the child's first year present an interesting class. It concurs with some earlier studies that have found paternal depression to be more common in the late than the early postpartum (Areias et al., 1996; Matthey et al., 2000). One explanation may be that mental health problems in fathers follow earlier onset of problems in their wives, who give birth and are intensively tied up with early child care, and thus more vulnerable to symptoms during the early postpartum (Areias et al., 1996).

Fathers with clinically significant mental health problems, a tenth in our sample, typically suffered the disorder only at a specific time-point. They were symptomatic either only during pregnancy (5%) or only when the child was 2 months old (3%). The rest of the symptomatic fathers (4%) suffered either chronic or high sporadic problems, belonging to the highly heterogeneous and unstable trajectory class. To our knowledge there are no prior paternal trajectory studies; this impedes proper comparison of the occurrence and frequency of the symptoms. Ramchandani et al. (2008) found a smaller number of fathers (2%) who were symptomatic only during pregnancy, but somewhat similarly to ours, 2% of fathers were depressed only when the child was 2 months old. They also reported a group of fathers who were depressed at both times (1%). The study was, however, based on clinical cut-off scores, not trajectories, and focused solely on depressive symptoms, which can explain somewhat lower percentages.

Interestingly, our study did not find a unified class of fathers suffering from chronic mental health problems, but instead, severe problems were highly heterogeneous in their timing and course. This has implications for clinical practice in maternal and child care. Despite increasing awareness of paternal mental health on family well-being (Ramchandani et al., 2011), paternal symptoms are not usually screened. Our findings emphasize the importance of screening fathers for mental health symptoms and providing support to them at multiple time-points during their transition.

Mental Health and Fathering Experience

Transition to parenthood is a period of profound change, with high demands set on new parents. Fathers face challenges particularly in balancing their time between work and family, managing the changes in family economy and accepting decreased time and intimacy with the partner (Genesoni & Tallandini, 2009). Therefore, although exciting and delightful, transition to parenthood is often experienced as stressful, and especially so among parents who suffer from mental health problems.

Previous research has reported connection between prenatal mental health problems and later negative fathering experience (Saisto et al., 2008). Our study extended this finding by investigating how specific timings and courses of paternal problems, depicted in mental health trajectory classes, associated with early fathering experience. Notably, the fathers with stable and low levels of mental health symptoms throughout the transition also experienced fathering most positively. Instead, the most negative fathering experience throughout the child's first year was found among the small group of fathers who suffered chronic or heterogeneously timed high levels of mental health problems.

Due to possibly intensive prenatal preparation for fatherhood (Habib & Lancaster, 2006; Vrejsweek et al., 2014), we assumed that paternal mental health problems during pregnancy would be harmful for early parenting. However, we did not find such a connection. Instead, it was fathers with mental health problems in early fatherhood, but not during pregnancy or the end of the child's first year, who showed more negative fathering experience than other fathers when the child was 2 months old. Once the child was a year old, the fathers no longer suffered mental health problems and their fathering experience was more positive. This rehabilitating course may reflect that, instead of prominent prenatal preparation, the adjustment to fathering primarily takes place in postpartum. In line with this view, Genesoni and Tallandini (2009) have suggested that the paternal prenatal image of and bonding with the foetus may actually be quite weak and much less concrete than the maternal one, due to the absent bodily connection.

Because the association between early fatherhood mental health problems and fathering experience was cross-sectional in nature, it is not possible to draw conclusions about causality. It may well be that early feelings of parenting incompetence and non-rewarding interactions lead to symptoms, or symptoms interfere with fathering tasks. With increasing adjustment to fatherhood during the child's first year, both mental health and fathering experience of these fathers improved. The result brings forth the benefit of psychological treatment on the early father–child dyadic relationship. As it appears that the amelioration of either mental health problems or negative fathering experience can positively affect the other, supporting the early father–child relationship may also reduce the effect of paternal depression on later family interaction and child development.

The Role of Former Infertility

Half of the parents in our study had experienced infertility and became pregnant through assisted reproductive treatment (ART). Conflicting views exist concerning mental health and parenting after ART. Our results correspond with those arguing for normative transition to fatherhood (Cohen et al., 2001; Colpin et al., 1999; Repokari et al., 2005), as we found similar mental health trajectory classes among ART and NC fathers. We further found that the trajectory classes similarly predicted fathering experience in ART and NC groups. The results are encouraging as they suggest that fathers' distress and negative emotions related to infertility (Burns, 2007) are relieved and balanced to normative levels once the treatment is successful and pregnancy proceeds.

Some earlier research has suggested more foetal- and child-related worry (Dunnington & Glazer, 1991) and higher parenting stress (Baor et al., 2004) among ART than NC parents. Our study partly concurs, as ART fathers reported more negative fathering experience on parenting domain, reflected in perceived lack of parenting resources. In contrast, their experiences of early dyadic interaction and infant characteristics were similar to NC fathers. The result may reflect that it takes longer to find self-assurance and parental competence after painful and frustrating experience of infertility (Dunnington & Glazer, 1991).

Limitations

Despite the relatively large sample and the longitudinal data, this study has limitations. First, we relied on self-reporting to determine fathers' mental health and parenting experience, although clinical interviews would have guaranteed more objective detection of problems. Second, challenges of including and maintaining fathers as respondents in developmental research are well-known. In our study, nearly 35% of the fathers missed at least one of the three measurement points, and drop-out rate was higher among NC than ART fathers and in families with maternal mental health problems. This may have caused bias towards optimal paternal mental health in our results. Third, as our primary interest in the latent class analysis was in detecting the unique courses of fathers' mental health, some variation in the level of symptoms was accepted within each class. Therefore, some ambiguity remains in weighting the clinical significance of the identified trajectories. Fourth, the present study sample is not nationally representative. The participants were older than the average age of new fathers in Finland and they included low levels of at-risk families. Therefore, our results can be generalized only to relatively low-risk populations.

Clinically, our findings emphasize the critical role of maternity clinics and child health centres in screening fathers, as well as mothers, for mental health symptoms. Providing help to families at multiple time-points during the pre- and postnatal period should aim at avoiding mental health problems to impair early parenting and further on child development.

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Timing of Early Maternal Mental Health and Child Cortisol Regulation†

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Maternal mental health problems can negatively impact children's physiological stress regulation. Yet, little is known of their long-term effects, especially related to the timing of maternal symptoms. We examined how maternal mental health problems during pregnancy versus in the early postpartum period predict children's cortisol levels and diurnal patterns at 10–12 years. Participants were a selection ($N = 102$) of an original sample of 805 Finnish families, who were followed from the second trimester of pregnancy (T1) to child's age of 2 months (T2) and 12 months (T3), and again at child's age of 10–12 years (T4). Based on the timing of psychological distress and depressive symptoms (T1–T3), the mothers could be assigned to three distinct mental health trajectory groups: mothers with prenatal mental health problems ($n = 15$), mothers with early postpartum mental health problems ($n = 15$) and mothers without mental health problems ($n = 72$). Children's cortisol (T4) was measured by saliva samples through five within-1-day assessments. The results show that maternal prenatal mental health problems predicted a relatively steep increase of child cortisol from awakening to 1 h later, indicating an intensified cortisol awakening response (CAR). Mothers' early postpartum mental health problems instead predicted a reduced CAR. Both maternal prenatal and postnatal mental health problems thus predicted children's later stress regulation, but in unique ways. We discuss the specific roles of direct biochemical

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effects during pregnancy and postpartum mother–infant interaction quality as modifiers of the hypothalamic–pituitary–adrenal system.

Key words: maternal mental health; prenatal anxiety; postpartum depression; child cortisol; CAR; cortisol diurnal pattern

Balanced functioning of the hypothalamic–pituitary–adrenal (HPA) axis and cortisol hormone is vital for stress adaptation. Stressful experiences in early childhood can, however, severely compromise the optimal functioning of the axis (Essex et al., 2011). Parental mental health problems constitute a substantial stress for children (Connell & Goodman, 2002), and early maternal symptoms can disturb the developing stress regulation system through prenatal biochemical and/or postnatal parenting processes (Gunnar & Donzella, 2002; Davis, Glynn, Waffarn & Sandman, 2011). Yet, little is known of the impact of the timing of maternal mental health problems on HPA axis development. Thus, our study examines the effects of maternal prenatal versus early postpartum depression and anxiety on children's cortisol levels and diurnal patterns at the age of 10–12 years.

Cortisol Dysregulation

The activation of the HPA axis serves adaptation in stressful situations by releasing the steroid hormone cortisol from the adrenal cortex. However, frequent activation can result in a permanent dysregulation of the axis, particularly when experienced during phases of rapid brain development such as prenatal period and infancy (Gunnar & Quevedo, 2007). The physiological dysregulation, in turn, is known to exert harmful effects on the functioning and development of vital brain regions such as the hippocampus, the amygdala and the frontal cortex (Carrion, Weems & Reiss, 2007; Frodl & O'Keane, 2013). Presumably mediated by the detrimental effects on the hippocampus, cortisol dysregulation can increase vulnerability to cognitive problems in learning and memory (Heffelfinger & Newcomer, 2001). Dysregulation further jeopardizes children's ability to regulate their behaviour (Luebbe, Elledge, Kiel & Stoppelbein, 2012) and emotions (Lam, Dickerson, Zoccola & Zaldivar, 2009) through non-optimal changes in frontal cortex functioning, which in turn increases the likelihood of physical and mental health symptoms (Essex et al., 2011).

Cortisol dysregulation is commonly determined by cortisol *level* in circulation, measured as a total or an average daily secretion level or as a single-point measure. Dysregulated cortisol level can indicate either hypersecretion or hyposecretion. *Hypersecretion* is suggested to be indicative of a currently stressed, hyperactive HPA (McEwen & Wingfield, 2003), whereas *hyposecretion* reflects reduced cortisol production, possibly due to more chronic stress that has caused 'exhaustment' of the mechanisms underlying HPA (Doom, Cicchetti, & Rogosch, 2014; Fries, Hesse, Hellhammer, & Hellhammer, 2005). Research among adults confirms associations between hypersecretion and acute depressive and anxiety symptoms (Gold & Chrousos, 2002), whereas chronic post-traumatic stress disorder (PTSD) has been linked with hyposecretion (Wahbeh & Oken, 2013). Among school-aged children, both early and current psychosocial stress have been found to be associated with hypersecretion (Cicchetti & Rogosch, 2001; Gustafsson, Gustafsson & Nelson, 2006), and, similar to adults, hyposecretion is associated with PTSD (Feldman, Vengrober, Eidelman-Rothman & Zagoory-Sharon, 2013). In addition, children with attention deficit hyperactivity disorder (Isaksson, Nilsson, Nyberg, Hogmark, &

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Lindblad, 2012) or disruptive behaviour disorder (Kohrt, Hruschka, Kohrt, et al. 2015) have been found to show low cortisol levels.

Cortisol secretion fluctuates greatly across day and night. Therefore, measurements of cortisol level are considered less sensitive markers of dysregulation than the measures of diurnal patterning (Sharpley, Kauter & McFarlane, 2010). *Diurnal pattern*, the hourly fluctuation in the amount of secreted cortisol throughout the day, reflects the ongoing change in the need of a person to be alert versus relaxed. In typical cortisol patterns among adults and school-aged children, the secretion is lowest around midnight and shows an intense trend upward towards morning. It reaches its peak approximately 30 min after awakening but remains elevated for at least another half an hour. This change in cortisol across the first hour after waking from sleep is called the *cortisol awakening response* (CAR) (Fries, Dettenborn & Kirschbaum, 2009). Thereafter, towards midday, afternoon and especially evening, the secretion decreases, which has been called the *diurnal cortisol decline* (DCD) (Edwards, Clow, Evans & Hucklebridge, 2001).

Dysregulated cortisol diurnal patterns typically include an intensified or a reduced CAR and/or a reduced DCD. Dysregulated patterns are suggested to be causal risk factors for mental health problems (Van den Bergh, Van Calster, Smits, Van Huffel & Lagae, 2008), as they have been found both to underlie the development of symptoms (Halligan, Murray, Martins & Cooper, 2007; Vrshek-Schallhorn et al., 2013) and, in some cases, to prevail even after the relief of symptoms (Havermans, Nicolson, Berkhof & deVries, 2011). In cross-sectional studies with adults, an intensified CAR has been found to be associated with work stress and general life stress (Chida & Steptoe, 2009), whereas a reduced CAR is known to connect with fatigue, burnout and exhaustion (Chida & Steptoe, 2009; Wessa, Rohleder, Kirschbaum & Flor, 2006). A reduced DCD has been shown to be associated with depression (Jarcho, Slavich, Tylova-Stein, Wolkowitz & Burke, 2013) and complicated grief (O'Connor, Wellisch, Stanton, Olmstead & Irwin, 2012). A study found that the combination of an intensified CAR and a reduced DCD was a common pattern in borderline personality disorder (Lieb et al., 2004). Somewhat differently, among school-aged children, an intensified CAR was found to be associated with both depression (Dietrich et al., 2013; Ulrike, Reinhold, & Dirk, 2013) and anxiety (Greaves-Lord et al., 2007), whereas a reduced CAR is known to relate with attention and conduct problems (Freitag et al., 2009). Yet, despite the associations with mental health problems, dysregulated cortisol levels and patterns are not deemed to be pathological *per se* and, due to genetic variability, it may be difficult to define clear-cut values for hypersecretion or hyposecretion (Nader & Weems, 2011).

Pregnancy and Child Cortisol Regulation

Although the foundation for stress regulation is genetically built (Young, Aggen, Prescott & Kendler, 2000), the early prenatal and postnatal development is critical in calibrating the regulatory functioning. During pregnancy, the foetal nervous system gradually matures and acquires the complex neurophysiological systems responsible for the regulation of stress, with HPA being one of them (Van den Bergh, Mulder, Mennes & Glover, 2005).

Maternal mental health during pregnancy is known to be essential for the development of the HPA in foetus (Reynolds, Labad, Buss, Ghaemmaghami & Räikkönen, 2013). Anxiety and depression can overactivate the maternal HPA, leading it to an increased or otherwise dysregulated production of cortisol (Van den Bergh et al., 2005). Normally, the majority of maternal cortisol is metabolized in

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the placenta. However, when the mother is highly stressed, this regulatory function may fail, which has negative effects on the developing foetal HPA (Sarkar, Bergman, O'Connor & Glover, 2008). In addition, the dysregulated maternal cortisol secretion can alter the foetal glucocorticoid gene expression in the amygdala, the hippocampus and the hypothalamus (Fujioka, Fujioka, Ishida, Maekawa & Nakamura, 2006; Welberg & Seckl, 2001) and thus lead to dysregulation of the foetal HPA. A further mechanism through which maternal mental health can affect foetal development is the stress-related increased maternal corticotropin-releasing hormone (CRH), which can trigger placental CRH production and lead to altered foetal neurological function (Majzoub & Karalis, 1999; Sandman, Davis, Buss & Glynn, 2011).

There is disagreement in the literature about the period of gestation in which maternal anxiety and depression are most harmful to the foetus (Glover, 2009), but the second trimester is one often suggested possibility. In line with that suggestion, maternal and foetal cortisol levels only become associated by the mid-gestation (Van den Bergh et al., 2005). Further, maternal HPA becomes markedly less responsive to stress towards late pregnancy (Sarkar et al., 2008), thus decreasing the potential for harmful effects of maternal cortisol passing to the foetus.

Several studies have reported the connection between maternal mental health problems during pregnancy and high cortisol levels in newborns and infants. For instance, the study by Field, Diego, Hernandez-Reif, Vera and Gil (2004) ($N = 92$) showed that maternal depression during the second trimester of pregnancy was associated with high maternal prenatal cortisol level (single assessment at variable times of day), and both of them predicted high cortisol levels in the newborns (single assessment after awakening). Another study among 116 dyads found that maternal prenatal stress and high cortisol level during the second and third trimesters (single assessment in the afternoon) were associated with larger cortisol responses to a physical exam in neonates (Davis et al., 2011).

In addition to the instant and short-term effects on the foetus and the newborn, maternal prenatal mental health problems are known to be deleterious to child development in the long run (Davis et al., 2011). Ample evidence shows that maternal anxiety and depression during pregnancy increase a risk for problems in child mental health (Davis & Sandman, 2012; Glover, 2009; Van den Bergh et al., 2008) and cognitive development (Sohr-Preston & Scaramella, 2006). In contrast, only a few studies have examined the effects of maternal prenatal mental health problems in predicting children's later cortisol levels or diurnal patterns. Two studies found association between maternal prenatal anxiety and adolescents' dysregulated diurnal patterns. Van den Bergh et al. (2008) showed that maternal anxiety during the second trimester predicted a combination of a low morning cortisol level (single assessment after awakening) and a reduced DCD among 14- to 15-year-olds ($N = 58$). O'Donnell et al. (2013) followed 889 mother–child dyads and found that high levels of mother's anxiety at the third trimester predicted both a reduced CAR and a reduced DCD among 15-year-olds. Further, an earlier study based on a smaller selection ($N = 74$) of children from O'Donnell et al.'s sample showed that maternal prenatal anxiety at the third trimester predicted high morning cortisol levels (single assessment after awakening) among 10-year-olds (O'Connor et al., 2005).

Early Postpartum and Child Cortisol Regulation

The daily cortisol diurnal pattern in early childhood differs to some extent from that of adults and older children (Watamura, Donzella, Alwin, & Gunnar, 2003). Although both the CAR and the DCD appear to be evident from infancy on and

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throughout childhood (Bäumler, Kirschbaum, Kliegel, Alexander, & Stalder, 2013; Gunnar & Donzella, 2002), particularly the DCD becomes more adult-like with the cessation of napping (de Weerth, Zijl, & Buitelaar, 2003). The typical levels of cortisol in both early and middle childhood are relatively low and appear to increase gradually towards the transition to adolescence (Oskis, Loveday, Hucklebridge, Thorn & Clow, 2009).

In the postpartum period, maternal mental health problems can impact the child's developing HPA through problematic mother–infant interactions and associated insecure attachments (Gunnar & Donzella, 2002). Compared to non-depressed mothers, depressed mothers are often emotionally unavailable, insensitive and unresponsive with their children (Bureau, Easterbrooks & Lyons-Ruth, 2009; Feldman et al., 2009), and their children are less likely to be securely attached (Edhborg, Lundh, Seimyr & Widström, 2003; Milan, Snow & Belay, 2009). Low maternal sensitivity and insecure attachment in turn have been associated with children's HPA dysfunction (Bernard & Dozier, 2010; Feldman et al., 2009).

A number of cross-sectional studies show associations between maternal postpartum depression and their infants' high cortisol levels (Brennan et al., 2008; Letourneau, Watson, Duffett-Leger, Hegadoren & Tryphonopoulos, 2011). Some follow-up studies show negative long-term impacts of maternal postpartum symptoms on children's HPA functioning, generally revealing elevated levels. A study followed children of mothers with postpartum depression and controls ($N = 87$) into adolescence and found high morning cortisol levels (single assessment after awakening) among offspring of depressed mothers (Halligan, Herbert, Goodyer & Murray, 2004). Another follow-up ($N = 74$) confirmed that maternal postpartum depression predicted high cortisol levels among 3-year-olds (Hessl et al., 1998), but the effect was no longer valid at 7 years (Ashman, Dawson, Panagiotides, Yamada & Wilkinson, 2002). Finally, the study by Essex, Klein, Cho and Kalin (2002) showed that maternal stress in the postpartum predicted children's high afternoon cortisol levels (single assessment) in pre-school age ($N = 282$), but only if the mothers were also concurrently stressed. Findings concerning the long-term impacts of maternal postpartum mental health problems are inconsistent as they consider varying developmental periods.

Current Study

Previous research suggests that maternal prenatal mental health problems have detrimental effects on the developing foetal and newborn HPA, which may lead to cortisol dysregulation in the long run. Further, maternal early postnatal symptoms can negatively impact the dyadic mother–child bond formation and thus expose the child to increased physiological stress. Yet, to the best of our knowledge, previous studies have not directly compared the impact of prenatal versus postpartum maternal symptoms, thus making it impossible to weigh the relative importance of both timings. As a further limitation, some of the studies have relied only on a single cortisol assessment, which excludes the possibility of examining both the level and the diurnal pattern.

Accordingly, we examine the timing of early maternal mental health problems predicting children's cortisol regulation, by comparing the effects of prenatal versus early postpartum psychological distress and depression on children's cortisol levels and diurnal patterns at the age of 10–12 years. To accomplish this, we utilize maternal mental health trajectories identified in our previous study (Vänskä et al., 2011). The trajectories depict subgroups of mothers who have experienced

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psychological distress and depression only in pregnancy (assessed at the second trimester) and only at early postpartum (child's age of 2 months) or of mothers who did not suffer early mental health problems. Such an approach allows us to directly test the specific timing impact of maternal mental health, without the confounding effects of mental health problems at other time points. We examine the maternal mental health impact on both the children's overall cortisol levels and their daily diurnal patterns, in order to reach a complete picture of the cortisol regulation and dysregulation throughout the day.

METHODS

Participants and Procedure

The original sample consisted of 805 Finnish mothers, who were participating in the study during their prepartum and postpartum periods: the second trimester of pregnancy (T1, 18–20 weeks of gestation) and when the child was 2 months (T2) and 12 months (T3) old. Fifty-two percent had undergone a successful assisted reproduction treatment (ART) with their own gametes ($N=417$) and 48% were naturally conceiving (NC) mothers ($N=388$). All the ART mothers entering the infertility clinics at years 1999–2000 in Finland were asked to participate in the study, and the NC group consisted of mothers participating in a routine ultrasound examination offered by community maternal care clinics. At each time point T1–T3, the mothers filled in questionnaires concerning their mental health and returned the questionnaires by mail.

A selection of the families ($N=102$) were recruited again when the children were 10–12 years old (T4, age $M=10.6$, $SD=0.6$). One of the selection criteria was the mothers' membership in mental health trajectory groups that were identified in our previous study (Vänskä et al., 2011), allowing the analyses for the present study. The selected families were first contacted through mail and telephone, to inquire about their willingness to participate. If a family agreed to take part, the research assistant visited their home. The ethical committees in participating clinics approved the study separately concerning the prepartum and postpartum periods (T1–T3) and the home visit assessment at T4.

The selected families ($N=102$) were representative of the original trajectories in all demographic measures: maternal education, $\chi^2(3, 645)=5.56$, $p=.08$; marital status, $\chi^2(1, 647)=3.01$, $p=.09$; parity, $\chi^2(1, 691)=0.03$, $p=.85$; number of previous marriages, $\chi^2(2, 651)=1.28$, $p=.53$; and gender of the child $\chi^2(1, 682)=0.00$, $p=.99$. Neither the age of mother, $t(657)=-1.35$, $p=.18$; nor the duration of the partnership, $t(644)=1.03$, $p=.30$; nor child's birth weight, $t(689)=-0.66$, $p=.51$; differed between the selected and non-selected families. However, the selected versus non-selected families differed according to fertility history, $\chi^2(1, 689)=5.07$, $p<.05$, as the selected families had somewhat more naturally conceiving (NC) and less ART families.

Measures

Maternal mental health trajectories

The timing of early maternal mental health problems was indicated by three maternal mental health trajectories that were identified in the original follow-up data ($N=805$) from pregnancy (T1) through 2 months (T2) and 12 months (T3) postpartum (Vänskä et al., 2011). The trajectories were based on two maternal mental health

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indicators, the psychological distress and the depressive symptoms. *Maternal psychological distress* was assessed with the 36-item General Health Questionnaire (GHQ-36) (Goldberg & Hiller, 1979), covering symptoms of depression (feelings of hopelessness and suicidal ideation), anxiety (feelings of being under constant pressure and panicking), sleeping difficulties (waking up at night and difficulties in falling asleep) and social dysfunction (feelings of inability to perform everyday tasks and social activities). Subjects estimated how the symptom descriptions matched their present state over the past weeks on a Likert scale (from 1 = *not at all* to 4 = *much more than usually*). *Maternal depressive symptoms* were measured by a shortened version of Beck's Depression Inventory (BDI-13) (Beck, Ward, Mendelsohn, Mock & Erlaugh, 1961), consisting of 13 descriptions of low mood, hopelessness and somatic signs of depression. Participants estimated their symptoms using a Likert scale (from 0 = *symptom not present* to 4 = *symptom present most of the time*).

In the previous study, we analysed the original data with the MPLUS 5 factor mixture modelling (Muthén, 2001). It identifies naturally occurring subpopulations from the data, called latent classes, and provides statistical tests to evaluate the number of these classes. The identification of trajectories was based on the differences in mean values of the observed variables (GHQ-36 and BDI-13) in latent classes. To avoid identifying an artificially high number of latent classes, due to highly correlating variables, we added a level factor with loadings fixed at one to indicate the individual variation in the level of symptoms across T1–T3 (Lubke & Neale, 2006). Figure 1 presents this factor mixture analysis design.

The analysis identified five mental health trajectories: (I) mothers without early mental health problems (75%, $n = 609$), (II) mothers with prenatal mental health problems (6%, $n = 47$), (III) mothers with early postpartum mental health problems (9%, $n = 70$), (IV) mothers with late postpartum mental health problems (6%, $n = 45$) and (V) mothers with heterogeneous high levels of mental health problems (4%, $n = 34$). For the present study, three maternal mental health trajectories were chosen, and they are presented in Figure 2. The choice of the three trajectories is due to both theoretical and practical reasons. The prepartum and postpartum trajectories were considered the best in analysing the timing effects, because the available literature provides hypotheses for distinct mechanisms (Brand & Brennan, 2009; Sohr-Preston & Scaramella, 2006). The trajectory of mothers without early mental health problems was necessary as a reference group. Practically, as the sample size was limited, focusing on the three largest trajectories made it possible to reach sufficient group sizes.

Thus, the maternal mental health trajectory groups in this study are as follows: *mothers without early mental health problems* ($n = 72$), who reported low levels of symptoms of psychological distress and depression throughout the pregnancy and postpartum periods; *mothers with prenatal mental health problems* ($n = 15$), who reported clinically significant mental health problems in pregnancy that then decreased to low or moderate levels in the early postpartum and remained fairly stable until the late postpartum; and finally, *mothers with early postpartum mental health problems* ($n = 15$), who showed a clinically significant peak in mental health symptoms in the early postpartum, when the child was 2 months old. On the contrary, in pregnancy as well as in the late postpartum, their symptom levels were relatively low.

Children's cortisol

At T4, when the children were 10–12 years, the research assistant visited families' homes, explaining the details of the project and training the parents and

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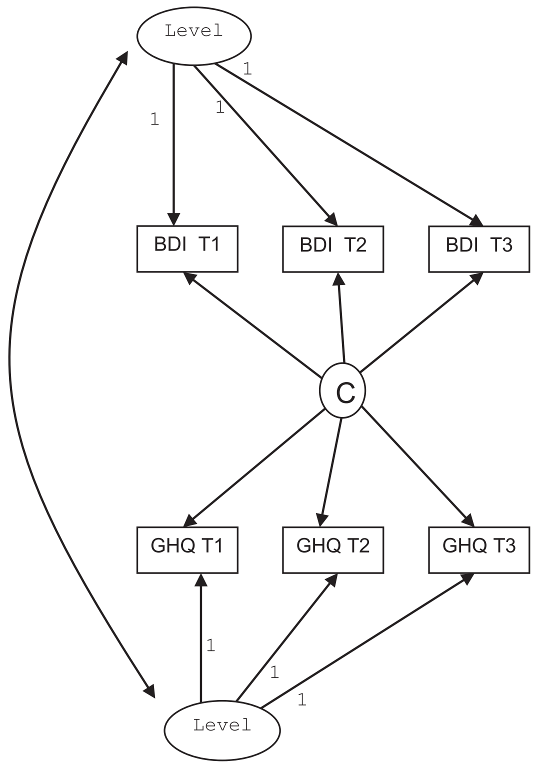

Figure 1. Factor mixture analysis design of maternal mental health in transition to parenthood.

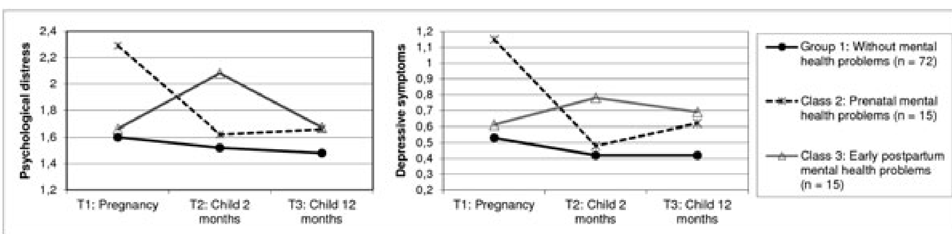

Figure 2. GHQ-36 and BDI-13 means in pregnancy and at 2 and 12 months postpartum according to maternal mental health trajectory group in the original data ($N = 805$).

children to collect the salivette samples. They collected the samples (C1–C5) five times during a regular school day (Tuesday, Wednesday or Thursday): immediately after awakening (C1), 30 min after awakening (C2), 1 h after awakening (C3), after returning from school in late afternoon (C4) and before going to sleep in the evening (C5).The salivette sampling tube consisted of a plastic sampling vessel with a suspended insert containing a sterile neutral cotton wool swab. The children were instructed to chew the swab for about 1 min and then to return it to the insert. The parents and children filled up together a structured diary concerning

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the exact time of taking each saliva sample. The five samples were kept refrigerated until the following day, when a research assistant came to get the samples and took them to the Helsinki University Central Hospital laboratory.

Salivette tubes were first centrifuged at 1000 *g* for 2 min to extract the saliva and then frozen. The samples were stored at −20°C until analysed. After thawing, the samples were extracted with dichloromethane. The phases were separated by centrifugation, and the lower organic phase was transferred to a conical tube and dried under nitrogen. Thereafter, cortisol was analysed by a relatively novel and sensitive method of liquid chromatography-tandem mass spectrometry, operating in the negative-mode electrospray ionization after separation on a reversed-phase column (Turpeinen, Välimäki, & Hämäläinen, 2009).

Salivary cortisol concentrations reflect the biologically active serum cortisol concentrations. The salivary concentrations of cortisol are in the low nanomolar range, and therefore, sensitive cortisol assays are required. The method applied was able to utilize as little as 0.1 mL of saliva. The lower limit of quantification was 0.070 nmol/L (Turpeinen et al., 2009). Children's cortisol values ranged between 0.1 and 17.7 nmol/L. Examination of the cortisol values identified one outlier case, whose scores were over 4 *SD* above the mean at each time point. The outlying values were rescored at 2 *SD* above the means and then included in the analyses. The family was contacted to check the child's somatic health. The number of children available for individual cortisol assessments ranged in different time points from 99 to 102, and 96 children had cortisol values for all five time points.

Child health and saliva collection-related events

Because cortisol levels vary according to chronic and transient illnesses, and major and daily stressful events (Bakkeheim, Mowinckel, Carlsen, Burney & Lødrup Carlsen, 2010; Kelly, Young, Sweeting, Fischer & West, 2008), children and parents filled up together a 13-item questionnaire on these issues. Seven items referred to *somatic health* (e.g. allergy, chronic illness and regular medication), three to *severe stress* (e.g. severe loss or accident during the last 6 months) and three indicated *stress during the very saliva collection day* (e.g. unusually exciting things that happened at the collection day). The response alternatives were yes/no. Earlier, at child's age of 7–8 years, parents had also reported by an open question on whether their child suffered any major illness or medical conditions. Their answers were categorized as 0 = *no illness*, 1 = *asthma*, 2 = *allergy*, 3 = *ordinary children's disease* and 4 = *severe or chronic illness*.

Maternal and child mental health

Maternal and child mental health were assessed at child's age of 7–8 years. *Maternal psychological distress* was indicated by GHQ-36 scores (Goldberg & Hiller, 1979). *Child internalizing and externalizing symptoms* were assessed by four scales (anxiety, depression, somatization and aggression) of the Parent Rating scales for the children component of the Behavior Assessment System for Children (Reynolds & Kamphaus, 1992) as well as one scale (attention) of parental questionnaire Five to Fifteen (Kadesjö et al., 2004).

Statistical Analyses

The missing cortisol values were imputed using the expectation maximization algorithm implemented in SPSS. All cortisol variables (C1–C5) were highly skewed, and a satisfactory normal distribution was not reached even with logarithmic

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transformations. Therefore, non-parametric methods with non-transformed values were used to examine how the timing of early maternal mental health was associated with children's cortisol levels and diurnal patterns.

Concerning the maternal mental health trajectories predicting children's cortisol *levels*, we used a median test to examine whether children from different trajectory groups (I–III) differed either in their average daily cortisol level or in cortisol levels measured at each individual time point (C1–C5). As *post hoc* tests, we used Mann–Whitney's *U*-tests to determine which pairs of the maternal mental health trajectory groups differed from each other.

Concerning the maternal mental health trajectories predicting children's cortisol *diurnal patterns*, we first analysed the daily diurnal patterns separately *within* each trajectory group. Friedman's test was used as an omnibus test to examine whether cortisol values fluctuated across the daily time points within each trajectory. As *post hoc* tests, we used Wilcoxon's signed-rank tests to examine the differences between each pair of consecutive daily time points (C1 versus C2, C2 versus C3, C3 versus C4 and C4 versus C5).

To examine the diurnal patterns further, we compared children's cortisol value difference scores *between* the trajectories using the median test. Cortisol value difference scores were computed between pairs of consecutive time points (i.e. C2–C1, C3–C2 and C4–C3). Further, to compare the overall change within the CAR, we computed a *CAR difference score* from awakening to 1 h after awakening (C3–C1), and to compare the change within diurnal cortisol decline, we computed a *DCD difference score* from afternoon to evening (C5–C4). As *post hoc* tests, we used Mann–Whitney's *U*-tests to determine which trajectory groups differed from each other in difference scores.

RESULTS

Descriptive Statistics

Table 1 shows the associations between the maternal mental health trajectories and relevant family background variables. Results show that former infertility was not associated with the level and timing of early maternal mental health problems, as the ART and NC groups did not differ statistically significantly in the distribution of mental health trajectories. Of demographic factors, only mothers' education was significantly associated with the trajectory membership. The mothers without mental health problems were more educated as compared with the mothers with prenatal mental health problems, $Z = -2.21$, $p < .05$. The trajectory groups did not differ in parental marital status, number of previous marriages or cohabiting partnerships, gender of the child or parity. Neither did the age of mother, $F(2, 104) = 1.23$, *ns*; the duration of the partnership, $F(2, 104) = 0.73$, *ns*; child's age, $F(2, 104) = 0.10$, *ns*; and child's birth weight, $F(2, 104) = 0.05$, *ns*; differ between the groups.

Table 2 reports the maternal mental health trajectory groups according to child somatic health, child stressful events, child and maternal mental health and the average times of the cortisol sampling. The three trajectory groups differed neither in child's recent somatic health and stressful events nor in the occurrence of major illness and medical complaints at the child's age of 7–8 years, $\chi^2 = 1.68$, $p = .28$. Further, the trajectories were similar according to child and maternal mental health at the child's age of 7–8 years. Children's awakening times ranged between 5:40 and 8:40, the average time being 6:54 ± 0.29, and children compliantly followed the next 0.5- and 1-h assessments. The afternoon saliva assessment varied between

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Table 1. Family background variables according to maternal mental health trajectory group ($N = 102$)

	I: Mothers without mental health problems ($n = 72$)		II: Mothers with prenatal mental health problems ($n = 15$)		III: Mothers with postpartum mental health problems ($n = 15$)		
	%	n	%	n	%	n	χ^2 (df)
Fertility history							0.45 (2)
ART	57.5	34	56.2	6	56.2	7	
NC	42.5	39	43.8	10	43.8	9	
Education (mother)							21.72* (6)
High professional	47.9	35	31.2	5	31.2	5	
Low professional	38.4	28	25.0	4	62.5	10	
Skilled worker	12.3	9	18.8	3	6.2	1	
Unskilled worker	1.4	1	25.0	4	0.0	0	
Marital status							1.37 (2)
Married	68.5	50	56.2	9	75	12	
Cohabitant	31.5	23	43.8	7	25	4	
Previous marriages/ cohabiting partnerships							4.55 (4)
None	65.8	48	75.0	12	87.5	14	
One	26.0	19	12.5	2	12.5	2	
Two or more	8.2	6	12.5	2	12.5	0	
Child's gender							0.51 (2)
Boy	46.6	34	50.0	8	56.2	9	
Girl	53.4	39	50.0	8	43.8	7	
Parity							0.02 (2)
Primiparous	57.5	42	56.2	9	56.2	9	
Multiparous	42.5	31	43.8	7	43.8	7	

*$p < .05$.

13:50 and 16:40, the average time being 15.07 ± 0.23. Finally, children's bedtime assessment varied between 20:00 and 22:40, the average being 21:13 ± 0.33. The mental health trajectory membership was not associated with the timing of the saliva collection, $F_{\text{Wilks lambda}}(10, 184) = 1.35$, $p = .20$.

We also tested, whether the *cortisol values* were associated with child's gender and age, family's fertility history (ART versus SC), maternal education, maternal and child mental health at child's age of 7–8 years or the timing of saliva collection. All associations were non-significant (p's ranging between .09 and .66), and these possible confounders were thus not considered in the analyses.

Differences between Trajectories in Children's Cortisol Levels

Results showed no differences between trajectories in the average daily cortisol levels ($Mdn = 3.44$ for children of mothers without mental health problems, $Mdn = 3.34$ for children of mothers with prenatal mental health problems and $Mdn = 3.32$ for children of mothers with early postpartum mental health problems). Cortisol levels differed, however, in some single-point measures. As Figure 3 and the group medians in Table 3 show, children's cortisol levels differed between

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Table 2. Child somatic health, child stressful events, child and maternal mental health and timing of the saliva sampling according to maternal mental health trajectory group ($N = 102$)

	I: Mothers without mental health problems ($n = 72$)		II: Mothers with prenatal mental health problems ($n = 15$)		III: Mothers with postpartum mental health problems ($n = 15$)		
	%	n	%	n	%	n	x^2 (df)
Child somatic health at 10–12 years							
Eczema							5.19 (3)
Yes	16.9	11	0	0	0	0	
No	83.1	54	100	12	100	15	
Allergy							3.14 (3)
Yes	18.5	12	33.3	4	6.7	1	
No	81.5	53	66.7	8	93.3	14	
Chronic illness							3.20 (3)
Yes	10.9	7	0	0	0	0	
No	89.1	57	100	12	100	15	
Regular medication							1.29 (3)
Yes	4.6	3	0	0	0	0	
No	95.4	62	100	12	100	15	
Antibiotic medication (past 2 weeks)							0.85 (3)
Yes	3.1	2	0	0	0	0	
No	96.9	63	100	12	100	15	
Influenza (past 2 weeks)							1.81 (3)
Yes	1.5	1	0	0	93.3	14	
No	98.5	64	100	12	6.7	1	
Child stressful events at 10–12 years							
Severe loss (past 6 months)							1.46 (3)
Yes	9.1	6	8.3	1	0	0	
No	90.9	60	91.7	11	100	15	
Accident (past 6 months)							1.81 (3)
Yes	1.5	1	0	0	6.7	1	
No	98.5	64	100	12	93.3	14	
Severe stress (past few months)							2.42 (3)
Yes	10.8	7	25.0	3	6.7	1	
No	89.2	58	75.0	9	93.3	14	
Taxing exam at the day of the saliva collection							1.12 (3)
Yes	6.2	4	8.3	0	0	0	
No	93.8	61	91.7	11	100	15	
Demanding things at the day of the saliva collection							0.42 (3)
Yes	1.5	1	0	0	0	0	
No	98.5	64	100	12	100	15	
Unusually exiting things at the day of the saliva sampling							1.70 (3)

(*Continues*)

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Table 2. (Continued)

	I: Mothers without mental health problems ($n = 72$)		II: Mothers with prenatal mental health problems ($n = 15$)		III: Mothers with postpartum mental health problems ($n = 15$)		
	%	n	%	n	%	n	x^2 (df)
Yes	12.3	8	0	0	13.3	2	
No	87.7	57	100	12	86.7	13	
Child mental health at 7–8 years							$F(df)$
Internalizing symptoms[a]	1.47	.23	1.44	.21	1.52	.16	.68 (2, 78)
Externalizing symptoms[b]	1.54	.27	1.63	.43	1.60	.21	.56 (2,81)
Maternal mental health when child 7–8 years							$F(df)$
Psychological distress (GHQ-36)	1.57	.31	1.67	.21	1.78	.48	2.42 (2, 83)
Timing of saliva collection							$F(df)$
At awakening	6:52	0:28	6:47	0:35	7:05	0:31	1.54 (2, 102)
30 min after awakening	7:23	0:28	7:18	0:36	7:35	0:31	1.38 (2, 102)
1 h after awakening	7:53	0:27	7:50	0:35	8:06	0:31	1.36 (2, 102)
Afternoon	15.07	0:26	15.00	0:17	15:19	0:31	2.25 (2, 102)
Before going to sleep	21:16	0:33	21:08	0:37	21.09	0:27	0.50 (2, 102)

[a]Mean score sum variable of *anxiety*, *depression* and *somatization* scales of Behavior Assessment System for Children (BASC) (Reynolds & Kamphaus, 1992).
[b]Mean score sum variable of *aggression* scale of BASC and *attention* scale of parental questionnaire Five to Fifteen (Kadesjö et al., 2004).

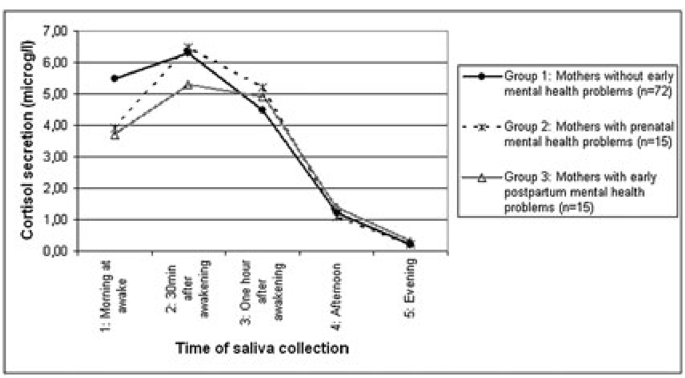

Figure 3. Children's cortisol value (µg/L) medians according to early maternal mental health trajectory group in the present subsample.

maternal mental health trajectories at awakening, C1: $\chi^2 = 9.74$, $p < .01$, and at 30 min after awakening, C2: $\chi^2 = 8.72$, $p < .05$. Pairwise comparisons revealed that at awakening (C1), children of mothers with prenatal mental health problems had lower cortisol levels than children of mothers without mental health problems, $p < .05$, while at 30 min after awakening (C2), children of mothers with prenatal mental health problems had higher cortisol levels than children of mothers with

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Table 3. Children's Cortisol Medians, Means and Standard Deviations According to Maternal Mental Health Trajectory Group (N = 102)

		I Mothers without mental health problems (n = 72)	II Mothers with prenatal mental health problems (n = 15)	III Mothers with early postpartum mental health problems (n = 15)
Children's cortisol values (μg/L)				
C1: Awake	Median	5.50	3.90	3.70
	M	5.67	4.36	4.37
	SD	5.48	2.16	2.19
	$W_{\text{C1 vs. C2}}$	−3.75***	−2.84**	−1.67
C2: 30 min after awakening	Median	6.30	6.50	5.20
	M	7.29	7.13	5.73
	SD	4.45	2.25	2.46
	$W_{\text{C2 vs. C3}}$	−4.66***	−3.13**	−1.08
C3: One hour after awakening	Median	4.50	5.20	4.90
	M	5.52	5.17	5.00
	SD	5.01	1.59	2.20
	$W_{\text{C3 vs. C4}}$	−6.68***	−3.41**	−2.61**
C4: Late afternoon	Median	1.20	1.10	1.40
	M	1.74	1.51	2.05
	SD	2.18	1.02	2.01
	$W_{\text{C4 vs. C5}}$	−6.41***	−3.33**	−2.62**
C5: Evening	Median	0.20	0.20	0.30
	M	0.75	0.35	0.80
	SD	1.82	0.57	1.92

**p < .01, ***p < .001
Note. *W* refers to Wilcoxon signed-ranked post-hoc test, indicating whether the ranked means differ between consecutive daily time points.

early postpartum mental health problems, $p < .05$. This suggested that the increase of cortisol from awakening to 30 min after awakening was steeper among the children of mothers with prenatal mental health problems as compared to the trajectories of mothers with early postpartum mental health problems and those without mental health problems. In contrast, the individual cortisol levels at 1 h after awakening (C3), the afternoon (C4) and the evening (C5) did not differ between the trajectory groups.

Children's Diurnal Cortisol Patterns within Trajectories

The results showed that children's cortisol secretion fluctuated across the day within each of the three trajectory groups: children of mothers without mental health problems, $\chi^2 = 228.07$, $p < .001$; children of mothers with prenatal mental health problems, $\chi^2 = 53.87$, $p < .001$; and children of mothers with postpartum mental health problems, $\chi^2 = 39.30$, $p < .001$. As Table 3 presents, pairwise analyses showed that among children of mothers without mental health problems, cortisol

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increased from awakening (C1) to 30 min after awakening (C2) and decreased thereafter towards 1 h after awakening (C3), at late afternoon (C4) and in the evening (C5). A similar diurnal pattern was found among children of mothers with prenatal mental health problems. In contrast, among children of mothers with early postpartum mental health problems, there was no change in cortisol from awakening (C1) to 30 min after awakening (C2) or from 30 min after awakening (C2) to 1 h after awakening (C3). Yet, similar to prenatal and non-mental health problem trajectories, there was a decrease of cortisol from 1 h after awakening towards late afternoon (C4) and evening (C5) in the early postpartum trajectory group. This suggested a reduced CAR among the children of mothers with early postpartum mental health problems, whereas mothers' early mental health problems were not associated with children's DCDs.

Differences between Trajectories in Children's Cortisol Diurnal Patterns

As the median tests in Table 4 show, cortisol difference scores of the pairs of consecutive time points (C2–C1, C3–C2, C4–C3), including the DCD difference score (C5–C4) did not differ between the maternal mental health groups. However, the CAR difference score from awakening to 1 h after awakening (C3–C1) differed between the groups. As shown in Table 4, pairwise comparisons revealed that the difference occurred between the children of mothers with prenatal mental health

Table 4. Children's Cortisol Difference Score Medians, Means and Standard Deviations According to Maternal Mental Health Trajectory Group (N = 102).

Children's cortisol value (μg/L) difference score		I Mothers without mental health problems (n = 72)	II Mothers with prenatal mental health problems (n = 15)	III Mothers with early postpartum mental health problems (n = 15)	Median test $\chi^2(2)$	Pairwise analyses[c]
C2-C1	Median	1.40	3.00	1.10	4.33	
	M	1.43	2.77	1.37		
	SD	3.00	2.49	3.30		
C3-C2	Median	−1.80	−1.40	.00	2.23	
	M	−1.87	−1.97	−0.73		
	SD	3.02	1.94	2.14		
C4-C3	Median	−3.1	−3.50	−3.10	3.83	
	M	−3.54	−3.66	−2.95		
	SD	3.44	2.03	3.66		
C3-C1[a]	Median	−1.1	1.30	.30	8.00*	I < II
	M	−0.43	0.81	.63		
	SD	3.61	2.41	3.56		
C5-C4[b]	Median	−.80	−.90	−1.10	0.89	
	M	−.99	−1.14	−1.26		
	SD	1.30	1.06	2.51		

*p < .05 *Note*. C1 = awakening cortisol, C2 = cortisol 30 minutes after awakening, C3 = cortisol one hour after awakening, C4 = late afternoon cortisol, and C5 = evening cortisol.
[a]CAR difference score representing the overall change within the cortisol awakening response.
[b]DCD difference score representing the change within the diurnal cortisol decline.
[c]Pairwise analyses referring to Mann-Whitney's U-tests.

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problems and the children of mothers without mental health problems. As depicted in Figure 3, the children of mothers with prenatal mental health problems showed an increase in CAR from C1 to C3, whereas the children of mothers without mental health problems showed a decrease in CAR from C1 to C3.

Discussion

We analysed the role of the timing of early maternal mental health problems in child's later stress regulation, by comparing the effects of prenatal versus early postpartum maternal symptoms on children's cortisol levels and diurnal patterns at the ages of 10–12 years. Results revealed that maternal depression and anxiety both during pregnancy and in the early postpartum period were associated with children's later stress regulation, but in different ways. Mother's prenatal problems seemed to influence the child's cortisol diurnal pattern towards an intensified awakening response (CAR), whereas maternal problems in the early postpartum period were associated with a reduced CAR.

The intensified CAR among the children of mothers with prenatal mental health problems was indicated by a combination of a relatively low cortisol level immediately after awakening and a relatively high level at 30 min after awakening. Further, the CAR pattern from awakening to 1 h after awakening showed an upward trend in the prenatal problems' group, while in the non-mental health problems group, the trend was downward. As far as we are aware, only one prior study has analysed the effect of maternal prenatal mental health on children's CARs. Contradictory to our findings, the study reported reduced CARs among adolescents (15-year-olds) of mothers with prenatal anxiety (O'Donnell et al., 2013). Two other available studies on maternal prenatal anxiety and children's later cortisol levels show contradictory results based on a single assessment right after awakening. In line with our results, Van den Bergh et al. (2008) reported low levels among adolescents, while O'Connor et al. (2005) reported high levels among 10-year-olds.

We found a reduced CAR among children of mothers with early postpartum mental health problems, indicated by statistically non-significant difference between cortisol levels from awakening to 30 min after awakening and further to 1 h after awakening. Previous studies, based on a single assessment after awakening, have reported high morning cortisol levels among pre-school-aged (Hessl et al., 1998) or adolescent (Halligan et al., 2004) children of mothers with postpartum depression. We are unaware of studies on maternal postpartum mental health effects on children's CARs. The discrepancies between the present and earlier studies are not easy to explain because of the different research settings (single measure versus diurnal pattern) and because the determinants and functions of the CAR are not yet fully understood (Law, Hucklebridge, Thorn, Evans & Clow, 2013).

Cortisol awakening response, the change in cortisol that occurs during the first hour after waking from sleep, is believed to be a sensitive, distinctive and fairly independent indicator of HPA function or dysfunction (Fries et al., 2009). Current theory suggests that it serves to mobilize resources to meet the perceived demands of the upcoming day (Chida & Steptoe, 2009). CAR has been found to be associated with several psychosocial factors. Whereas an intensified CAR appears to be associated with current stress and bodily overactivation, a reduced CAR is more often found in states of burnout and exhaustion (Chida & Steptoe, 2009). Depression, in turn, has been found to relate to both intensified (Vrshek-Schallhorn et al., 2013) and reduced (Stetler & Miller, 2005) CARs among adults. Researchers emphasize the nature and intensity of the distress, suggesting that intensified

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awakening response is typical in milder and more transient experiences of distress, while the reduced CAR underlies more chronic stress resulting in exhaustion (Fries et al., 2005). In relation to our results, this suggests that the alterations in CAR among children of mothers with early postpartum mental health problems would perhaps be more chronic and severe in nature, as compared to the alterations among children of mothers with prenatal problems.

From the child's perspective, it differs whether the mother suffers from mental health problems only prenatally or during the early postpartum period. In pregnancy, there are biochemical effects of maternal cortisol that modify the developing foetal HPA (Sarkar et al., 2008; Van den Bergh et al., 2005). Our study suggests that the alterations are towards steeper activation of the HPA in the morning, depicted by relatively low cortisol levels at awakening and followed by a sharp increase towards 30 min and 1 h after awakening. In line with previous studies (O'Connor et al., 2005; O'Donnell et al., 2013; Van den Bergh et al., 2008), our study suggests that the impact of maternal prenatal depression and anxiety is long-lasting in nature, as the alterations were evidenced in middle childhood. Interestingly, more current maternal mental health was both similar between the trajectory groups and unconnected with children's cortisol, which highlights the importance of the early development.

In the postpartum period, the maternal mental health impact on child's HPA occurs via dyadic interaction (Gunnar & Donzella, 2002). During the first few months, patterns of interaction are established between the mother and the infant, mainly through maternal touch and voice, as well as her gestures and gaze towards the baby (Crockenberg & Leerkes, 2000; Feldman et al., 2009). In optimal interaction, the mother reinforces the infant's positive affects and actively soothes and relieves his/her distress (Bernier, Carlson, & Whipple, 2010). If the mother suffers from mental health problems, her ability to regulate the infant's affective states may be compromised. Anxious and depressed mothers show intrusive or withdrawing behaviours that do not match the infant's emotional state and regulatory needs (Bureau et al., 2009; Feldman et al., 2009), thus leaving the infant alone to struggle with overwhelming arousal. Without maternal co-regulation, the child's early attempts to self-regulate strain the young body's developing stress physiology, causing HPA overactivity (Feldman et al., 2009). If this becomes a stable pattern, the axis might, over time, get exhausted and result in dampening of the responses (Fries et al., 2005). Thus, one possible mechanism explaining the child's reduced CAR in middle childhood may relate to the timing of maternal mental health problems into the early months, which has interfered with the earliest forms of child emotion regulation.

Unlike the effects on CAR, children's average daily cortisol level was unaffected by early maternal mental health. In other words, children in all three maternal mental health groups had similar cortisol levels, when analysed as one value presenting the average cortisol production of the day. Critics have remarked that single assessments as well as general cross measures of cortisol may be insensitive markers of HPA vulnerability, due to not taking account of the diurnal variability (Sharpley et al., 2010). Our study is in line with this view.

Limitations

The study had a longitudinal data setting and provided the possibility to compare distinct effects of either prenatal or postnatal maternal symptoms on several aspects of child cortisol regulation. Yet, the study has limitations. First, the

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maternal groups with prenatal and postnatal mental health problems were both small (each $n = 15$), which led to only moderate statistical power and prevented us from directly comparing nonlinear differences between the groups. Further research with larger samples and more advanced modelling of the daily diurnal cortisol patterns with trajectory setting is thus needed. Second, we were unable to include mothers with mental health problems during the later postpartum period, which limits the generalizability of our findings. Third, maternal mental health was assessed through self-reports, although clinical interviews would have guaranteed a more accurate detection of the problems. Fourth, although we measured children's cortisol at five time points throughout 1 day, we were unable to collect samples across several days. Studies show that the day-to-day variation in children's cortisol levels can be marked (Hruschka, Kohrt & Worthman, 2005), particularly among children of mothers with early mental health problems (Halligan et al., 2004, 2007). Our results need to be interpreted with caution, as they depict only 1-day diurnal levels of children's cortisol excretion. Fifth, our cortisol assays can be criticized for not being run for duplicate. Luckily, the analysis method that we used has been shown to be both sensitive and reliable (Turpeinen et al., 2009). Sixth, the seasonal change in the amount of daily light in Finland is substantial, which can have an impact on the cortisol secreted at different times of the year (Persson et al., 2008). Yet, we controlled the effect of seasonal change by collecting all saliva samples during the dark winter months (late October–early March) and tested that the month and day of the saliva sampling were independent of the maternal trajectory group. Finally, several other possible confounders were not included. In particular, we were unable to control the mother–child relationship quality or children's cortisol levels before middle childhood. Children's early dysregulated cortisol patterns are likely to have occurred more frequently in families with maternal mental health problems during the prepartum and postpartum periods.

In summary, our findings suggest that both prenatal and postnatal maternal mental health problems are connected with children's later cortisol diurnal patterns, but in different ways. Maternal prenatal symptoms were associated with a relatively steep increase of cortisol from awakening to 1 h later, while a reduced CAR was evidenced among children of mothers with early postpartum symptoms. The different associations might relate to the idea that there are non-optimal biochemical effects during pregnancy that modify the HPA system towards more alertness and responsiveness, whereas problems in mother–infant interaction in the postpartum signify exhaustion in the HPA axis. The signs of exhaustion and burden in the HPA system are possibly due to the harmful effects of maternal depressive or anxiety symptoms on early attachment relationship and child emotional regulation. Specific attention should be paid that not only maternal early postpartum mental health symptoms are adequately treated but also that the mother and the child receive support for the development of their dyadic relationship, if difficulties emerge. Screening and treatment of maternal and dyadic problems can help prevent their harmful effects on later child development and, as suggested by this study, particularly stress physiology.

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