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The consequences of miscarriage on parental investments

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The Consequences of Miscarriage on Parental Investments[1]

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Pregnancy loss is often a traumatic event which may impact both parents and subsequent children. Using Norwegian registry data, we exploit the random nature of single, early miscarriages to examine the impact of pregnancy loss on parental investment and family outcomes. We find that pregnancy loss improves maternal health investments in the subsequent pregnancy regarding supplement use, smoking, preventative healthcare, and physician choice. While a miscarriage negatively affects labor market attachment, it has limited effects on children born after the loss. This suggests that investment in the next pregnancy may offset the negative consequences of stress associated with pregnancy loss.

JEL Classification: *JEL I12, J13*

Keywords: *Miscarriage, parental investment, healthcare use, household labor supply*

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There is a burgeoning economics literature on shocks and investment during pregnancy and early childhood. Negative prenatal shocks, such as malnutrition, natural disasters, radiation, and parental death, are often associated with poorer cognitive, behavioral, and educational outcomes, with lasting effects into adulthood (see reviews in Currie and Almond 2011 and Almond, Currie, and Duque 2018). A common, yet under-examined shock is pregnancy loss; an often traumatic ending to about 15 percent of recognized pregnancies, with an estimated 23 million losses occurring annually (Farren et al. 2020; Quenby et al. 2021).[2] A miscarriage is defined as the involuntary termination of a fetus before the 23rd week of pregnancy, however, most miscarriages occur within the first 12 weeks. The majority of early pregnancy losses arise from random chromosomal abnormalities that affect the viability of the fetus (Larsen et al. 2013).[3] Although employed in the economics literature as an exogenous shock to birth timing and maternal outcomes (e.g., Hotz, McElroy, and Sanders 2005; Miller 2011; Buckles and Munnich 2012), pregnancy loss is rarely considered a shock that may impact the long-term outcomes of parents and subsequent children.[4]

Using the universe of children born in Norway between 2006 and 2018, this is the first study to investigate the impact of pregnancy loss on parental investment in the next pregnancy and subsequent children's birth and health outcomes. We also examine parental health, physician choice, and labor market outcomes during the subsequent pregnancy. While most pregnancy losses are random (85-90 percent), it is estimated that up to 10 or 15 percent are driven by individual risk factors such as previous pregnancy loss, assisted conception, high parental age, low BMI, substance use, persistent stress, and some disorders and chronic diseases (García-Enguídanos et al. 2002; Maconochie et al. 2007). We address this non-random component in several ways. First, we focus on mothers who experience a maximum of one miscarriage in the first trimester as there is evidence that multiple and late pregnancy losses may be indicative of underlying health issues (Linehan et al. 2019) which may affect parental and child outcomes.

[2] Pregnancy loss is alternatively labelled miscarriage or spontaneous abortion. In this paper we use the terms pregnancy loss and miscarriage interchangeably. While rates vary, it is reported that ~15 percent of clinical recognized pregnancies end in miscarriage. In addition, it is estimated that undetected pregnancy loss occurs at a further rate of 8 to 22 percent. Statistics on recognized miscarriage may be prone to under-reporting where home-managed losses are unobserved, so an estimation of home managed losses are included in our figures (Everett 1997).

[3] A chromosome abnormality is a missing, extra, or irregular portion of chromosomal DNA.

[4] Two recent studies have examined the consequences of miscarriage for mothers. The first by Rellstab, Bakx, and Garcia-Gomez (2022) using data from the Netherlands finds that early pregnancy losses increase the use of mental health services in the year the miscarriage took place, but there are no impacts on labor market outcomes. The second by Kalsi and Liu (2022), uses the NLSY97 data and a fixed effects model to show that pregnancy loss is associated with a fall in labor supply up to seven years after the loss, and a reduction in income of ~$5,000.

Second, we adopt two estimation strategies. Using OLS conditional on known risk factors, we compare the outcomes of families who experience a pregnancy loss prior to the birth of their first child to those who did not experience a loss prior to their first birth. Then, to address potential omitted-variable bias, we restrict our sample to families with two children and compare those who experienced a pregnancy loss between the two births to those who did not. Thus, in an approach similar to Currie and Schwandt (2013), we examine differences in the outcomes of siblings and thus account for fixed maternal characteristics that may be associated with parent and child outcomes and the risk of pregnancy loss. The fixed effect results may provide a lower bound as such parents know they can carry a child to term and therefore may be less affected by a pregnancy loss compared to parents who have never had a child (OLS sample). In addition, as we focus on subsequent pregnancies and children, by design, our analysis excludes those who select out of parenthood or never carry a child to term. Thus, to be included in our sample, parents must have a subsequent birth. Yet the majority of women who have a miscarriage go on to have a successful birth (82% in our sample).[5]

A potential mechanism through which pregnancy loss may impact parent and child outcomes is via changes in maternal investment in the subsequent pregnancy. Fear of recurrent pregnancy loss may result in heightened stress and anxiety (Geller, Kerns, and Klier 2004; Fertl et al. 2009) which induces mothers to change their level of investment in later pregnancies (for a review, see Lee, McKenzie-McHarg, and Horsch 2017). It is estimated that 20 percent of women who experience a pregnancy loss develop some form of depression and/or anxiety, with symptoms still evident for up to three years (see review in Nynas et al. 2015). In addition, 50 to 60 percent of women become pregnant again within 12 months of experiencing a loss (Lamb 2002), thus for many women, the loss is still salient at the time of the next pregnancy. As a result, mothers may invest more or less in the subsequent pregnancy.

Potentially, mothers could decrease or delay their investment if uncertainty around the outcome of the pregnancy drives ambivalence and detachment toward the fetus (Christiansen 2017). In particular, women may detach themselves from the pregnancy in the early stages as a protection mechanism against experiencing further grief if they miscarry again. Indeed, there is some

[5] Note that we technically rely not only on the randomness of miscarriages conditional on observables, but also on the randomness of mothers selecting into our sample of subsequent pregnancies conditional on observables. The 18 percent of women we observe who have a single medically assisted miscarriage and do not show up in our sample of subsequent births are older, less likely to be married, and less likely to have a college education compared to our sample of women who experience a miscarriage and go on to have a subsequent birth. We control for these characteristics in our regressions.

evidence that maternal-fetal attachment is lower in pregnancies following a loss, particularly before the week of gestation at which the previous loss occurred (Franche and Mikail 1999). There is also some suggestive evidence that parents delay announcing and seeking medical care for the subsequent pregnancy (Ney et al. 1994) and feel less emotional attachment (Robertson and Kavanaugh 1998), although these findings are based on small sample studies. There is also evidence that those with mental health difficulties invest less in their physical health (Hoang et al. 2019), therefore if women have lingering mental health issues arising from the initial pregnancy loss, they may lower or delay investment until the pregnancy becomes viable (i.e., after 12 weeks).

It is also possible that mothers may increase their level of investment in the next pregnancy. This may occur if mothers feel personally responsible for the loss (Nikcevic, Kuczmierczyk, and Nicolaides 1998), and believe that changing their behavior, e.g., through adopting a healthier lifestyle, may impact the outcome of the subsequent pregnancy. Given the largely random nature of miscarriages, especially early and first losses, increasing prenatal investment in healthy behaviors, with the exception of smoking and drug abuse, is unlikely to prevent a miscarriage from occurring. However, assuming the child survives, this increased investment may have a positive impact on birth and health outcomes. There is a large literature demonstrating that higher levels of parental investment early in life facilitate human capital development with long-term impacts across the lifecycle (Cunha and Heckman 2007; Currie and Almond 2011). In particular, there is evidence that higher levels of prenatal investment in the form of supplementation use and improved diet and nutrition can positively impact the developing child (reviews include Bell et al. 2018; Borge et al. 2017; Easey et al. 2019; Iglesias Vázquez, Canals, and Arija 2019; Yeoh et al. 2019).[6]

Conversely, if mothers enter the pregnancy following a miscarriage in a heightened state of stress, this may have a negative impact on the developing child via changes in fetal

[6] For example, the introduction of the workplace smoking ban, which reduced the incidence of maternal smoking during pregnancy, improved birth outcomes (e.g., Bharadwaj, Johnsen, and Løken 2014; Hajdu and Hajdu 2018). In addition, studies exploiting changes in prenatal maternity leave policies report positive effects on birth and later outcomes, although the effects are mixed (see review in Ahammer, Halla, and Schneeweis 2020). The impact of prenatal shocks to nutritional investment is examined by Almond and Mazumder (2011) and Almond, Mazumder, and van Ewijk (2015), who find negative effects on birth outcomes and childhood test scores for pregnancies that coincide with Ramadan.

programming (Seckl and Meaney 2004; Nakamura, Sheps, and Clara Arck 2008).[7] Essentially, heightened stress leads to an elevated stress response in the mothers which can disrupt or inhibit the child's nervous, endocrine, and immune systems (Parker and Douglas 2010). A review of the impact of stress in pregnancy finds that the structural impact of stress on the child's brain can negatively affect neurodevelopment, cognitive development, temperament, and psychiatric disorders (Van den Bergh et al. 2020). A number of studies in the economics literature have examined the short and long-term impact of prenatal stress inducted by exogenous shocks such as natural disasters, terrorist attacks, conflict, and parental death on child outcomes (examples include Currie and Rossin-Slater 2013; Quintana-Domeque and Ródenas-Serrano 2017; Mansour and Rees 2012). One study that measures stress directly, using cortisol from blood samples, shows that children exposed to higher levels of stress in utero have worse cognitive, health, and educational outcomes, however, there are no effects on birth outcomes (Aizer, Stroud, and Buka 2016). Other studies, using the death of a parent during pregnancy as a proxy for stress and grief, finds some small effects on birthweight, but no effects on later educational attainment, earnings, or health in adulthood (Black, Devereux, and Salvanes 2016; Persson and Rossin-Slater 2018).

Pregnancy loss itself has been used as a random exogenous shock. Delays in motherhood induced by pregnancy loss have been found to increase earnings and work hours (Miller 2011; Li 2012). The random occurrence of pregnancy loss, conditional on controls for known risk factors, is also employed as an instrumental variable (IV) to examine the impact of teen pregnancy (Hotz, Mullin, and Sanders 1997; Hotz, McElroy, and Sanders 2005). Building on this work, Ermisch and Pevalin (2005) use pregnancy loss as an IV when reporting that younger mothers fare worse on the marriage market. Buckles and Munnich (2012) find an improvement in child outcomes with an added year between siblings, citing larger results when the exogenous shock of pregnancy loss is employed over standard OLS. In addition, Karimi (2014) shows that larger birth spacing due to miscarriage increases the probability of labor market re-entry between births and income after the second birth in Sweden. One of the few studies to examine the consequences of pregnancy loss itself is a recent study by Rellstab, Bakx, and

[7] This arises because stress is a state of threat to homeostasis, the stable internal system our bodies maintain despite our fluctuating external environment. To restore stability, the body produces a stress response that involves disrupting or inhibiting the nervous, endocrine, and immune systems. This stress response prioritizes survival over less essential functions such as growth and reproduction (Joseph and Whirledge 2017). There can be beneficial physiological and psychological effects of the stress response, however prolonged or repeated disruptions to these systems can have negative consequences for the mother and child. In particular, the nervous and endocrine systems co-regulate the immune system, which is essential for the establishment and maintenance of pregnancy and fetal programming (Parker and Douglas 2010).

Garcia-Gomez (2022) which examines the mental health and labor market consequences of miscarriage in the Netherlands. They find that hospital-treated pregnancy losses increase the use of mental health services in the year the miscarriage took place, but there are no impacts on parent's labor market outcomes. Conversely, Kalsi and Liu (2022) use NLSY97 data and show that a miscarriage is associated with a significant income loss and a sustained decline in labor supply in the US context.

Our paper takes a step beyond this literature by considering pregnancy loss as a health shock that may change prenatal investment with consequences for parents' and subsequent children's outcomes. In particular, we make three main contributions.

First, we add to the literature on early-life shocks by studying the consequences of a health event that as many as 15-20% of childbearing women worldwide experience and that we still know little about. In particular, we focus on miscarriages that occur within the first 12 weeks of pregnancy as these are the most prevalent. Hence, the frequency of this shock is higher by many factors than exposure to natural disasters or the death of relatives during pregnancy which are typically studied in this literature. Thus, the potential costs to society are large. Moreover, despite decades of medical progress, early pregnancy losses due to chromosomal abnormalities are very difficult to prevent. Hence, understanding the consequences of pregnancy loss is key to determining the costs associated with childbearing.

Second, we use unique data on early miscarriages contained in the Norwegian birth registry that allows us to identify both self-reported (not medically assisted) and medically assisted pregnancy losses for the entire population. This is in contrast to Rellstab et al. (2022) who focus only on miscarriages that require hospitalization and Kalsi and Liu (2022) who rely on a small survey sample from the NLSY97. Moreover, we study the behavioral outcomes of parents and uniquely, the health outcomes of subsequent children.

Third, we provide novel direct evidence on parental investment behavior using measurements from registry data. While most of the literature on early-life shocks considers direct effects on human capital outcomes, defensive investments such as healthcare or pharmaceutical uptake are often unmeasured or only available for a small subset of the population. In this paper, changes in parental behavior due to a prenatal shock – a pregnancy loss – are studied directly to provide information on their importance as a channel through which miscarriages affect long-term outcomes. Hence, this paper contributes to a small but growing literature on measuring the willingness to pay for wellbeing using data on families' defensive investment behavior (see, e.g., Deschênes et al., 2017).

Overall, we find that pregnancy loss increases maternal investment in the subsequent pregnancy through increased supplementation, decreased smoking, and increased prenatal healthcare. We also find that mothers are more likely to switch their GP following a loss and take more sick leave during the subsequent pregnancy. Maternal labor market engagement also declines up to two years after the birth. However, this is not driven by poorer health, as mothers who experience a pregnancy loss typically have better physical health during the subsequent pregnancy. At birth, firstborn children born after a pregnancy loss have a slightly higher birthweight (~8 grams), but there are no effects on any other child outcome. There is little evidence of heterogeneity by child gender and maternal education, however, smokers are more likely to change their behavior compared to non-smokers. These findings suggest that increased investment in the next pregnancy may offset any of the negative consequences associated with the initial pregnancy loss.

By testing for and documenting the consequences of pregnancy loss, we contribute to increased public discourse around miscarriage and possible supports that could be put in place to mitigate any negative effects. Given the high prevalence rate of miscarriages and the estimated annual cost of, for example, £471 million in the UK (Quenby et al. 2021), the welfare consequences are likely to be large, particularly when compared to less frequent and short-term shocks that are typically examined in this literature.

I. Data & Context

We use Norwegian Registry data, a linked administrative dataset that covers the Norwegian population and provides information about labor market status, demographics, and family relations. We merge this data to the datasets described below using personal identification numbers for parents and children. We focus on the sample of births between 2006 and 2018.

A. Birth & Maternal Investment data

Data on births, pregnancy losses, and maternal health and health behavior during pregnancy are obtained from the Medical Birth Registry of Norway, which contains records for all births with a minimum gestation period of 12 weeks since 1967. The records include information on date of birth, age of the mother and father, measures of infant health, and method of delivery. Most importantly, the birth registry contains information about the number of previous pregnancy losses the mother experienced before week 12, as well as late miscarriages for children born in 1999 or later. This information is captured by family doctors, specialists, or midwives based on self-reports and medical history. Note, that the birth registry only records the number of miscarriages which occurred, it does not capture the timing of each loss.

The birth registry also contains information about the mother's health behavior during pregnancy including whether she supplemented folic acid and multivitamins before and during the pregnancy, whether she smoked at the start of and during pregnancy, and whether she received an additional prenatal test for birth defects.[8] Interventions to increase prenatal investment in supplementation, smoking cessation, and pre-natal care have been successful in improving maternal and child outcomes (Lassi et al. 2014) and are recommended by the WHO (World Health Organization 2016). The data also contains information on a set of health conditions experienced by the mothers prior to and during pregnancy, such as hypertension, gestational diabetes, and preeclampsia.

The registry also captures the baby's weight (in grams), an indicator of low birthweight (<2500g), Apgar scores,[9] duration of gestation (in weeks), and whether the delivery was by caesarean section. Low birthweight babies are well-established to have worse short-run and long-run human capital formation (e.g., Black, Devereux, and Salvanes 2007; Cook and Fletcher 2015) and, together with Apgar scores and gestational length, birthweight is a common metric for child health at birth that is associated with adult outcomes (for a review of studies, see Currie and Almond 2011). We use caesarean section delivery as a proxy for an unhealthy birth. C-sections are relatively uncommon in the Norwegian context (about 87% of births in our sample are vaginal), and medically indicated c-sections (e.g. excessive bleeding) are determined by poor maternal and/or child health factors at the outset or during labor (Sandall et al. 2018; Mascarello, Horta, and Silveira 2017; Polos and Fletcher 2019; Currie and MacLeod 2016; Witt et al. 2015).

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[8] The tests for birth defects involve amniocentesis and blood tests which identify chemical markers in the mother's blood. These tests are usually only administered to mothers over the age of 38 and those with genetic disorders in the family. See https://www.fhi.no/en/publ/2016/non-invasive-prenatal-testing-trisomy-21-18-og-13/ .

[9] Apgar scores are determined for newborns at one and five minutes after birth as a means of quickly summarizing the child's health. The test assesses color, heart rate, reflexes, muscle tone, and respiration. Higher scores, between 7 and 10, are considered an indication of good health (Simon, Hashmi, and Bragg 2021).

B. Health Data

In Norway, health services are publicly financed and universally accessible to all citizens. The services are organized into two levels: primary care and specialist care. Primary health care is the responsibility of the municipalities and includes general practitioners, emergency rooms, infant and child health care centers, school health services, and elderly care. Specialist care is the responsibility of the four health regions in Norway and it includes somatic specialist care, psychiatric health services, and private referral specialists.

General practitioners (hereafter GPs) and local emergency rooms (hereafter ERs) are the basis of primary care services. The vast majority of citizens belong to a specific GP's list, and GPs diagnose their patients, certify sick leave, prescribe treatments, and refer their patients to specialist care when needed. They also follow up on their patient after they have received care in the specialist system. In general, the GPs serve as gatekeepers to the specialist care system and health-related welfare benefits. Patients are allowed to switch GPs twice within one calendar year; in addition to these ordinary changes, individuals can change their regular GP if they report a change of address to the Norwegian National Registry or if their regular GP leaves the surgery or reduces the size of their patient list. This information allows us to assess whether mothers are more likely to switch their GP following a pregnancy loss.

Information on visits to GPs and ERs is obtained from the Control and Payment of Health Refunds database and is available between 2006 and 2021. GPs and ERs are obliged to report all consultations and relevant International Classification of Primary Care (ICPC-2) codes to this claims database to receive payment. ICPC codes convey information about the assessment of the patient's health problems and the type of care provided.[10] This allows us to assess the health issues detected during each visit. We analyze primary care use and diagnosis for both mothers and children. To assess whether prenatal visits to the GP are induced by the mother or the health practitioner, we also consider the timing of the first prenatal visit. As the first visit must be initiated by the mother, this would suggest demand, rather than supply, side effects.

Specialist care is provided through public hospitals and outpatient care clinics, but it can also be provided through contracted private specialists. The first contact with specialist care takes place via the referral of the patient by the GP or the ER. It is not possible for a patient to proceed directly to specialist care within the public health care system. Information on the use of such

[10] Specifically, each ICPC code is made of one letter, indicating where the symptoms or diseases are located in the body, and two numbers indicating whether the GPs assessed health symptoms and diseases.

services is obtained from the Norwegian Patient Registry (NPR) and is available between 2008 and 2020. This dataset allows us to study the impact of pregnancy loss on hospitalizations (inpatient admissions) and consultations at outpatient clinics. An inpatient admission includes both overnight stays and day treatments, such as less invasive surgical procedures. These data also allow us to identify planned and emergency admissions and the medical conditions diagnosed at admission, following the 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD10).

C. Employment data

Annual parental earnings data are obtained from the tax registry and include labor earnings, taxable sick pay, unemployment benefits, and parental leave payments. We use the log of mothers' and fathers' earnings two years after birth as outcome variables. We focus on earnings two years after the birth as families should have completed their paid parental leave at this stage and for the majority of families, it is before the birth of the next child. Sick leave is reported by the Social Security Administration which contains information on all sickness absences lasting longer than three days (eight days for public sector workers), and that must be certified by a physician. The data contain start and end dates for all certified illness-related work absences. We only consider absences taken for the employee's own health (i.e., absence due to illness of other family members is not included). The data also includes a variable indicating total sick leave payments during a period of absence. We consider both the number of days and the total payments for long-term sick leave that start after the conception of the child up to the birth and sick pay two years after the birth. During pregnancy, maternal and/or practitioner perception of risk may be skewed and a "better safe than sorry" approach may be adopted for those who experienced a previous loss (Lyerly et al. 2009). Thus, sick leave may be considered a measure of investment as some studies have found an association between prenatal maternity leave and improved birth outcomes (Ahammer, Halla, and Schneeweis 2020). We also measure the length of paid maternity and paternity leave using data from the Social Security Administration that contain the exact start and end date of the paid leave period.

D. Norwegian Context

All women in Norway are entitled to free antenatal care. Mothers are eligible for eight prenatal appointments which they can attend at a GP or midwife clinic. The first appointment is booked by the mother between weeks 6 and 12 where routine tests are administered and mothers are provided with lifestyle and health information about the pregnancy and birth. Further check-ups take place at 24, 28, 32, 36, 38, 40 and 41 weeks. Women attend an ultrasound at the hospital at around 18 weeks.[11] Appointments with a midwife are longer than appointments with the GP and both have access to similar medical equipment to perform check-ups. While we can identify prenatal visits with the GP in the reimbursement data, midwives are, however, employed by the municipality and therefore do not bill 'fee for service' requests. Hence, we do not observe the number of midwife visits in the administrative data. Assuming that mothers take advantage of all eight check-ups, we can analyze whether mothers change the share of prenatal visits they choose to have with their GP following a pregnancy loss.

If a miscarriage occurs it can be treated in three ways – expectant management (remains of the pregnancy leave the body naturally), medical management (using a drug such as misoprostol), and surgical removal. About 70 percent of miscarriages are treated using expectant or medical treatment, and 30 percent are surgical removal (Linnakaari et al. 2019). Using a subset of the registry data, of the 40,280 women who reported a previous early miscarriage in the birth records since 2015, 18,873 did not receive medical treatment for a miscarriage between 2006 and 2015. This implies that 47 percent of women did not require medical care for the miscarriage.

In Norway, following a first pregnancy loss, women are informed that the probability of miscarrying again is low and that the next pregnancy is likely to be normal. Women are recommended to wait until they have had at least one period before trying to conceive again. They are also advised to avoid smoking, alcohol, and excessive caffeine, and to take folic acid while trying to conceive. If women experience three or more losses, they are recommended to see a fertility specialist.

II. Estimation Strategy

Our estimation strategy proceeds in two steps and exploits the near-random nature of single, early pregnancy losses. First, we use OLS to compare women who had a pregnancy loss before the birth of their first child to women who did not. We restrict our analysis to single miscarriages which occurred during the first 12 weeks of pregnancy as these are more likely to

[11] Mothers who are older than 38 years at the time of birth have access to additional antenatal care such as genetic risk assessment and an ultrasound appointment at week 12.

be random. Larsen et al. (2013) summarize the biological evidence on the occurrence and mechanisms behind sporadic (one or two) and recurrent (three or more) miscarriages. There is strong evidence that about 85 percent of early pregnancy losses are caused by random fetal chromosomal abnormalities.[12] Chromosomal abnormalities are less common in late and recurrent losses. Miscarriages that occur after the first trimester are associated with further pregnancy loss and complications in subsequent pregnancies (Linehan et al. 2019). Thus, while there is a strong argument that most single, early pregnancy losses are random, this is not the case for the rarer events of recurrent and late miscarriage, thus we exclude mothers with miscarriages that occur between 12 and 23 weeks and multiple miscarriages from our sample. Similarly, we exclude stillbirths which are defined as losses that occur after 24 weeks.[13] We also exclude assisted conceptions as they have a higher incidence of ending in pregnancy loss (Maconochie et al. 2007), as well as teen pregnancies (under 20 years) and mothers older than 45 years at the child's birth.[14]

Another consideration is the *recognition* of miscarriage and the timing of this recognition. Women who are actively trying to conceive or those who have struggled with conception may engage in cycle tracking and early pregnancy detection. Thus, the observed increase in miscarriage rates over time may be a feature of increased recognition of pregnancy, especially with improved pregnancy tests. In particular, increases in reported miscarriage are strongest in the first seven weeks and absent after 12 weeks, and are higher among white and better educated women (Lang and Nuevo-Chiquero 2012). Indeed, one study finds that while the timing of pregnancy awareness did not change between 1995 and 2013, early detection is

[12] In fetal development, chromosomes act as blocks of DNA that contain instructions on development such as how cells are formed and eye color. At conception, the fetus can receive too many or too few chromosomes. The reasons for this are viewed as a random developmental occurrence, but it means the fetus will not be able to develop normally, resulting in a miscarriage. It is very unlikely to recur. www.nhs.uk/conditions/miscarriage/causes

[13] 1% of the sample are pregnancies that end in late miscarriage, 0.2% are stillbirths or do not survive the first year, and 2% are IVF births. The categories are not mutually exclusive, thus less than 3% of pregnancies are excluded from the sample due to these issues.

[14] In further work on teen pregnancy, termination (abortion) is shown to censor miscarriage (Ashcraft, Fernández-Val, and Lang 2013; Ashcraft and Lang 2006; Fletcher and Wolfe 2009). While we do not observe abortion history in the data, in Norway in 2020, 85 percent of terminations took place within nine weeks of conception (Løkeland et al. 2021), thus it is reasonable to expect that some miscarriages were prevented by termination. In particular, we must consider how termination may censor recurrent miscarriage. Where three or more miscarriages take place, the cause is no longer considered to be largely random, therefore there may be a proportion of women who undergo multiple terminations and, for some of these people, repeat terminations may censor multiple miscarriages. However, given the relative rarity of multiple abortions (0.16 to 0.48 percent of women) and multiple miscarriages (1 to 2 percent of women), we do not anticipate that this will significantly bias our results. Furthermore, we exclude women with two miscarriages (despite indications that most pregnancy loss in this group would also be random) as some people in this group may have had an abortion, which would censor a third loss.

higher for older women and white women in the US (Branum and Ahrens 2017). Thus, reported rates of miscarriages may be higher among higher-SES women. Yet there is evidence that miscarriage is more likely to occur in lower-SES women, potentially driven by health gradients or access to healthcare (Hotz, McElroy, and Sanders 2005; Hotz, Mullin, and Sanders 1997; Li 2012; Miller 2011). To address these issues, we control for observable maternal and family characteristics that are associated with increased recognition of miscarriage, risk of loss, and non-random miscarriage – namely, parental age, education, and marital status. We also consider differential effects arising from child gender, maternal education, and smoking status.

First, we consider outcomes Y for mother j during the pregnancy/birth of her first live child, where P is a binary indicator of previous pregnancy loss, and D is a vector of demographics including child gender, mother's civil status, and parents' age (using age dummy variables) and level of education at the time of birth. The estimating question is

$$Y_j = \alpha_0 + \alpha_1 P_j + \alpha_2 \boldsymbol{D}_j + \varepsilon_j.$$

Second, to counteract potential endogeneity arising from unobserved factors that may influence the probability of experiencing a pregnancy loss and later outcomes, we also employ maternal fixed effects. Specifically, we restrict our analysis to two-sibling families and compare those who experienced at most one early pregnancy loss between the birth of the two siblings to two-sibling families who did not. Essentially, the mother's behavior and outcomes during the birth of her first child serve as a benchmark for her behavior and outcomes during the birth of her second child born following a miscarriage. This approach allows us to control for maternal characteristics that are constant across children, that is, we can leverage within-family between-sibling differences in exposure to pregnancy loss. This helps us account for unobservable genetic or anatomic factors that may influence miscarriage and parent/child outcomes. In the OLS specification, one could argue that we are not only estimating the effect of experiencing a miscarriage, but the effect of experiencing a miscarriage and the effect of experiencing a previous pregnancy. In the fixed effects estimation, however, we compare mothers with and without a miscarriage who previously had a successful pregnancy, thus this concern is less of an issue.

While the use of fixed effects allows us to control for time-invariant maternal factors, we also control for variables that vary across siblings such as child gender. Finally, as birth spacing between siblings is a determinant of child outcomes and increases with miscarriage (Buckles and Munnich 2012), we control for the ages of parents at the birth of both siblings. Similar to the OLS models, parental education and marital status are also allowed to vary over time in the model.

Thus, in our fixed effects (FE) approach we examine differences in outcomes for mother j's second live child compared to first live child I, where P a binary indicator of previous pregnancy loss. Controls include $\boldsymbol{D}$, a vector of demographics including the gender of each child, mother's civil status, and parents' age, and education level at the time of each birth. Thus, the estimating equation is

$$Y_{ij} = \beta_0 + \beta_1 P_{ij} + \beta_2 \boldsymbol{D}_{ij} + f_j + \varepsilon_{ij.}$$

The main limitation of our approach is that it requires the exclusion of groups of women for whom the impact of pregnancy loss may be greater i.e., those who never had a successful pregnancy (OLS strategy) or who never had a second child (FE strategy). Therefore, our results may be a lower bound.

D. Descriptive statistics

Table 1 presents the descriptive statistics comparing (1) all births in Norway between 2006 and 2018, (2) the OLS estimation sample i.e., all first births excluding those with multiple miscarriages, stillbirths, IVF births, and teen pregnancies (<20yrs), (3) families who experienced a miscarriage before the birth of the first child, with the same exclusions, (4) the FE estimation sample, i.e., all two sibling families with the same exclusions, (5) all two-sibling families who experienced a miscarriage between the birth of the two siblings.

Table 1 shows that our estimation samples are broadly similar to the sample of all births in Norway, however, they have slightly higher education and income, and are less likely to be foreign-born. Their health characteristics are largely similar. The table also shows that, as suggested by the literature (Maconochie et al. 2007; Turkeltaub et al. 2019), mothers who miscarry are on average older, and their partners are older, (columns 3 and 5). We control for these factors in our model. Note that, on average, women in our FE sample who experience a miscarriage have birth spacing between their first and second child that is approximately 7 months wider than women who do not.

To consider whether the health and investment characteristics of mothers who have a miscarriage differ from those who do not, we conduct a placebo test using the FE sample but only consider the pregnancy which occurred before the miscarriage. As shown in Appendix Table A1, we find that there are no differences in the health outcomes of mothers who went on to experience a miscarriage after the birth of their first child and those who did not (in terms of pregnancy diabetes, hypertension, and preeclampsia), however, mothers who went on to have a miscarriage after the birth of their first child engaged in poorer health behaviors in that pregnancy (less folic acid and more smoking). Thus, while there are little health differences across the groups, there are differences in health behaviors, and hence we observe that such mothers are likely to change their health behaviors following the miscarriage.

Table A1 also reports another placebo test which shows that there are no significant differences in parental earnings before the first child is born among those who do and do not experience a miscarriage either before the first birth (OLS) or between the first and the second birth (FX). Hence, families who experience a pregnancy loss are not negatively selected in terms of earnings.

III. Results

A. Maternal investment

First, we consider the impact of a pregnancy loss on maternal investment during the subsequent pregnancy. Table 2 shows the effects for maternal folic acid use, multivitamin use, and smoking status before and during pregnancy, as well as additional prenatal testing, for both the OLS and FE models. The OLS specification, shows the difference in maternal investment between mothers who experienced a pregnancy loss before the birth of their first child and those who did not. For the FE specification, the coefficients indicate the difference in maternal investment between siblings, conditional on a pregnancy loss between the two births. Results are similar across both OLS and FE models. Following a pregnancy loss, mothers are more likely to take folic acid and multivitamins both before and during the next pregnancy, and they are less likely to smoke at the start and during the next pregnancy. We also find that they are significantly more likely to have prenatal tests checking for birth defects. The effect sizes are slightly larger in some of the OLS models, representing a 44/8 percent increase in folic acid intake before/during pregnancy, a 24/8 percent increase in multivitamin intake before/during pregnancy, and a 6/10 percent decrease in smoking at the start/during pregnancy. The corresponding effect sizes of the FE models are 36/7 percent (folic acid), 18/9 percent (multivitamins), and 15/17 percent (smoking).[15] The cost of vitamins and folic acid are not covered by the healthcare system and thus are fully paid by the mothers. These defensive investments cost mothers approximately NOK 1500-2000 ($140-190) in 2018.[16] Although this is less than 1 percent of their average annual salary, the large number of women changing their behavior indicates that many families have a higher willingness to pay for preventive investments. This increased investment may be driven by a heightened sense of personal responsibility for the subsequent pregnancy and earlier, and more frequent, contact with health care providers as described below.

Next, we consider the mother's healthcare use during the subsequent pregnancy. Again, we report both OLS and FE results. In general, the size of the effects is larger in the OLS models. Table 3 shows that on average mothers have 11 health care visits during pregnancy. Following a pregnancy loss there is an increase in the total number of primary health care visits by between 4 to 8 percent (FE and OLS models respectively). Mothers who experienced a previous loss have an increased number of GP visits (column 2), lab tests (column 4), and prenatal checks related to the pregnancy at the GP (and not with the midwife, column 5) in both the OLS and FE results. While there is an increase in primary care ER visits in the OLS results, the size of the effect on the incidence of hospital care is very small.[17]

Column 6 shows that these increases in healthcare visits are, to some extent, driven by an increase in psychological symptoms in the OLS models, but not in the FE models. This result is intuitive as women who have previously given birth know that they can carry a child to term (FE) and therefore they are less likely to experience significant psychological stress in the next pregnancy, while women who have never carried a child to term (OLS) are more likely to be affected by the previous pregnancy loss. However, for the FE mothers, it is possible that the

[15] Note that the OLS model might partly measure the joint effect of having a miscarriage and the effect of experiencing a previous pregnancy. Therefore, mothers may change their behavior following a miscarriage due to a fear of miscarrying again and because they have more experience with pregnancy. Thus, even in the absence of a miscarriage, mothers may always behave more cautiously in the subsequent pregnancy. Nevertheless, when we analyzed the pregnancy behavior of mothers who never experienced a miscarriage, we found that mothers tend to behave less carefully in their second pregnancy in terms of supplementation and smoking compared to their first pregnancy. Thus, the experience effect may go in the other direction than the effects we estimate in Table 2. Results are available upon request.

[16] The costs are estimated based on prices for supplements from online pharmacies in Norway such as www.farmasiet.no.

[17] Appendix Table A2 shows the impact of pregnancy loss on the incidence of hospital care experienced by mothers during pregnancy. In general, the effects are very small. Mothers who experience a miscarriage are less than 1 percent more likely to attend the hospital during the pregnancy compared to mothers who do not. This small effect is driven by both inpatient and outpatient visits and acute and elective admissions. Appendix Table A3 also shows that they are driven by visits related to the pregnancy, as well as non-pregnancy-related visits. Similarly, they result from the supervision of both normal and high-risk pregnancies.

levels of distress experienced do not necessitate a GP visit, or that their increased investment helps to offset any distress attributed to the miscarriage.[18] Overall, mothers who experienced a miscarriage have more contact with the healthcare sector during the subsequent pregnancy, which results in overall higher reimbursement costs by between 4-10 percent in the FE and OLS sample, as demonstrated in column (7). These findings may be driven by an abundance of caution by either the pregnant woman or the health professionals. As GPs are gatekeepers for specialist care as well as additional testing, the increase in lab tests and prenatal checks suggests that GPs are somewhat more cautious with pregnant women who experienced a recent pregnancy loss.

Next, we examine the timing of prenatal visits. The first column of Table 4 shows that women who experienced a pregnancy loss attended their first prenatal visit slightly earlier than those who did not. Although the effect is small, (3.9 days in OLS and 1.5 days in FE), it suggests that demand for more prenatal care comes (at least partly) from the mother rather than the health professional, as only mothers can initiate the first visit. Hence, the evidence in Tables 3 and 4 suggests that there is both a demand effect for more healthcare through earlier first pregnancy appointments, as well as a supply effect through increased specialist referrals and lab tests. Table 4 also reports the number of GP visits by trimester. Mothers who had a miscarriage attended more visits in all trimesters in the OLS models and the first and second trimesters in the FE models. However, in all cases, the size of the effect is larger in the first trimester. This aligns with our hypothesis that women are more likely to take additional precautions during the period when the pregnancy is most vulnerable i.e. the first 12 weeks. Table 4 also shows that women who experienced a pregnancy loss are no more or less likely to require hospital care during the pregnancy (FE). However, women who experienced a miscarriage before the birth of their first child (OLS) are more likely to attend the hospital during all trimesters, with larger effects in the first trimester. This suggests that women are more likely to avail of health care in the earliest stages of pregnancy which is the most vulnerable time for pregnancy loss.

As discussed earlier, patients are allowed to switch their GP twice within a calendar year. In Table 5, we focus on the FE sample and show that women who had a miscarriage are more likely to switch GP between their two pregnancies (by ~5 percentage points) compared to

[18] Note that this is in line with Rellstab et al. (2022) who find that mothers are more likely to have mental health issues right after experiencing a miscarriage, but that these negative effects are short-lived likely due to mothers conceiving again shortly after a pregnancy loss.

women who did not experience a miscarriage. There is no evidence of heterogeneity, as switching takes place among high and low-educated mothers and non-foreign-born and foreign-born mothers. However, mothers who have a doctor as a relative (e.g. parent/grandparent/uncle/aunt with a degree in medicine) have a higher probability of switching following a pregnancy loss, suggesting a role for information provision. Appendix Table A4 shows that mothers are more likely to switch to GPs who are female, younger, and non-specialists, as well as those who have shorter patient lists and better patient ratings. GPs with shorter patient lists typically have shorter waiting times for scheduling appointments and more time to spend with each patient, and such GPs are more likely to be younger and female. Thus, it appears that women who have a miscarriage switch to GPs who will dedicate more time to them, again suggesting that women who miscarry engage in more preventative care. However, as shown in column (6), they are not more likely to switch to a GP with a higher tendency to prescribe sick leave. Overall, this suggests that mothers' choice is influenced by doctor characteristics that are identifiable from the official website of the Health Directory.

B. Sick Leave and Labor Market

Next, we consider the impact of a previous pregnancy loss on sick days and sick pay. Women with a history of pregnancy loss may have worse health overall, alternatively, sick leave may be considered as a precaution by the mother and/or her doctor following a pregnancy loss. Thus, while no more physically unwell, women with a history of loss may take more leave. Table 6 shows that there is an increase in sick leave and sick pay during the pregnancy, an increase of about three (FE) to nine (OLS) days for women with a history of loss. Note that sick leave has no direct financial costs for employed mothers as the replacement rate is 100% from the first day.[19] Hence, the direct costs from increases in sickness absences during the subsequent pregnancy are borne by employers and society rather than the pregnant mother. Nevertheless, long sickness absences might indirectly have future career costs for mothers and constitute another defensive investment behavior. Next, we consider whether this increased sick leave is driven by poorer health or increased investment.

Table 7 shows the impact of pregnancy loss on gestational diabetes, hypertension, and pre-eclampsia in the subsequent pregnancy. There are some differences between the OLS and FE

[19] The sick days and sick pay data we observe comes from the Social Security Registry. In these data, all days are counted, not only the days on which the employee should have been at work. The employer's period is counted from and including the first full day of sick leave. The employee must have worked for you for at least four weeks in order to be entitled to sick-pay.

results. For women who experience a miscarriage before the birth of their first child, they are more likely to be diagnosed with gestational diabetes, but less likely to be diagnosed with hypertension compared with women who did not experience a miscarriage. For the FE sample, they are less likely to be diagnosed with hypertension during their current pregnancy compared to their pregnancy prior to the miscarriage. On the one hand, the improved health indicated by lower hypertension levels could arise from increased investment, which we see through increased supplementation and decreased smoking. On the other hand, the increased gestational diabetes diagnosis could result from the increase in GP visits and lab tests shown in Table 2. Thus, those who engage with health services may be more likely to be diagnosed with conditions than those who have a condition but do not attend health services. In sum, these results suggest that women who experienced a previous miscarriage do not enter the next pregnancy with substantially poorer health outcomes.

Finally, we consider the impact of pregnancy loss on maternal and paternal labor market engagement within two years after the birth of the subsequent child.[20] Table 8 shows that maternal labor income is negatively affected by pregnancy loss for both the OLS and FE samples, however, there are no effects for fathers. This drop appears to be driven by a reduction in the mother's earnings, which suggests that, following a pregnancy loss, upon the birth of the new child, the mother reduces her employment. In addition, we also see a significant increase in sick pay in the two years after birth. Note that mothers in our sample are entitled to 39-46 weeks of paid maternity leave with a 100% replacement rate up to annual earnings of NOK 600,000 in 2018 (mean annual earnings are approximately 325,000 for mothers). In addition, a large share of mothers with very high earnings have employers, such as the public sector, that top-up the leave benefits to reflect the full replacement rate above NOK 600,000. Alternatively, parents can choose an 80% replacement rate with a longer leave duration. Mothers are also entitled to one year of job protection. Mothers and fathers are also entitled to parental leave, which they can divide. For our cohorts, the quota that is exclusively reserved for fathers is 4-15 weeks of paid leave. Hence, an income reduction can result from taking longer or unpaid leave, a slower career progression after birth, or a change in work hours or jobs. While we provide marginally significant evidence that mothers increase the length of their maternity leave after a miscarriage and fathers decrease their leave days in the OLS sample, we do not

[20] Note that Appendix Table A1 presents a placebo test showing that maternal and paternal earnings in the year before the birth of the first child do not differ between those who experienced a miscarriage and those who did not both in the OLS and FX sample.

find that mothers who experienced a pregnancy loss are more likely to choose longer paid leave in the FE sample. Thus, it appears that mothers reduce their workloads upon the birth of the subsequent child, perhaps due to an increase in parental time investment, while fathers, perhaps due to household budget constraints, do not change their workload. Evidence is mixed on how parental leave affects child outcomes. A change to maternity leave in 1977 in Norway that provided 4 months of paid leave and 12 months of unpaid leave for all eligible mothers had significant positive impacts on high school completion and wages, driven by large effects for the children whose mothers could not take much leave under the previous rules (Carneiro, Løken, and Salvanes 2015). However, studies examining the impact of extensions to paid leave in later periods after birth show no effects or negative effects on child outcomes, with some evidence of heterogenous effects (Baker and Milligan 2016; Dahl et al. 2016; Danzer and Lavy 2018).

Overall, the finding that women who experience a miscarriage are more likely to engage in greater supplementation and less smoking (Table 2), attend the GP more frequently (Table 3), and attend visits earlier in pregnancy (Table 4), matched with the finding that they are less likely to have significant health conditions in the pregnancy (Table 7) and more likely to take sick leave (Table 6) and time off work after the birth (Table 8) suggests that women are investing in more preventative health care in their subsequent pregnancy which is consistent with the investment hypothesis. In addition, there is also evidence that physicians increase their investment in women following a pregnancy loss by ordering more tests and checks (Table 3) and certifying more sick leave (Table 6). While part of this defensive investment is at the mother's own cost, a substantial share of the costs, such as sickness absence or healthcare take-up, are publicly funded.

One could argue that maternal age might be a "bad control" as one of the consequences of a miscarriage is that mothers are slightly older when they have a subsequent child. In Appendix Table A7, we omit all the control variables (Panel A) and controls for mothers' and fathers' age at birth (Panel B) and present a subset of our main results. We show that the estimated effects in the OLS regressions are not substantially altered by omitting all the controls or the indicators for parental age. The fixed effects estimates are also pointing in the same direction as our preferred estimates, nevertheless, they are larger in absolute values when omitting all or some of the controls. All effects are very precisely estimated and are significant on the 1% significance level.

B. Child outcomes

In this section, we consider the impact of pregnancy loss on subsequent child outcomes. Given their exposure to increased investment while in-utero, it is possible that such positive health behaviors translate into better child outcomes. However, it is also possible that the fear and anxiety of miscarrying again, and the consequent increase in stress, may offset these positive benefits. Table 9 reports the impact of a previous loss on the birth outcomes of the subsequent child. There are no effects in the FE models. In the OLS models, children born following a miscarriage are 8 grams heavier than those born with no previous miscarriage. The effect size is smaller in scale than those found in studies of prenatal grief by Black, Devereux, and Salvanes (2016) and Persson and Rossin-Slater (2018), reporting a *decrease* in birthweight of 18 to 19 grams. There are no effects on Apgar scores at 1 minute or a low birthweight indicator, however, children born following a miscarriage have a shorter length of gestation, are more likely to be born by caesarean section, and have higher Apgar scores at 5 minutes. The effect on c-sections is 9 percent and is driven by an increase in both planned and unplanned c-sections.[21] The effect on pregnancy length is very small, representing one-third of a day earlier. In sum, experiencing a loss has very little or no impact on the birth outcomes of subsequent children.

Tables 10 and 11 examine the impact of pregnancy loss on the number of healthcare visits experienced by the subsequent child. Again, there are no effects for the FE sample. For the OLS sample, children born following a pregnancy loss experience more healthcare visits in the first two years of life, with an increase in the number of GP and ER visits, which is partly attributed to an increase in visits due to injuries (Table 10), and an increase in the number of hospitalizations (Table 11). This may reflect cautiously on the part of the parent, who continues to seek out medical care for the subsequent child. The sizes of the effects are relatively small, however, an increase of about 7 percent for primary care visits and 4 percent for hospital visits.

Overall, apart from a small impact on birthweight and healthcare visits, being born after a miscarriage has limited effects on children. We hypothesize that this could be attributable to lingering investment decisions and stress that affect household characteristics after birth.

C. Heterogeneity

[21] Results available upon request.

In Appendix Table A5 and A6 (OLS and FE respectively), we present a range of heterogeneity tests for a selection of the results on which we observe significant effects.

First, we test for differences by child gender. This is motivated by mixed evidence on heterogenous gender effects for parental preferences for investment and the impact of prenatal shocks and investment. For example, depending on the setting, parents invest more in girls or boys, with knock-on effects for child outcomes (Baker and Milligan 2016; Bharadwaj and Lakdawala 2013). There is also some evidence that boys are more susceptible to a poor prenatal environment, such as through exposure to alcohol (Nilsson 2017). However, gender differences are not consistently found, for example, Quintana-Domeque and Ródenas-Serrano (2017) find no gender effects regarding the impact of terror attacks on birth outcomes. As shown in Tables A5 and A6, there is little evidence of heterogeneity by gender. Mothers of girls who are born following a miscarriage in the OLS sample have fewer prenatal care visits and take fewer sick days, however, among the FE sample, they take more sick days with girls.

Next, we consider mothers who were smoking at the start of the pregnancy versus those who were not. In our main analysis, we control for socioeconomic risk factors associated with miscarriage, acknowledging that 10 to 15 percent of pregnancy losses are not attributed to random chromosomal abnormalities (Larsen et al. 2013). In effect, this means that for a proportion of our sample, the loss was not random. Smoking while pregnant is a strong predictor of miscarriage. There is a 1 percent increase in the relative risk of miscarriage per cigarette smoked per day; smoking cessation at conception or early in pregnancy reduces the risk of miscarriage by 25 percent compared to people who smoke further into pregnancy, while non-smokers and former smokers have a similar risk of miscarriage (Pineles, Park, and Samet 2014). As shown in Table A5 and A6 there is some evidence that smokers are more likely to change their behavior following a pregnancy loss. In particular, smokers are more likely to increase their folic acid (OLS and FE), reduce their smoking (OLS), take fewer sick days and have less hypertension (OLS), and visit the GP earlier in the pregnancy (FE), compared to non-smokers.

Finally, we examine lower and higher-educated mothers. Maternal education affects child health through the uptake of prenatal care, smoking status, marriage, and fertility decisions (Currie and Moretti 2003). Employing fixed effects controls for time-invariant aspects of this effect, however, it is reasonable to anticipate that mothers with higher and lower education levels may make different fertility and investment decisions before and after pregnancy loss.

We expect higher-educated mothers to recognize pregnancy and pregnancy loss earlier in gestation (Lang and Nuevo-Chiquero 2012). Thus, this could increase stress for a longer proportion of the pregnancy and may also have investment effects. There is some evidence that early maternal investment has larger positive effects for the children of more educated mothers (Del Bono et al. 2016). For lower educated women, there is evidence that many will have a higher endowment level of stress, which is controlled for through our fixed effects specification, but also that stress in this group is more variable and will have a greater impact on their children (Aizer, Stroud, and Buka 2016). As shown in Tables A5 and A6, there is no evidence of heterogeneity in the majority of outcomes considered, with the exception of higher-educated mothers attending the GP earlier in the pregnancy, but having fewer prenatal care visits overall in the OLS models. In sum, the results of the heterogeneity analysis suggest that the consequences of pregnancy loss are similar across child gender and maternal education, yet smokers, who may feel a particular responsibility for the loss, are more likely to change their behavior following a miscarriage.

V. Conclusion

There is growing evidence on the impact of prenatal shocks on child outcomes (Almond, Currie, and Duque 2018), and while the destigmatization of pregnancy loss is increasing, little is known about the impact of this common and largely random event on families (Quenby et al. 2021). This study is the first to causally examine the impact of pregnancy loss on the mother's and physician's behavior during the subsequent pregnancy, as well as the impact on children born following the pregnancy loss. We show that miscarriage leads to an increase in investment in the subsequent pregnancy by both the mother and the healthcare professional, with few negative effects on subsequent children. Thus, while miscarriage is a traumatic experience for many families, this study shows that following a miscarriage, the majority of women (82 percent) go on to have a successful birth in a relatively short time period (7 months), with no negative consequences for the child. While increased prenatal investment may be costly for the mother, in terms of behavioral change, and the state, in terms of increased healthcare and social security costs, it is likely that these costs are mitigated by the birth of a healthy child.

The medical, psychological, and epidemiological literature indicates increased anxiety, depression, and stress for women who experience miscarriage (Geller, Kerns, and Klier 2004), yet these studies are largely associational and based on small samples. The economics literature also demonstrates the impact of stress in utero generated by the loss of a family member (e.g., Black, Devereux, and Salvanes 2016; Persson and Rossin-Slater 2018). Only two studies to date (Rellstab et al. 2022; Kalsi and Liu, 2022), focus on miscarriages specifically, however their analysis is restricted to the effects on parents directly after the miscarriage. In this paper, we focus on the next and successful pregnancy and study the behavior of both parents and physicians, as well as labor market and health outcomes of parents and children. Using unique registry data which provides detailed information on investment measures during and after pregnancy, we find that a history of miscarriage results in improved nutrition and decreased smoking. In addition, pregnancy loss leads to a more cautious approach to the subsequent pregnancy, through increased use of sick leave and more prenatal healthcare, despite evidence that the physical health of women who experience a miscarriage is similar or slightly better than women who do not. This cautiousness is also evident in the finding that women who experience a loss are more likely to seek out GPs who have shorter patient lists and higher ratings. However, we also observe cautiousness by GPs, who increase their referrals for specialist testing following a pregnancy loss and certify more sick leave. The sub-group analysis based on child gender and maternal education found little evidence of heterogeneity, however, smokers are more likely to change their health behaviors in the subsequent pregnancy compared to non-smokers. As smoking is a risk factor for pregnancy loss, and mothers who experience a loss are encouraged to reduce their smoking, miscarriage thus signifies a significant intervention that is likely to change smoking behavior.

After experiencing a pregnancy loss, many women may undergo increased stress and anxiety in the subsequent pregnancy due to a fear of miscarrying again, however, it appears that increasing investment in the pregnancy serves as a countervailing force to mitigate the negative effects of any prenatal stress. Thus, the null effects on children reported here may reflect a possible balancing out of the negative effects of stress and the positive effects of investment. However, without a direct measure of stress, we cannot formally test this hypothesis. Future work should examine directly assessed measures of miscarriage-induced stress and its effect on subsequent outcomes. This would allow for a breakdown of the countervailing influences of stress and investment on maternal and child outcomes.

These results stand in contrast to other work on prenatal shocks to maternal mental health and highlight the importance of the origin of the shock. Aizer et al. (2016) and Persson and Rossin-Slater (2018) do not find evidence of changes in maternal investment (or income in the case of

Persson and Rossin-Slater 2018) in response to increased stress. We theorize that strong investment effects arise here because the shock is more directly related to pregnancy. In addition, we find that effects persist beyond the birth of the subsequent child, with lower maternal labor market engagement up to two years after the birth. While this could be interpreted as a depletion of maternal human capital (and income) that could be costly in the long run, it also serves as an investment in subsequent offspring.

There are some limitations to our estimation strategy. We do not observe termination of pregnancy in our data, which could censor miscarriage (Ashcraft and Lang 2006; Ashcraft, Fernández-Val, and Lang 2013; Fletcher and Wolfe 2009) – that is, we may be including women in the sample who terminated pregnancies that, if not terminated, would have resulted in miscarriages. If a woman terminated a pregnancy between two births in advance of a miscarriage, she may have been selected out of the miscarriage group and into the no-miscarriage group. If a woman experiences a loss between births and multiple terminations censoring multiple miscarriages, they will not be caught by our exclusion criteria. The absence of information on abortion also precludes us from calculating bounds on our estimations as outlined by Hotz, Mullin, and Sanders (1997).

A second limitation is that the fixed effects estimates likely represent a lower bound. By restricting the FE sample to two sibling families we exclude groups for whom pregnancy loss may be more traumatic such as those with no living children and those with repeated experience of loss (Huffman, Swanson, and Schwartz 2010). Thus, while we conclude that miscarriage has a protective effect for subsequent children as increased investment counteracts increased stress, this cannot be generalized to the entire population of women who experience pregnancy loss. However, the similarity of the FE and OLS results, which focus on women experiencing a miscarriage before the birth of any of their children, suggests that our results are generalizable for first births as well as families with multiple children. It also suggests that maternal behavior changes in similar ways following a loss, although the effects are generally larger in the OLS models.

Finally, while the majority of women give birth relatively soon after experiencing a miscarriage, some women – particularly older women and those with more than one miscarriage – may select out of further pregnancy (Smith, Ewings, and Quinlan 2009). While we control for birth spacing as a fertility decision arising from a previous loss, we do not consider the impact of pregnancy loss on selecting out of further pregnancy or other household outcomes such as the breakdown of relationships (Neff and Karney 2004). While 7 percent of our observations in the FE sample change the partner between the first and the second live birth, 93 percent experience a miscarriage between two successful pregnancies with the same partner. For the OLS sample, we cannot study relationship resolutions and the numbers here might be larger. Hence, these are important considerations of the impact of pregnancy loss that should be examined in follow-up work.

A further consideration is birth spacing and fertility decisions that arise from pregnancy loss. Over 50 percent of women who experience a miscarriage become pregnant within the next two years (Smith, Ewings, and Quinlan 2009). By nine months after miscarriage, there is evidence that women may continue to experience clinically significant levels of stress (Farren et al. 2020), however, for women who conceive within six months of miscarriage, there is associative evidence that pregnancy and birth outcomes tend to be better than for women with longer pregnancy intervals (Love et al. 2010). Conversely, within the birth spacing literature, there is evidence that intervals of up to six months between pregnancies that result in live births are associated with worse outcomes compared to 18-month intervals, particularly in older women (Schummers et al. 2018). In the FE regressions, by including the age of mothers at the births of the children before and after the miscarriage, we inherently control for the impact of birth spacing. However, we do not observe the timing of pregnancy loss between these two births, therefore we cannot consider the impact of the intended birth spacing, just the actual birth spacing. This means we cannot distinguish between mothers who recognize a subsequent pregnancy while experiencing acute distress from a recent loss or mothers who only become pregnant many months after the miscarriage.

Pregnancy loss is a common, taboo, and emotionally disruptive event. Arising in part from high short-term economic costs (estimated at £471 million in the UK annually) and estimates of the psychological and physical impacts of miscarriage, there is an increasing demand for robust analyses of the implications of miscarriage and improved support for those experiencing it (Quenby et al. 2021). A recent review of the evidence on approaches to treating miscarriage concluded that the pervasive attitude of acceptance undermines and risks dismissing the impact of miscarriage (The Lancet 2021). Thus, this paper is a major contribution to the discourse on miscarriage by employing careful identification and specification to examine the effect that pregnancy loss has on subsequent maternal and physician investment and child outcomes. As research and understanding on the impact of miscarriage and other prenatal shocks to mental health continues, investment and long-term support are vital considerations.

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Tables and Figures

Table 1 Descriptive statistics

	(1) All Births	(2) OLS Sample	(3)	(4) FE Sample	(5)
		All	Miscarriage	All	Miscarriage
(A) <u>Demographics</u>					
Nb Children	2.32	1.83	1.79	2.30	2.30
Not single at birth	0.93	0.91	0.92	0.95	0.94
Male child	0.51	0.51	0.51	0.52	0.51
Mother's age at birth	30.60	28.44	29.15	29.43	29.98
Father's age at birth	33.60	31.47	32.17	32.34	32.73
Foreign mother	0.29	0.30	0.29	0.25	0.24
Foreign father	0.27	0.28	0.27	0.24	0.22
(B) <u>Health</u>					
Smoking at start of pregnancy	0.21	0.22	0.20	0.21	0.21
Smoking at end of pregnancy	0.18	0.19	0.17	0.18	0.19
Birth weight (grams)	3498.74	3440.42	3445.24	3546.14	3542.70
Apgar score 1-minute	8.75	8.64	8.63	8.78	8.77
Apgar score 5-minutes	9.52	9.46	9.46	9.53	9.53
C-section	0.17	0.17	0.20	0.14	0.15
Pregnancy length in weeks	39.29	39.48	39.43	39.50	39.46
Sickness leave during pregnancy (days)	59.70	48.43	55.95	57.55	61.56
Sickness leave during pregnancy (NOK)	38498.52	28353.30	33564.46	35063.49	37773.99
(C) <u>Socio-Economics Status</u>					
Education at birth: Mother has college degree	0.52	0.54	0.50	0.57	0.57
Education at birth: Father has college degree	0.37	0.37	0.35	0.40	0.41
Mother's annual income year of birth (NOK)	349053.94	345641.72	347959.76	357128.91	363165.37
Father's annual income year of birth (NOK)	531651.71	499228.55	504904.90	535464.36	544485.61
Spacing between 1st and 2nd born (in months)	37.85	.	.	37.62	44.33
N	758,823	268,093	32,511	294,731	30,039

Note: Column (1) includes all births in Norway between 2006 and 2018. Column (2) includes all births included in the OLS estimation, which excludes multiple miscarriages, stillbirths, IVF births, and teen pregnancies (<20yrs). Column (3) includes the descriptives for mothers (and their families) who had an early miscarriage before the birth of their first child. Column (4) includes the FE estimation sample – all two sibling families excluding those with multiple miscarriages, stillbirths, IVF births, and teen pregnancies. Column (5) includes the descriptives for mothers (and their families) who had an early miscarriage between the first and second birth (i.e., among the sample used for the FE estimation).

Table 2 Effect of a previous pregnancy loss on maternal investment in the subsequent pregnancy

	(1) Folic acid before	(2) Folic acid during	(3) Multivitamins before	(4) Multivitamins during	(5) Smoking start	(6) Smoking during	(7) Prenatal Test
OLS	0.131***	0.058***	0.043***	0.039***	-0.013***	-0.019***	0.007***
	(0.003)	(0.002)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
Mean	.299	.752	.179	.466	.212	.181	.056
N	243,867	243,867	243,867	243,867	242,367	234,391	238,347
FE	0.106***	0.052***	0.031***	0.037***	-0.031***	-0.030***	0.013***
	(0.009)	(0.008)	(0.007)	(0.009)	(0.007)	(0.008)	(0.005)
Mean	.298	.737	.170	.424	.203	.181	.055
N	281,075	281,075	281,075	281,075	279,235	271,045	275,695

Note: Coefficients and standard errors are reported. The top panel reports the results of the OLS estimation (first birth sample) and the bottom panel from the fixed effect estimation (two sibling sample). Each set of parameters is from a separate regression of the outcome variables on miscarriage history. In the top panel, we use the sample of mothers who successfully delivered the first child and present estimates for an indicator that takes value one if the mother experienced a single pregnancy loss before the first birth, and 0 otherwise. The controls include indicators for whether the mother was not cohabiting at the time of the child's birth, the child's gender, indicators for the age of mother and father at the year of birth, whether the mother and father had a college degree in the year the child was born, indicators for whether the mother and father were born in Norway or not and birth year fixed effects. Robust standard errors are in parentheses.

In the bottom panel, we use the sample of mothers with two children and present estimates for an indicator that takes value one if the mother experienced a single pregnancy loss between the two births and 0 if she has no history of pregnancy loss. Controls include indicators for whether the mother was not cohabiting at the time of the children's birth, children's gender, indicators for the age of mother and father at the time of birth, for whether the mother and father had a college degree in the year the children were born, indicators for whether the father was born in Norway or not. In the fixed effects models, the standard errors are clustered at the mother level.

Data source: Medical Birth Registry for the years 2006 to 2018. Significance levels: * < 0.10, ** < 0.05, *** < 0.01.

Table 3 Effect of pregnancy loss on maternal health during pregnancy: primary healthcare

	(1) Total Primary Care Visits	(2) GP	(3) ER	(4) Lab Tests	(5) Prenatal Check	(6) Psychological ICPC2-P	(7) Reimbursement Costs
OLS	0.881^{***}	0.753^{***}	0.129^{***}	0.326^{***}	0.113^{***}	0.072^{***}	339.036^{***}
	(0.045)	(0.043)	(0.008)	(0.023)	(0.015)	(0.013)	(14.951)
Mean	10.9	10.3	.529	4.7	3.08	.369	3398
N	261182	261182	261182	261182	261182	261,182	261182
FE	0.388^{***}	0.377^{***}	0.011	0.145^{**}	0.039	-0.000	131.027^{***}
	(0.110)	(0.106)	(0.021)	(0.058)	(0.040)	(0.030)	(36.264)
Mean	10.9	10.5	.469	4.61	3.19	.296	3335
N	291344	291344	291344	291344	291344	291,344	291344

Note: Coefficients and standard errors are reported. Column (1) includes the number of annual visits to the primary health care visits during pregnancy (to the assigned GP or to a primary care emergency center). In column (2), the dependent variable is the number of GP visits. In column (3), the dependent variable is the number of primary care ER visits. The dependent variable in column (4) is the number of laboratory tests performed during visits (for example, blood testing of total cholesterol, analyses of creatinine, potassium, glycosylated hemoglobin for the determination of long-term blood sugar, or rapid test for the detection of helicobacter pylori infection, CPR test, pregnancy test, test for bacterial antigen for streptococci and mononucleosis or glucose chemical analysis). In column (5), the dependent variable is the number of primary care appointments dedicated to prenatal checks, which include the (i) first-time complete examination and guidance of pregnant women as well as completion of an approved pregnancy record, (ii) supplements of later pregnancy controls and (iii) pregnancy control where a midwife (employed by the GP assigned to the pregnant woman) carries out a second or subsequent pregnancy check in collaboration with a doctor, but without a simultaneous doctor's consultation. In column (6) the dependent variable is the number of primary care visits where there was a diagnosis related to psychological symptoms or diagnoses. The dependent variable in column (7) is the total amount of reimbursement costs associated with primary health care visits during pregnancy.

The top panel reports the results of the OLS estimation (first birth sample) and the bottom panel from the fixed effect estimation (two sibling sample). Each set of parameters is from a separate regression of the outcome variables on miscarriage history. In the top panel, we use the sample of mothers who successfully delivered the first child and present estimates for an indicator that takes value one if the mother suffered a single pregnancy loss before the first pregnancy, and 0 otherwise. The controls include indicators for whether the mother was not cohabiting at the time of the child's birth, the child's gender, indicators for the age of mother and father at the year of birth, whether the mother and father had a college degree in the year the child was born, indicators for whether the mother and father were born in Norway or not and birth year fixed effects. Robust standard errors are in parentheses.

In the bottom panel, we use the sample of mothers with two children and present estimates for an indicator that takes value one if the mother suffered a single pregnancy loss between births and 0 if she has no history of pregnancy loss. Controls include indicators for whether the mother was not cohabiting at the time of the children's birth, children's gender, indicators for the age of mother and father at the time of birth, for whether the mother and father had a college degree in the year the children were born, indicators for whether the father was born in Norway or not. In the fixed effects models, the standard errors are clustered at the mother level. Data Sources: Control and Payment of Health Refunds database between 2006 and 2018. Significance levels: * < 0.10, ** < 0.05, *** < 0.01.

Table 4 Effect of pregnancy loss on maternal health during pregnancy: Timing of visits

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
		Primary Health Care			*Hospital Care Extensive Margin*		
	First Visit	1^{st} Trimester	2^{nd} Trimester	3^{rd} Trimester	1^{st} Trimester	2^{nd} Trimester	3^{rd} Trimester
OLS	-3.891***	0.569***	0.398***	0.260***	0.173***	0.010***	0.009***
	(0.237)	(0.020)	(0.019)	(0.023)	(0.003)	(0.002)	(0.001)
Mean	50.6	3.56	3.47	5.33	.553	.878	.939
N	254,557	261,182	261,182	261,182	227,955	227,955	227,955
FE	-1.511*	0.272***	0.126**	0.077	-0.006	0.008	0.007
	(0.775)	(0.052)	(0.051)	(0.062)	(0.009)	(0.006)	(0.005)
Mean	51.3	3.39	3.49	5.5	0.665	0.883	0.934
N	285,911	291,344	291,344	291,344	250,451	250,451	250,451

Note: Coefficients and standard errors are reported. The top panel reports the results of the OLS estimation (first birth sample) and the bottom panel from the fixed effect estimation (two sibling sample). Each set of parameters is from a separate regression of the outcome variables on miscarriage history. In the top panel, we use the sample of mothers who successfully delivered the first child and present estimates for an indicator that takes value one if the mother suffered a single pregnancy loss before the first pregnancy, and 0 otherwise. The controls include indicators for whether the mother was not cohabiting at the time of the child's birth, the child's gender, indicators for the age of the mother and father at the year of birth, whether the mother and father had a college degree in the year the child was born, indicators for whether the mother and father were born in Norway or not and birth year fixed effects. Robust standard errors are in parentheses.

In the bottom panel, we use the sample of mothers with two children and present estimates for an indicator that takes value one if the mother suffered a single pregnancy loss between births and 0 if she has no history of pregnancy loss. Controls include indicators for whether the mother was not cohabiting at the time of the children's birth, children's gender, indicators for the age of mother and father at the time of birth, for whether the mother and father had a college degree in the year the children were born, indicators for whether the father was born in Norway or not. In the fixed effects models, the standard errors are clustered at the mother level.

Data Sources: Columns 1-4 use variables obtained from the Control and Payment of Health Refunds database between 2006 and 2018. Columns 5 to 7 use information from the National Patient Register for the years 2008 to 2018. Significance levels: * < 0.10, ** < 0.05, *** < 0.01.

Table 5 Effect of pregnancy loss on switching GP between two pregnancies

	All	*Heterogeneity*		
Miscarriage	0.051** (0.005)			
High Education		0.048*** (0.006)		
Low Education		0.056*** (0.008)		
Doctor relative[a]			0.080*** (0.009)	
Non-doctor relative			0.040*** (0.006)	
Foreign born				0.058*** (0.010)
Non foreign-born				0.049*** (0.006)
p-value		0.408	0.000	0.459

Note: Coefficients and standard errors reported. Each set of parameters is from a separate OLS regression of the outcome variables on miscarriage history (1 = a single pregnancy loss between births, 0 = no history of pregnancy loss). The controls include indicators for whether the mother was not cohabiting at the time of the child's birth, the child's gender, indicators for the age of mother and father at the year of birth, whether the mother and father had a college degree in the year the child was born, indicators for whether the mother and father were born in Norway or not. Robust standard errors are in parentheses. Data Sources: Control and Payment of Health Refunds database between 2006 and 2018. Doctor Relative: Parent/Grandparent/Uncle/Aunt has a degree in medicine. Significance levels: * < 0.10, ** < 0.05, *** < 0.01.

Table 6 Effect of pregnancy loss on sick leave during the subsequent pregnancy

	(1) Sickness days	(2) Sickness pay
OLS	8.792***	5840.6***
	(0.420)	(314.0)
Mean	50.0	29,335
N	243,867	243,867
FE	2.669**	2160.1**
	(1.134)	(858.4)
Mean	58.7	35,800
N	281,075	281,075

Note: Coefficients and standard errors are reported. The top panel reports the results of the OLS estimation (first birth sample) and the bottom panel from the fixed effect estimation (two sibling sample). Each set of parameters is from a separate regression of the outcome variables on miscarriage history. In the top panel, we use the sample of mothers who successfully delivered the first child and present estimates for an indicator that takes value one if the mother suffered a single pregnancy loss before the first pregnancy, and 0 otherwise. The controls include indicators for whether the mother was not cohabiting at the time of the child's birth, the child's gender, indicators for the age of mother and father at the year of birth, whether the mother and father had a college degree in the year the child was born, indicators for whether the mother and father were born in Norway or not and birth year fixed effects. Robust standard errors are in parentheses.

In the bottom panel, we use the sample of mothers with two children and present estimates for an indicator that takes value one if the mother suffered a single pregnancy loss between births and 0 if she has no history of pregnancy loss. Controls include indicators for whether the mother was not cohabiting at the time of the children's birth, children's gender, indicators for the age of mother and father at the time of birth, for whether the mother and father had a college degree in the year the children were born, indicators for whether the father was born in Norway or not. In the fixed effects models, the standard errors are clustered at the mother level. Significance levels: * < 0.10, ** < 0.05, *** < 0.01.

Table 7 Effect of pregnancy loss on maternal health during the subsequent pregnancy

	(1) Pregnancy diabetes	(2) Hypertension	(3) Preeclampsia
OLS	0.006^{***}	-0.004^{***}	0.002
	(0.001)	(0.001)	(0.001)
Mean	.024	.024	.041
N	243,867	243,867	243,867
FE	0.001	-0.006^{**}	0.001
	(0.003)	(0.003)	(0.003)
Mean	.020	.019	.027
N	281,075	281,075	281,075

Note: Coefficients and standard errors are reported. The top panel reports the results of the OLS estimation (first birth sample) and the bottom panel from the fixed effect estimation (two sibling sample). Each set of parameters is from a separate regression of the outcome variables on miscarriage history. In the top panel, we use the sample of mothers who successfully delivered the first child and present estimates for an indicator that takes value one if the mother suffered a single pregnancy loss before the first pregnancy, and 0 otherwise. The controls include indicators for whether the mother was not cohabiting at the time of the child's birth, the child's gender, indicators for the age of mother and father at the year of birth, whether the mother and father had a college degree in the year the child was born, indicators for whether the mother and father were born in Norway or not and birth year fixed effects. Robust standard errors are in parentheses.

In the bottom panel, we use the sample of mothers with two children and present estimates for an indicator that takes value one if the mother suffered a single pregnancy loss between births and 0 if she has no history of pregnancy loss. Controls include indicators for whether the mother was not cohabiting at the time of the children's birth, children's gender, indicators for the age of mother and father at the time of birth, for whether the mother and father had a college degree in the year the children were born, indicators for whether the father was born in Norway or not. In the fixed effects models, the standard errors are clustered at the mother level. Data source: Medical Birth Registry for the years 2006 to 2018. Significance levels: * < 0.10, ** < 0.05, *** < 0.01.

Table 8 Labor market outcomes 2 years after the birth of the subsequent child

	(1) Labor income	(2) Sickness pay	(3) Earnings (including taxable benefits)	(4) Duration of parental leave (days)
Mothers				
OLS	-4637.5***	1352.3***	-2044.6**	0.842*
	(1060.9)	(173.9)	(1034.8)	(0.447)
Mean	239,177	5,000	291,558	293
N	243,867	243,867	243,474	206,743
FE	-9340.5***	1068.6*	82.5	1.132
	(3452.2)	(622.9)	(2571.4)	(1.402)
Mean	205,651	10,293	304,237	292
N	281,075	281,075	281,075	244,828
Fathers				
OLS	-1684.0	380.2**	-1525.2	-0.706*
	(1750.9)	(178.4)	(1743.8)	(0.423)
Mean	340,695	5,221	424,307	67
N	243,867	243,867	243,776	118,262
FE	2586.2	-277.6	5447.1	-2.808
	(4960.9)	(570.2)	(4732.7)	(1.990)
Mean	366,400	5,589	468,387	68
N	281,075	281,075	281,037	145,415

Note: Coefficients and standard errors are reported. The top panel reports the results of the OLS estimation (first birth sample) and the bottom panel from the fixed effect estimation (two sibling sample). Each set of parameters is from a separate regression of the outcome variables on miscarriage history. In the top panel, we use the sample of mothers who successfully delivered the first child and present estimates for an indicator that takes value one if the mother suffered a single pregnancy loss before the first pregnancy, and 0 otherwise. The controls include indicators for whether the mother was not cohabiting at the time of the child's birth, the child's gender, indicators for the age of the mother and father at the year of birth, whether the mother and father had a college degree in the year the child was born, indicators for whether the mother and father were born in Norway or not and birth year fixed effects. Robust standard errors are in parentheses.
In the bottom panel, we use the sample of mothers with two children and present estimates for an indicator that takes value one if the mother suffered a single pregnancy loss between births and 0 if she has no history of pregnancy loss. Controls include indicators for whether the mother was not cohabiting at the time of the children's birth, children's gender, indicators for the age of mother and father at the time of birth, for whether the mother and father had a college degree in the year the children were born, indicators for whether the father was born in Norway or not. In the fixed effects models, the standard errors are clustered at the mother level.
In column 4, we only include families where the mother is eligible for paid maternity leave. Significance levels: * < 0.10, ** < 0.05, *** < 0.01.

Table 9 Effect of a previous pregnancy loss on birth outcomes in the subsequent child

	(1) Birthweight	(2) Low birth weight	(3) Apgar 1	(4) Apgar 5	(5) C-section	(6) Pregnancy length (days)
OLS	8.037**	0.000	-0.004	0.010*	0.016***	-0.342***
	(3.368)	(0.001)	(0.008)	(0.006)	(0.002)	(0.081)
Mean	3446	.039	8.63	9.45	.171	279
N	243,814	243,814	243,767	243,758	243,867	243,166
FE	11.120	-0.002	0.000	0.011	-0.005	-0.004
	(8.122)	(0.003)	(0.023)	(0.017)	(0.005)	(0.206)
Mean	3552	.0258	8.78	9.53	.135	279
N	281,019	281,019	280,852	280,859	281,075	280,451

Note: Coefficients and standard errors are reported. The top panel reports the results of the OLS estimation (first birth sample) and the bottom panel from the fixed effect estimation (two sibling sample). Each set of parameters is from a separate regression of the outcome variables on miscarriage history. In the top panel, we use the sample of mothers who successfully delivered the first child and present estimates for an indicator that takes value one if the mother suffered a single pregnancy loss before the first pregnancy, and 0 otherwise. The controls include indicators for whether the mother was not cohabiting at the time of the child's birth, the child's gender, indicators for the age of mother and father at the year of birth, whether the mother and father had a college degree in the year the child was born, indicators for whether the mother and father were born in Norway or not and birth year fixed effects. Robust standard errors are in parentheses. In the bottom panel, we use the sample of mothers with two children and present estimates for an indicator that takes value one if the mother suffered a single pregnancy loss between births and 0 if she has no history of pregnancy loss. Controls include indicators for whether the mother was not cohabiting at the time of the children's birth, children's gender, indicators for the age of mother and father at the time of birth, for whether the mother and father had a college degree in the year the children were born, indicators for whether the father was born in Norway or not. In the fixed effects models, the standard errors are clustered at the mother level. Data source: Medical Birth Registry for the years 2006 to 2018. Significance levels: * < 0.10, ** < 0.05, *** < 0.01.

Table 10 Effect of a previous pregnancy loss on the number of primary health care visits experienced by the subsequent child

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Ages 0-2				Ages 1-2			
	Total	GP	ER	Injuries	Total	GP	ER	Injuries
OLS	0.812***	0.490***	0.321***	0.035***	0.550***	0.345***	0.205***	0.029***
	(0.059)	(0.045)	(0.024)	(0.006)	(0.048)	(0.037)	(0.019)	(0.005)
Mean	11.2	8.03	3.2	.452	8.45	6.12	2.33	.378
N	261182	261182	261182	261182	241731	241731	241731	241731
FE	-0.106	-0.114	0.009	0.004	-0.102	-0.112	0.010	0.025
	(0.131)	(0.105)	(0.054)	(0.020)	(0.113)	(0.092)	(0.046)	(0.019)
Mean	10.8	7.87	2.93	.484	7.63	5.6	2.03	.405
N	291344	291344	291344	291344	278027	278027	278027	278027

Note: Coefficients and standard errors are reported. The top panel reports the results of the OLS estimation (first birth sample) and the bottom panel from the fixed effect estimation (two sibling sample). Each set of parameters is from a separate regression of the outcome variables on miscarriage history. In the top panel, we use the sample of mothers who successfully delivered the first child and present estimates for an indicator that takes value one if the mother suffered a single pregnancy loss before the first pregnancy, and 0 otherwise. The controls include indicators for whether the mother was not cohabiting at the time of the child's birth, the child's gender, indicators for the age of mother and father at the year of birth, whether the mother and father had a college degree in the year the child was born, indicators for whether the mother and father were born in Norway or not and birth year fixed effects. Robust standard errors are in parentheses.

In the bottom panel, we use the sample of mothers with two children and present estimates for an indicator that takes value one if the mother suffered a single pregnancy loss between births and 0 if she has no history of pregnancy loss. Controls include indicators for whether the mother was not cohabiting at the time of the children's birth, children's gender, indicators for the age of mother and father at the time of birth, for whether the mother and father had a college degree in the year the children were born, indicators for whether the father was born in Norway or not. In the fixed effects models, the standard errors are clustered at the mother level. Data Sources: Control and Payment of Health Refunds database between 2006 and 2018. Significance levels: * < 0.10, ** < 0.05, *** < 0.01.

Table 11 Effect of a previous pregnancy loss on the prevalence of any hospitalization of the subsequent child

	(1)	(5)
	Ages 0-2	Ages 1-2
OLS	0.014***	0.018***
	(0.003)	(0.003)
Mean	.699	.428
N	261182	241731
FE	0.000	0.013
	(0.008)	(0.011)
Mean	.684	.426
N	291344	278027

Note: Coefficients and standard errors are reported. The top panel reports the results of the OLS estimation (first birth sample) and the bottom panel from the fixed effect estimation (two sibling sample). Each set of parameters is from a separate regression of the outcome variables on miscarriage history. In the top panel, we use the sample of mothers who successfully delivered the first child and present estimates for an indicator that takes value one if the mother suffered a single pregnancy loss before the first pregnancy, and 0 otherwise. The controls include indicators for whether the mother was not cohabiting at the time of the child's birth, the child's gender, indicators for the age of the mother and father at the year of birth, whether the mother and father had a college degree in the year the child was born, indicators for whether the mother and father were born in Norway or not and birth year fixed effects. Robust standard errors are in parentheses.

In the bottom panel, we use the sample of mothers with two children and present estimates for an indicator that takes value one if the mother suffered a single pregnancy loss between births and 0 if she has no history of pregnancy loss. Controls include indicators for whether the mother was not cohabiting at the time of the children's birth, children's gender, indicators for the age of mother and father at the time of birth, for whether the mother and father had a college degree in the year the children were born, indicators for whether the father was born in Norway or not. In the fixed effects models, the standard errors are clustered at the mother level. Data Sources: National Patient Registry between 2008 and 2020. Significance levels: * < 0.10, ** < 0.05, *** < 0.01

Appendix

Table A1 Placebo tests

	(1) Mother's labor income before pregnancy	(2) Father's labor income before pregnancy	(3) Folic acid during pregnancy	(4) Smoking during pregnancy	(5) Pregnancy diabetes	(6) Hypertension	(7) Preeclampsia
OLS	-1226.3	2353.9					
	(1020.4)	(1851.2)					
Mean	323,008	454,366					
N	254,915	247,482					
FE	-1573.7	3423.0	-0.020***	0.019***	0.000	0.002	-0.000
	(1557.1)	(2668.9)	(0.004)	(0.004)	(0.001)	(0.002)	(0.002)
Mean	333,547	466,330	0.166	0.193	0.015	0.025	0.40
N	120,166	120,164	120,178	116,745	120,178	120,178	120,178

Note: Coefficients and standard errors are reported. OLS estimates are based on the first birth sample. The FX sample includes mothers with two children and the table presents estimates for an indicator that takes value one if the mother suffered a single pregnancy loss between births and 0 if she has no history of pregnancy loss. Only the outcomes of the first-born children (born before the miscarriage) are included. The controls include indicators for whether the mother was not cohabiting at the time of the child's birth, the child's gender, indicators for the age of mother and father at the year of birth, whether the mother and father had a college degree in the year the child was born, indicators for whether the mother and father were born in Norway or not and birth year fixed effects. Robust standard errors are in parentheses. Significance levels: * < 0.10, ** < 0.05, *** < 0.01.

Table A2 Specialist care visits during pregnancy: extensive margin

	(1) Any Visit	(2) Any Inpatient Visit	(3) Any Outpatient Visit	(4) Acute Admission	(5) Elective Admission	(6) Length of Stay (Days)
OLS	0.009***	0.019***	0.009***	0.063***	0.007***	0.062***
	(0.001)	(0.002)	(0.001)	(0.003)	(0.002)	(0.014)
Mean	.939	.0908	.938	.309	.923	.267
N	227,955	227,955	227,955	227,955	227,955	227,955
FE	0.007	-0.008	0.008*	0.024**	0.006	-0.011
	(0.005)	(0.006)	(0.005)	(0.010)	(0.005)	(0.044)
Mean	.943	.0842	.942	.287	.926	.249
N	250,451	250,451	250,451	250,451	250,451	250,451

Note: Coefficients and standard errors are reported. The top panel reports the results of the OLS estimation (first birth sample) and the bottom panel from the fixed effect estimation (two sibling sample). Each set of parameters is from a separate regression of the outcome variables on miscarriage history. In the top panel, we use the sample of mothers who successfully delivered the first child and present estimates for an indicator that takes value one if the mother suffered a single pregnancy loss before the first pregnancy, and 0 otherwise. The controls include indicators for whether the mother was not cohabiting at the time of the child's birth, the child's gender, indicators for the age of mother and father at the year of birth, whether the mother and father had a college degree in the year the child was born, indicators for whether the mother and father were born in Norway or not and birth year fixed effects. Robust standard errors are in parentheses.
In the bottom panel, we use the sample of mothers with two children and present estimates for an indicator that takes value one if the mother suffered a single pregnancy loss between births and 0 if she has no history of pregnancy loss. Controls include indicators for whether the mother was not cohabiting at the time of the children's birth, children's gender, indicators for the age of mother and father at the time of birth, for whether the mother and father had a college degree in the year the children were born, indicators for whether the father was born in Norway or not. In the fixed effects models, the standard errors are clustered at the mother level.
Specialist visits are considered during pregnancy up to a week prior to the delivery. Data Sources: National Patient Registry between 2008 and 2018.
Significance levels: * < 0.10, ** < 0.05, *** < 0.01.

Table A3 Specialist care visits during pregnancy: extensive margin (type)

	(1) Any Obstetric ICD10 O or Z30-39	(2) Check-ups ICD10 Z except 30-39	(3) (Potential) Complications ICD10 O	(4) Supervision of Normal Pregnancy ICD10 Z34	(5) Supervision of High-Risk Pregnancy ICD10 Z35
OLS	0.009***	0.009***	0.066***	0.021***	0.026***
	(0.001)	(0.002)	(0.003)	(0.003)	(0.002)
Mean	.929	.092	.343	.64	.123
N	227,955	227,955	227,955	227,955	227,955
FE	0.007	0.005	0.033***	0.023**	0.018**
	(0.005)	(0.006)	(0.010)	(0.009)	(0.007)
Mean	.934	.0844	.353	.615	.137
N	250,451	250,451	250,451	250,451	250,451

Note: Coefficients and standard errors are reported. The top panel reports the results of the OLS estimation (first birth sample) and the bottom panel from the fixed effect estimation (two sibling sample). Each set of parameters is from a separate regression of the outcome variables on miscarriage history. In the top panel, we use the sample of mothers who successfully delivered the first child and present estimates for an indicator that takes value one if the mother suffered a single pregnancy loss before the first pregnancy, and 0 otherwise. The controls include indicators for whether the mother was not cohabiting at the time of the child's birth, the child's gender, indicators for the age of mother and father at the year of birth, whether the mother and father had a college degree in the year the child was born, indicators for whether the mother and father were born in Norway or not and birth year fixed effects. Robust standard errors are in parentheses.

In the bottom panel, we use the sample of mothers with two children and present estimates for an indicator that takes value one if the mother suffered a single pregnancy loss between births and 0 if she has no history of pregnancy loss. Controls include indicators for whether the mother was not cohabiting at the time of the children's birth, children's gender, indicators for the age of mother and father at the time of birth, for whether the mother and father had a college degree in the year the children were born, indicators for whether the father was born in Norway or not. In the fixed effects models, the standard errors are clustered at the mother level.

Specialist visits are considered during pregnancy up to a week prior to the delivery. Data Sources: National Patient Registry between 2008 and 2018.

Significance levels: * < 0.10, ** < 0.05, *** < 0.01.

Table A4 Effect of pregnancy loss on type of GP switching between two pregnancies

	(1) Male GP	(2) Age of GP	(3) Specialist GP	(4) GP List Length	(5) Mean GP Rating	(6) GP SL Leniency
Change GP*Miscarriage	-0.043**	-4.326***	-0.061***	-90.450***	0.119***	0.003
	(0.019)	(0.346)	(0.020)	(12.513)	(0.034)	(0.011)
Miscarriage	0.017***	1.514***	0.025***	32.315***	-0.051***	-0.005***
	(0.003)	(0.055)	(0.003)	(1.860)	(0.005)	(0.002)
Mean	.513	47.4	.672	1288	4.07	1.27
N	221201	221201	221201	221201	205965	221372

Note: Coefficients and standard errors are reported. The estimation is based on the sample of mothers with two children and presents estimates for an indicator that takes value one if the mother suffered a single pregnancy loss between births and 0 if she has no history of pregnancy loss. Controls include indicators for whether the mother was not cohabiting at the time of the children's birth, children's gender, indicators for the age of mother and father at the time of birth, for whether the mother and father had a college degree in the year the children were born, indicators for whether the father was born in Norway or not. In the fixed effects models, the standard errors are clustered at the mother level. In column (6), GP Sick Leave (SL) Leniency is computed as the total number of sick leaves a given GP awards per woman minus the number of sick leaves for the focal women divided by the total number of women of fertile age attended by the same GP.
Data Sources: Control and Payment of Health Refunds database between 2006 and 2018.
Robust standard errors are in parentheses. Significance levels: * < 0.10, ** < 0.05, *** < 0.01.

Table A5 Heterogeneity: Interactions for OLS

	(1) Folic acid during	(2) Smoking during	(3) Total PC visits	(4) First GP visit	(5) Sickness days	(6) Hypertension
Miscarriage	0.059***	-0.020***	0.985***	-4.132***	10.036***	-0.004***
	(0.003)	(0.003)	(0.063)	(0.330)	(0.585)	(0.001)
Girl	0.001	-0.002	0.048	-1.086***	1.683***	-0.002***
	(0.002)	(0.002)	(0.030)	(0.171)	(0.272)	(0.001)
Miscarriage	-0.001	0.001	-0.213**	0.497	-2.567***	-0.002
x girl	(0.005)	(0.005)	(0.090)	(0.473)	(0.839)	(0.002)
N	243,867	243,867	261,182	254,557	261,182	254,557
Miscarriage	0.035***	-0.001**	0.854***	-3.876***	9.394***	-0.003***
	(0.002)	(0.000)	(0.049)	(0.260)	(0.470)	(0.001)
Smoking	-0.249***	0.841***	0.359***	-0.560**	0.384	0.010***
	(0.003)	(0.002)	(0.039)	(0.229)	(0.345)	(0.001)
Miscarriage	0.103***	-0.030***	0.161	-0.152	-3.404***	-0.007***
x smoking	(0.007)	(0.005)	(0.122)	(0.629)	(1.054)	(0.002)
N	242,367	234,233	259,593	253,017	242,367	242,367
Miscarriage	0.059***	-0.020***	1.049***	-4.598***	8.886***	-0.004***
	(0.003)	(0.002)	(0.070)	(0.353)	(0.449)	(0.001)
High educated	0.020***	-0.029***	-1.210***	2.125***	-12.410***	-0.002*
mother	(0.003)	(0.003)	(0.035)	(0.205)	(0.400)	(0.001)
Miscarriage	-0.007	0.006	-0.327***	1.376***	-0.896	-0.001
x educ. mother	(0.008)	(0.007)	(0.091)	(0.474)	(1.243)	(0.003)
N	243,867	234,391	261,182	254,557	243,867	243,867

Note: The table reports the results of the OLS estimation (first birth sample). Each set of parameters is from a separate regression of the outcome variables on miscarriage history. We use the sample of mothers who successfully delivered the first child and present estimates for an indicator that takes value one if the mother suffered a single pregnancy loss before the first pregnancy, and 0 otherwise. The controls include indicators for whether the mother was not cohabiting at the time of the child's birth, the child's gender, indicators for the age of the mother and father at the year of birth, whether the mother and father had a college degree in the year the child was born, indicators for whether the mother and father were born in Norway or not and birth year fixed effects. Robust standard errors are in parentheses. Significance levels: * < 0.10, ** < 0.05, *** < 0.01.

Table A6 Heterogeneity: Interactions for FE

	(1)	(2)	(3)	(4)	(5)	(6)
	Folic acid during	Smoking during	Total PC visits	First GP visit	Sickness days	Hypertension
Miscarriage	0.059***	-0.031***	0.296*	-2.063*	2.661*	-0.007*
	(0.011)	(0.010)	(0.152)	(1.083)	(1.561)	(0.004)
Girl	-0.014	0.001	0.073	-1.591***	0.016	0.003
	(0.015)	(0.015)	(0.044)	(0.333)	(2.195)	(0.005)
Miscarriage	0.002	-0.002	0.188	1.121	1.148**	-0.002
x girl	(0.003)	(0.003)	(0.213)	(1.498)	(0.476)	(0.001)
N	281,075	271,045	291,344	285,911	281,075	281,075
Miscarriage	0.036***	-0.008***	0.399***	-0.890	3.474***	-0.005*
	(0.008)	(0.003)	(0.116)	(0.828)	(1.228)	(0.003)
Smoking	-0.233***	0.869***	-0.014	1.163**	0.927	0.006***
	(0.006)	(0.003)	(0.068)	(0.524)	(0.709)	(0.002)
Miscarriage	0.063***	0.022	-0.136	-3.931*	-4.814	-0.003
x smoking	(0.024)	(0.015)	(0.333)	(2.278)	(3.177)	(0.008)
N	279,235	270,871	289,445	284,058	279,235	279,235
Miscarriage	0.050***	-0.028***	0.175	-2.668**	2.208*	-0.006**
	(0.008)	(0.008)	(0.190)	(1.296)	(1.184)	(0.003)
High educated	0.007	-0.003	-0.013	1.203	-7.782***	-0.002
mother	(0.006)	(0.006)	(0.201)	(1.453)	(0.836)	(0.002)
Miscarriage	0.024	-0.029	0.345	1.867	5.732	0.005
x educ. mother	(0.029)	(0.027)	(0.225)	(1.568)	(3.831)	(0.010)
N	281,075	271,045	291,344	285,911	281,075	281,075

Note: The sample includes mothers with two children and the table presents estimates for an indicator that takes value one if the mother suffered a single pregnancy loss between births and 0 if she has no history of pregnancy loss. Controls include indicators for whether the mother was not cohabiting at the time of the children's birth, children's gender, indicators for the age of mother and father at the time of birth, for whether the mother and father had a college degree in the year the children were born, indicators for whether the father was born in Norway or not. In the fixed effects models, the standard errors are clustered at the mother level. Significance levels: * < 0.10, ** < 0.05, *** < 0.01.

Table A7 Robustness: Removing Control Variables

	(1) Folic acid during	(2) Smoking during	(3) Total PC visits	(4) First GP visit	(5) Sickness days	(6) Hypertension
	Panel A: No control variables					
OLS	0.064***	-0.021***	0.950***	-3.840***	8.574***	-0.003***
	(0.002)	(0.002)	(0.046)	(0.265)	(0.424)	(0.001)
N	243,867	234,391	261,182	254,557	243,867	243,867
FX	0.111***	-0.079***	1.807***	-8.798***	18.277***	-0.014***
	(0.008)	(0.007)	(0.105)	(0.733)	(1.071)	(0.003)
N	281,075	271,045	291,344	285,911	281,075	281,075
	Panel B: No control variables for parental age					
OLS	0.059***	-0.017***	0.867***	-3.810***	8.381***	-0.003***
	(0.002)	(0.002)	(0.105)	(0.237)	(0.421)	(0.001)
N	243867	234391	261,182	254,557	243867	243867
FX	0.110***	-0.078***	1.728***	-8.400***	17.629***	-0.014***
	(0.008)	(0.007)	(0.105)	(0.737)	(1.072)	(0.003)
N	281075	271045	291,344	285,911	281075	281075

Note: The table reports the results of the OLS estimation (first birth sample) and the fixed effect estimation (two sibling sample). Each set of parameters is from a separate regression of the outcome variables on miscarriage history and present estimates for an indicator that takes value one if the mother suffered a single pregnancy loss before the first or the second pregnancy, and 0 otherwise. Control variables in Panel B include indicators for whether the mother was not cohabiting at the time of the children's birth, the children's gender, whether the mother and father had a college degree in the year the children were born, indicators for whether the father was born in Norway or not. Robust standard errors are in parentheses. In the fixed effects models, the standard errors are clustered at the mother level. Significance levels: * < 0.10, ** < 0.05, *** < 0.01.