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The Impact of Childhood Health Shocks on Parental Labor Supply[1]

by Tine L. Mundbjerg Eriksen[2], Amanda Gaulke[3], Niels Skipper[4] & Jannet Svensson[5]

Abstract

Causal estimates of the effects of child health shocks on parental labor market outcomes are important for making efficient child disability insurance policy. We leverage the onset of type 1 diabetes (T1D) in childhood to investigate the link between child's health and parental labor supply. We argue that T1D hits children as-if randomly because the exact cause is unknown, and it has low inheritability. T1D is characterized by a sudden, unpredictable onset, and receiving treatment is crucial to even short-term survival. Using Danish administrative registry data with quasi-experimental methods we show that mothers adjust their labor supply on the intensive margin and experience a 4-5% decrease in wage income that extends at least ten years after diagnosis. This reduction in wage income is similar in magnitude and duration to the motherhood penalty in Denmark. Maternal wage income and labor supply effects are smaller than previous estimates using disabilities that qualify for welfare, emphasizing the importance of not confounding welfare with child health. Fathers do not experience any long-term reduction in wage income.

JEL: J22, I12, I14

Keywords: Parental labor supply; chronic disease; health shocks

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1. Introduction

When a child is diagnosed with a chronic condition, it could potentially affect the whole family. It is important to know the extent to which a childhood diagnosis of a chronic health condition affects parental labor market outcomes. Since parents may need to reduce their labor supply to help manage their child's chronic illness, child disability insurance may be needed to help these families remain out of poverty. Federal spending on Supplemental Security Insurance (SSI) for the disabled under age 18 was approximately $9.4 billion in fiscal year 2019 (United States Social Security Administration (2019)). However, if the relationship between child health and parental labor supply is not causal, these funds may be used more efficiently. If there is a causal relationship, this would suggest that families of children with a disability not currently covered by child disability insurance may need the extra assistance. Given the well-established relationship between health and wealth (see Smith (1999) for an overview), poor health may be a channel for the intergenerational transmission of poverty.

In this paper we examine whether there are spillover effects on parents when their child is diagnosed with Type 1 Diabetes (T1D) using Danish administrative registry data. Specifically, we test whether there are changes in maternal and paternal labor market outcomes when their child is diagnosed with T1D.

It is difficult to establish a causal relationship between a child's health and their parent's outcomes because it might not be poor health, but rather family factors that are associated with poor health (i.e. low socio-economic status is tied to poor health, and poor labor market outcomes). To deal with the potential endogeneity, we use T1D as an as-if random shock because it is more exogenous than other health shocks and a common childhood chronic condition.

T1D is, second to asthma, the most common chronic health condition in children and adolescents in most of the Western world. In the US, an estimated 1.25 million children and adults live with T1D, at an estimated annual cost of US$ 14.4 billion (Tao et al. (2010)). In Denmark, approximately 32,000 people are diagnosed with T1D, including 3,500 children. The yearly incidence rate has more than doubled in the past 20 years, with 400 new cases currently diagnosed each year, and experts only expect the trend to continue. T1D has, from an identification viewpoint, a favorable set of features. First, the exact cause of the disease is unknown. If there was a strong degree of inheritability, reductions in parental labor supply may be driven by the parents themselves suffering from the condition, instead of the child's diagnosis. However, there is only a three percent risk of T1D in children of mothers with T1D and there is only a five percent risk in children with fathers with T1D (Pociot and Lernmark (2016)).[6] The disease is characterized by a rapid onset in children and adolescents, and affected individuals will *not* go undiagnosed: At the turn of the 19th century, before insulin treatment was discovered, a patient diagnosed with T1D had an average life expectancy of two years from diagnosis (Hakim et al. (2013)). If individuals could go undiagnosed, the control group would be contaminated by treated individuals, which would bias the estimate downwards. We will show later in the paper that there is not a socio-economic status (SES) gradient in the prevalence of T1D which means that we are not confounding a health shock with SES. Taken together, this set of characteristics makes T1D close to a natural experiment.

In addition to using an as-if random source of a childhood health shock, we benefit from using full population Danish administrative registry data. We know the exact diagnosis, meaning we are able to distinguish T1D from the more common Type 2 diabetes (T2D) which is important because T2D is correlated with lifestyle characteristics (for example diet and sedentary behavior). The health records also include the exact date of diagnosis meaning

[6] To compare this with another common childhood condition, Starck, Grünwald, and Schlarb (2016) find that among children with ADHD, 41 percent of mothers and 51 percent of fathers also have ADHD.

we can compare outcomes between our treatment and control groups prior to diagnosis to show that parents have similar labor market outcomes prior to treatment. The longitudinal nature of the data allows us to compare families five years prior to diagnosis through up to ten years after diagnosis. This gives us a better understanding of the dynamics and persistence of the labor market impacts.

T1D is severe enough to be covered by the American with Disabilities Act, but it does not qualify one for additional welfare in Denmark. This is important because other papers estimating the impacts of child health on parental labor market outcomes include disabilities based on being severe enough to qualify for welfare, which means they are confounding the impact of a childhood health shock with the impact of additional welfare. For example, Powers (2001) discusses that while disabilities included in her definition could lead to receiving SSI, it is not possible to determine in the data whether the family also qualifies for SSI or Temporary Aid for Needy Families. Also, Gunnsteinsson and Steingrimsdottir (2019) include a group of disabilities called “SSI” and discuss how parents can receive welfare to make up for lost wages in Denmark for those disabilities. This definition of disability likely overestimates the true impact of a childhood health shock because of the work disincentives associated with welfare.

Our results show that mothers are not more likely to have zero wage income after diagnosis, but, conditional on working, are more likely to work part-time after diagnosis. The reduction in hours worked leads to a 4-5 percent decline in wage income, which persists at least ten years after the child is diagnosed. We find smaller magnitudes of the impacts on mothers than Powers (2001) and Gunnsteinsoon and Steingrimsdottir (2019) suggesting that the work disincentives of welfare may be impacting their results. There is no corresponding persistent wage decline for fathers, likely due to a reduction in labor supply only in the year of diagnosis. After that time, paternal labor supply adjusts back to pre-diagnosis levels.

Mothers may be reducing their labor supply for a variety of reasons. Given the unpredictability and time-intensive treatment required to manage T1D, mothers may be reducing their labor supply to help children manage the disease. The reduction by mothers, instead of fathers, could be due to economic reasons (in our sample mothers earn 36 percent less than fathers) or due to gender roles (mothers are traditional caregivers). Mothers may also experience stress or sorrow over having a sick child and may reduce their labor supply due to reduction in mental health.

The rest of the paper is organized as follows. Section 2 provides background on T1D and Section 3 provides the related literature. Section 4 discusses the Danish administrative registry data. Section 5 discusses the difference-in-differences and event study specifications. Section 6 discusses the results. Section 7 summarizes and concludes.

2. Background on T1D

T1D is an auto-immune disease in which the body attacks the insulin-producing beta cells which are needed to maintain a stable blood glucose level (often referred to as blood sugar). With the loss of these beta cells, the person with T1D becomes dependent on insulin treatment for the rest of his/her life. It is very important that one keeps their glucose levels within target because there are serious negative consequences to hyperglycemia (high blood glucose) such as kidney diseases, blindness, amputation, heart disease and there are serious negative consequences to hypoglycemia (low blood glucose) including seizure, being in a coma, et cetera (Rawshani A, Sattar N, Franzén S, et al. (2018), Dybdal, Tolstrup, Sildorf et al. (2017), White, Sun, Cleary et al. (2010), Fergus, Northam and Ryan (2019), Sandahl, Nielsen, and Svensson (2016), and the Writing Group for the DCCT/EDIC Research Group (2015)).

Managing T1D is very time consuming and complicated. Soloweijczyk (2004) states that T1D is unique because of the large amount of disease management that is required from those diagnosed and their families. Frequent glucose monitoring is important to determine how much insulin to take. This includes both a base rate, called a basal, and an amount for eating based on the number of carbohydrates consumed and the blood glucose prior to the meal, which is called a bolus. Insulin is administered either by syringe or insulin pump. The carbohydrate ratio may vary with time of the day. The need for basal insulin can vary over the day and needs to be adjusted due to the amount and intensity of physical activity and stress. Additionally, one may need to spread out (extend) the insulin depending on the fat and protein content of food consumed. If one suffers from hypoglycemia, a sugary snack (for example: glucose tablet, candy, juice) must be taken to avoid becoming unconscious. As children are constantly growing and changing their behavior, it is necessary to adjust both the basal and bolus insulin based on reviewing past glucose values for specific patterns.[7]

The care of children with T1D falls onto parents as evidenced by the medical literature. For example, Silverstein et al. (2005) state, "Young children, including school-aged children, are unable to provide their own diabetes care, and middle school and high school students should not be expected to independently provide all of their own diabetes management care." To further incentivize Danish parents to manage their child's T1D well, parents may be reported for child abuse if their child's disease is too poorly managed. Some examples of how parents help their children include planning healthy meals, counting carbohydrates, measuring and administering insulin, monitoring blood glucose, scheduling and providing transportation to medical appointments, picking up or ordering medicine, and

[7] This can result in people with T1D needing to be fairly rigid with some aspects of life in order to eliminate possible sources of variation and nail down the exact cause of the issue. However, sometimes it does appear that one gets a large shock that temporary throws things off.

assisting in case of a severe hypoglycemia or hyperglycemia.[8] Despite advancements in medical technologies, T1D is unique in its impact on parental sleep (Cobry and Jaser (2019) and Pillar et al. (2003)). Given how complex and time-consuming managing T1D is, it is likely that parents are affected by their child's diagnosis. A parent may need to cut back hours at work or switch to more flexible jobs in order to better help manage the disease. Thus, while previous work has established negative associations between child health and maternal labor supply, this paper adds to the literature by using an as-if random shock to estimate plausibility causal impacts on parental labor supply.

3. Literature Review

We would theoretically expect that having a child diagnosed with T1D would lead to reductions in labor supply because it is time consuming and unpredictable. Gould (2004) builds a theoretical model that incorporates both time and money to explain why there is not a clear prediction on labor supply. Specifically, she shows that for illness that are time-intensive and unpredictable one would expect a reduction in labor supply; however, for illnesses that are financially intensive one would expect a positive impact on labor supply. Consistent with the model, Gould empirically finds that single mothers work less if the child has a time-intensive illness and married mothers work less (on both the extensive and intensive margin) if the child has a severe illness that is unpredictable. While T1D is a financial-intensive illness as well in the United States, the Danish health system results in much lower costs for those with T1D.[9] Given the universal access to health insurance, having

[8] Parents also need to make sure their child is getting enough exercise, which helps keep the glucose levels in check. Parents advocate on behalf of the child to make sure child-care providers and teachers are aware of how to help manage the disease. Young children may not understand why they need finger pokes to test their glucose or insulin shots to maintain a healthy glucose level. It can be hard to measure food if children are so young that part of a meal ends up on the floor, or because the child is not under continuous supervision. Children may not always be aware of why they feel poor (glucose issue versus other issue). The insulin rates need to be adjusted as children grow.

[9] In Denmark, health care is universal and financed through taxes. Danish health insurance includes in and out patient hospital stays with no copayments, and primary care physicians. All medical aids necessary for treating

health insurance is not tied to the employment status of the parents. Findings of a reduction in labor supply would be consistent with economic theory.

Previous research tends to find associations with child health and mother's labor supply (Salkever (1982), Breslau, Salkever, Staruch (1982), Powers (2003), Portersfield (2002), Baydar, Joesch, Kieckhefer, Kim and Greek (2007), Cidav, Marcus, Mandell (2012), and Burton, Chen, Lethbridge and Phipps (2017)). Kvist, Nielsen and Simonsen (2013) find reductions in labor supply for both parents when a child is diagnosed with Attention Deficit Hyperactive Disorder (ADHD), although this is partly due to differences in socio-economic background and mental health. DeRigne and Porterfield (2017) also find impacts of child health on both parents, but that the magnitude is smaller for fathers, consistent with a study on the labor market impacts of autism (McCall and Starr (2016)).

There are many empirical challenges in estimating the causal impact of a child illness on parental labor supply. One challenge is if children with an illness or disability are more likely to have a parent with an illness or disability, then it is not clear that the reduced labor supply is due to the child's health condition. Currie, Shields and Price (2007) use English data to show that nearly 60% of the variation in child health is potentially explained by unobserved family characteristics. Given the low degree of inheritability of T1D, this is less of an issue in our study.

Powers (2001) further discusses limitations in related studies due to endogeneity issues related to parents overstating their child's illness if they do not want to work. Thus, research may over-estimate the true impact by attributing a lower labor supply to the sick child if it ignores these issues. Given that T1D is severe enough to be covered by the

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diabetes are supplied free of charge. However, prescription drugs (including insulin) are not free of charge. They are subsidized by the government and the coinsurance is a declining function of accumulated yearly spending. In 2016, the mean (median) yearly prices on insulin medications were approximately $1,029 ($962) corresponding to yearly out-of-pocket expenditures of approximately $239 ($229) for children and adolescents. Low income families may apply to the government to have the out-of-pocket cost waived.

Americans with Disabilities Act, we do not have to worry about parents overstating the impact.

Unlike other disabilities or chronic conditions that start at birth, T1D can occur throughout childhood (or even adulthood). For illnesses or disabilities that occur at or close to birth, the effect may be underestimated because the diagnosis is confounded with having a child. For example, if mothers reduce their labor supply after their child is born (regardless of child health), the marginal impact may appear smaller when treatment and control mothers are compared. However, if mothers would have increased their labor supply after the baby is old enough to receive an outside form of childcare, then the marginal effect of a sick child may be larger because the control group mothers returned to work while the treated mothers may have remained out of the labor force or returned in a part-time capacity only. For example, Zhu (2016) finds the gaps in maternal employment grow between the birth of a disabled baby and his/her second birthday.

This paper is able to better distinguish the treatment and control period by leveraging knowledge of the exact date of diagnosis. Gunnsteinsson and Steingrimsdottir (2019) centers their event study around the birth of a child and defines treatment as a diagnosis in the first ten years of life. We are able to show that parents had similar labor market outcomes after their child's birth but before the diagnosis by using data starting five years prior to diagnosis, which leads more credibility to the diagnosis being as-if random.

To address the endogeneity concerns, recent papers have been looking for plausibly exogenous variation to use to estimate effects. Corman, Noonan and Reichman (2005) look at the impact from having a child born with a serious health problem and use the availability of adoption agencies and the availability of a neonatal intensive care unit in hospitals as a source of exogenous variation. Frijters, Johnson, Shah and Shields (2009) use child handedness as an instrumental variable to examine how child development affects maternal labor force participation. Child handedness is related to measures of child development but should not affect maternal labor force participation through any other channel. The authors find that an increase in developmental delays does reduce maternal labor force participation. Thus, a finding of a reduction in labor supply due to having a child diagnosed with T1D would be consistent with these recent papers, but in the context of a disease that is not congenital.

4. Data and descriptive statistics

The data stems from several Danish registers. Children diagnosed with T1D are drawn from the clinical register DanDiabKids (see Svensson et al. (2016)). It contains information on all Danish children and adolescents (<18 years) diagnosed with T1D. Each child is identified with a person-ID (*CPR-nummer*) and the exact date of diagnosis is recorded. From 1990 to 2017 we observe 5,838 children who are diagnosed with T1D. The mean age at onset is 9.34 years (SD 4.05). To facilitate our analysis, for each child with T1D we identify and match five control children that do not develop diabetes in the period of observation. The children are matched based on the exact date of birth and sex (29,190 children). Each child in the control group is assigned a pseudo date of onset corresponding to the child in the diabetes group for whom they serve as control.

Through population registries within Statistics Denmark, the children can be linked to their parents. For the parents we observe labor income, if they work fulltime/part-time, are employed in the private vs. public sector, educational attainment, the number of children in the household, if they are immigrants, age, and prescription drug expenditures related to drugs targeting the nervous system (anti-depressants and anti-anxiety drugs etc.). These data points are recorded on a yearly basis. For the parents of the children we construct a yearly panel starting five years before onset of diabetes and ending ten years after.

As matching only on date of birth and sex is relatively crude, we compare parental characteristics of children who are diagnosed with diabetes to the controls measured two years before disease onset so parental characteristics cannot be impacted by the diagnosis; see Table 1. We are able to identify the mother for 5,779 (99%) of the children with diabetes and 28,671 (98.2%) of the children in the control group. Similarly, fathers are identified for 5,427 (92.3%) of the children with diabetes and 26,681(91.4%) of the children in the control group. Mothers of children with diabetes differ in a statistical sense from the mothers of the children in the control group along a couple of dimensions. Mothers of children with diabetes are significantly less likely to have immigrant background. The difference is highly significant, and the relative difference is also quite large - mothers of children with diabetes are 34% less likely to be immigrants. This finding is consistent with previous research finding a higher incidence of T1D in the Nordic countries (International Diabetes Foundation).[10] This higher incidence does not contradict the medical literature showing genetics plays only a small role because T1D could be due to environmental factors.[11] Further, mothers of children with diabetes have slightly fewer children (2.31 vs 2.34) with the difference being statistically significant at the 5% level, albeit the magnitude of the difference is small. Mothers of children with diabetes are also slightly less likely to have an academic degree (>= Master's degree), 7% vs 8%. The fathers are different between the two groups along the same dimensions as the mothers.

In appendix table A1 we have regressed the outcome of a child developing T1D in two years on the characteristics above. Despite some differences in observable characteristics, we do not find any strong evidence that T1D in children is tied to

[10] The IDF 2017 Atlas provides incidence rates of T1D for those 20 years old or younger across countries. Finland ranks 1, Sweden ranks 3, Norway ranks 5 and Denmark ranks 10. The United States ranks 1 if the outcome is instead the number of people 20 years old or younger who are diagnosed with T1D.

[11] See https://www.jdrf.org/t1d-resources/about/causes/ for a brief discussion of how early exposures to environmental factors is a research interest.

socioeconomic status. Recent evidence also shows that Danish children with T1D have similar standardized test scores in math and reading as their peers; see Skipper et al. (2019). This lends further credibility to the assumption that T1D can be interpreted as a near-random health shock.

To further support the claim that T1D hits children as-if randomly, Figure 1 plots the log of the wage income for the treatment and control mothers. The level and trend of mothers are the same five years to one year prior to diagnosis. In the year of diagnosis, there is a divergence such that the log wage income for mothers whose child is diagnosed with T1D falls below the log wage income for mothers who child is not diagnosed. This gap persists for at least ten years after diagnosis.

We also plot the same log wage income for fathers whose children will be diagnosed with T1D compared to fathers whose children will not be diagnosed in Figure 2. Similar to Figure 1, the level and trends of log wages from five years prior to one year prior to diagnosis are the same between the treatment and control fathers. The main difference for fathers is that the decline in log wage income for treated fathers is much more transitory; specifically, by three years after diagnosis, the treatment and control fathers experience similar levels and trends in log wage income again.

5. Empirical strategy

As pointed out in the previous section, the diagnosis of T1D is arguably a (near) random, unforeseeable shock to child health. To investigate potential effects of diabetes onset on parental labor market outcomes, we start out by estimating event-study equations of the following form:

$$y_{it} = \alpha_0 + \sum_{j=-5}^{-2} \delta_j \cdot I_{it}(j = t) \cdot I_i(Diabetes = 1) + \sum_{j=0}^{10} \delta_j \cdot I_{it}(j = t) \cdot I_i(Diabetes = 1) + \beta_t + immig_i + \varepsilon_{it} \qquad (1)$$

where y_{it} denotes the outcome of interest (e.g. wages or labor market participation). As is standard in the literature, we estimate effects relative to j=-1, or one year prior to diagnosis. The δ_j's are estimates (j years before or after diagnosis) of the effects of having a child with T1D. Our four main outcomes are labor force participation (having positive wage income), wage income (in logs), working part time, and working in the public vs private sector. The individual control variable is immigration status since it is the main characteristic in which covariates did not balance across treatment and control in Table 1. We also control for year fixed effects (β_t). The above analysis is repeated for each outcome for both mothers and fathers.

We also estimate a simplified version of (1) with just one pre-/post treatment indicator:

$$y_{it} = \alpha_0 + \beta \cdot I_{it}(post = 1) + \gamma \cdot I_i(Diab = 1) + \delta \cdot I_{it}(post = 1) \cdot I_i(Diab = 1) + \beta_t + immig_i + \varepsilon_{it} \qquad (2)$$

Here our parameter of interest (the difference-in-differences estimate) is δ. We estimate (2) both with and without individual level fixed effects, and we also investigate the sensitivity of leaving out the onset year. We again control for immigrant status. Standard errors are clustered at the individual level in both the event study and difference-in-differences regressions.

6. Results

The event study results for our main outcomes of interest are shown in Figure 3. Panel A shows the differences in the probability of having a positive wage income for mothers. The differences are small and statistically insignificant both before and after the onset of diabetes. Turning to panel B with the log wage income, it is clear that the wage income of mothers between the two groups does not differ in the pre-onset years; the estimated differences in wage income is numerically small and statistically insignificant. In the year of diagnosis, the mothers of children with diabetes earn around four percent less, which is to be expected given that some children will be diagnosed earlier in the year. The decline in the wage income becomes larger and statistically significant for years t=1 to t=10, corresponding to a decline in wage income of three to five percent. This suggests that at least ten years after the child is diagnosed with T1D, mothers of affected children still earn around five percent less compared to mothers in the control group.

To put this into context, Simonsen and Skipper (2006) estimate the effect of motherhood on wages in Denmark to be around 6.5 percent. Lundborg, Plug, and Rasmussen (2017) estimate the motherhood penalty (also in Denmark) by using IVF as an instrumental variable for motherhood and find a 3.4 percent decline in wages two to five years after treatment. Lundborg, Plug and Rasmussen (2014) look at long run impacts from having a child using the IVF instrumental variable and find negative impacts on wages that persist at least ten years after the birth of a child. Thus, the magnitude and duration of the wage decline from having a child diagnosed with T1D is similar to the penalty from having a child.

Turning to intensity of work, there is an economically meaningful increase in the probability of working part-time conditional on working in the year of diagnosis (panel C, figure 1). The difference is 12.4 percentage points (pp), given the pre-onset mean is 36 percent, which corresponds to a relative increase of around 33 percent. This difference declines in t=1 and stabilizes to around two pp for the years t=2…10 (see panel C). This decline in labor supply is consistent with the theoretical prediction from Gould (2004) since T1D is time-intensive and unpredictable. Panel D shows the results on the probability of working in the public sector conditional on working. The public sector in Denmark may be more appealing after the child is diagnosed because of increased work flexibility. In the year of diagnosis, this is 2.0pp higher for the mothers in the diabetes group, however it declines to around 1.5pp in the following years and is insignificant in most years. The pre-onset mean is 55 percent; thus, in terms of magnitude, the differences are small.

For the same set of outcomes, we estimate the difference-in-differences model shown in equation (2). For each outcome, three specifications are reported: a standard version with group effects, one with individual fixed effects, and one with individual fixed effects leaving out the year of diagnosis. These results are found in panel A of Table 2. The previous findings are confirmed; wage income is significantly lower for mothers in the diabetes group (4.6 to 4.9pp) and the probability of working part-time is increased (2.8 to 3.8pp). We do not find any significant effects on the probability of having positive wage income nor on working in the public sector. Switching to the public sector is significant on the 10 percent level in two specifications, however.

Our results are similar to the results found in Juame and Willén (2018). They estimate how parental labor supply is impacted by school closings due to teacher strikes in Argentina. They also find that mothers reduce their labor supply and that mothers face a decline in earnings of around three percent of the mean earnings. This paper complements our work in that we find different types of shocks seem to lead to similar results in terms of parental labor supply.

We do a back-of-the envelope calculation to determine the present discounted value of the lost wages in the year of diagnosis through ten years after using our difference-in-differences estimate of the maternal wage decline. Following Cellini and Turner (2019) we use a 5 percent discount rate in our calculation. The lost wages amount to a decline in maternal income of DKK 91,433 or $13,749. If we scale this by the 5,779 mothers with a child diagnosed during our sample period, this means the total lost wages are DKK 528 million or $79.5 million. Given that the wage decline may persist longer than ten years after diagnosis, this number is likely an underestimate of the cost to families.

The same analyses are carried out for the fathers; see figure 4 and panel B of Table 2. For the fathers there is a temporary difference in working part time only in the year of diagnosis (3pp. relative to pre-treatment mean of 23 percent). There is an income drop of around 4pp in the year of diagnosis persisting for two years post diagnosis, but then the income gap closes. Turning to the difference-in-differences regressions, we only observe significant differences for the fathers on wage income and the probability of working part time, though none of the differences are significant at the 5 percent level in the fixed effects specifications that leaves out the onset year. This is also similar to Juame and Willén (2018) which find no impacts on father's labor supply overall.

Given that we find some characteristics are significantly related to being diagnosed with T1D in the next two years, we check whether our results are robust to adding controls for observable characteristics into the regressions. Results are shown in the appendix in Figure A1 (maternal results) and Figure A2 (paternal results). The results are very consistent both in a quantitative and qualitative sense.

Heterogeneity analysis

The responses outlined above potentially mask some heterogeneity. For instance, in families where the children are younger at the time of onset, the labor supply response may be different as younger children need more care from the parents. We consider differential labor market responses for four subgroups of mothers based on: 1) educational attainment (at least a Master's degree), 2) being a single parent, 3) if the child was younger than six years at diabetes onset, and 4) if the child is female in case parents treat children differently by their sex. Specification (2) is re-estimated including sub-group specific dummies in levels and interacted with the indicators *post*, *diab*, and the interaction of the two (estimated sequentially for each sub-group). To investigate longer run responses the year of diagnosis has been left out in these analyses.

Panel A (Table 3) shows the results on maternal educational attainment. For all four outcomes, the mothers with a master's degree or more do not have different outcomes compared to the mothers in the control group (with similar levels of education). Not only are the estimates insignificant at the 5 percent level they are also small in magnitude. Different explanations for this finding are possible: the opportunity costs of the highly educated mothers are higher (reflected in the mean wage income) or these mothers may be in jobs where working hours are more flexible.

For the single mothers (panel B, Table 3) there are no significant differences; however, the point estimate suggests that they earn 8.9 percent less wage income. We find the group of mothers whose child was younger than six at disease onset had larger decreases in income (8.6 percent). We do not find any differences in the labor market response of the mother depending on the sex of the child (Panel D, Table 3).

Mothers may be reducing their labor supply more than fathers due to differences in earnings (economic reason) or due to traditional gender roles (mothers are expected to be the ones caring for their children). In a separate analysis, we also look at the group of mothers who earn less than their partners (conditional on parents living together). In our sample 29.5 percent of mothers earn more than fathers, conditional on living together the year prior to diagnosis. We do not find any evidence of a differential response if the mother earns less than the other parent, nor do we find different responses in families with more than two children (results not reported). While it would be interesting to compare what happens in same sex couples, the sample size is not large enough to compare those with a child with T1D to those with children without T1D.

Mechanisms

While we observe significant reductions in maternal labor supply when a child is diagnosed with T1D, the underlying mechanisms are unclear. As the condition is chronic, care and support of the child are obvious candidates. However, stress or 'sorrow' over suddenly having a child with a severe chronic disease may be another dimension that could affect labor supply negatively. Given that our results of reduced labor supply hold regardless of whether the mother earns more or less than the father, it does not seem to be the case that it is due to increased opportunity costs for one parent.

While we do not have access to time-use data for the parents, we do have access to information on their prescription drug purchases. We aggregate yearly total spending (copayment + insurance) on prescription drugs related to the nervous system.[12] This drug group includes anti-anxiety medications such as benzodiazepines (e.g. Xanax) but also medications related to treating depression (SSRIs).

Mothers may be more impacted by increased stress since Hauser-Cram, Warfield, Shonkoff, Krauss, Sayer and Upshur (2001) find that a child illness negatively impacts the mother's level of stress, although there is no impact on the father. Morris (2012) finds working may improve mental health for mothers who have a child with a disability who is older as working could be considered a coping strategy, but there is no impact for fathers. Schiaffini, Carducci, Cianfarani, Mauti, and Nicolais (2019) find two thirds of parents with a child with T1D have clinical levels of trauma.

[12] ATC main group N. The Anatomical Therapeutic Chemical (ACT) Classification System is an international drug classification system that classifies the active ingredient according to the organ or system on which they act and their therapeutic, pharmacological and chemical properties. N refers to drugs targeted the nervous system.

The event study results are reported for mothers (panel A) and fathers (panel B) in Figure 5. Generally, the parents of affected children do not have different drug expenditures. For all years, the differences are small and insignificant. Estimating equation (2) for this outcome yields similar results: For both mothers and fathers we see statistically insignificant differences, and the magnitudes are generally small (<10 percent relative to pre-treatment mean). These results are robust to using a dummy variable equal to one if the person has any expense in this category.

7. Conclusion

In this paper we use the as-if random health shock of a child getting diagnosed with T1D to estimate a plausibly causal impact on parental labor supply. The exact cause of T1D is unknown and not related to lifestyle (unlike Type 2 Diabetes), the condition is unforeseeable with a low degree of inheritability and diagnosis is not related to socio-economic status. Additionally, while being a serious chronic health condition, it does not qualify one for welfare in Denmark. This makes T1D a good candidate to overcome the econometric issues in studying how child health affects parents. Using an event study and a difference-in-differences estimation with Danish administrative registry data, we look at a variety of parental labor market outcomes from five years prior to ten years after diagnosis.

We find that effects are strongest for mothers. While our results show no effect on labor force participation, we find that conditional on working, mothers are more likely to work part-time through at least ten years after the diagnosis. These labor supply reductions lead to a decline in wage income of between four and five percent. However, for mothers with high educational attainment (Master's degree or more) there is no significant change in labor supply at the five percent level. We do not find a corresponding wage decline for fathers when their child is diagnosed, except for in the year of diagnosis through two years after. At that point, father's labor market outcomes return to the pre-diagnosis levels.

While concerns have been raised about the external validity of Danish data, the United States health care system is not representative of how most developed countries set up health insurance. For example, the New York State Department of Health lists numerous countries with access to universal health care including, but not limited to, Australia, Belgium, Canada, Finland, France, Germany, Israel, Japan, New Zealand, Singapore, South Korea, the United Arab Emirates and the United Kingdom. Thus, while our results may not hold in the United States setting in which parents may experience job lock, other countries with universal health care may have more similar results to Denmark. Also, given numerous proposals by politicians in the United States to move towards universal health care, it is important to understand how parents may react in that type of health insurance environment.

The impacts on mothers is economically important. The magnitude of the reduction in wage income mothers face is similar in magnitude to the motherhood penalty. These mothers may benefit from welfare to replace lost wages, as is done for other disabilities in Denmark. Given the unpredictability of T1D and need for constant monitoring, it would not be feasible to have a medical professional caring for the child 24-7 instead of the parents.

There are important medical implications as well. Nielsen et. al (2019) show that among children with T1D there are significant differences in children's glucose control across levels of maternal education in Denmark, despite the universal access to health care. Thus, even though we find less educated mothers are reducing their labor supply more than more educated mothers, previous research finds that those children are still having clinically meaningful worse disease management. Perhaps these mothers would not need to reduce their labor supply as much if there were more options for flexibility in their jobs, since we find a marginally significant shift from the private sector to the public sector.

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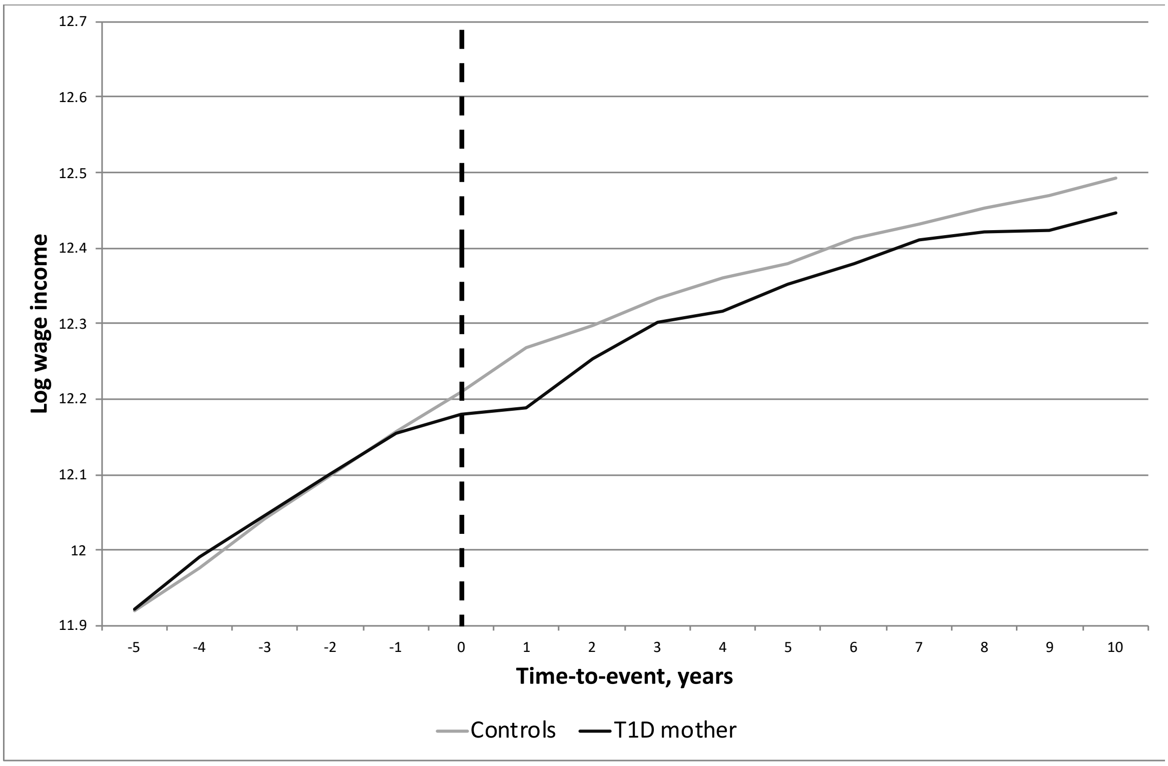
TABLE 1: Observable characteristics of parents 2 years prior to diagnosis year

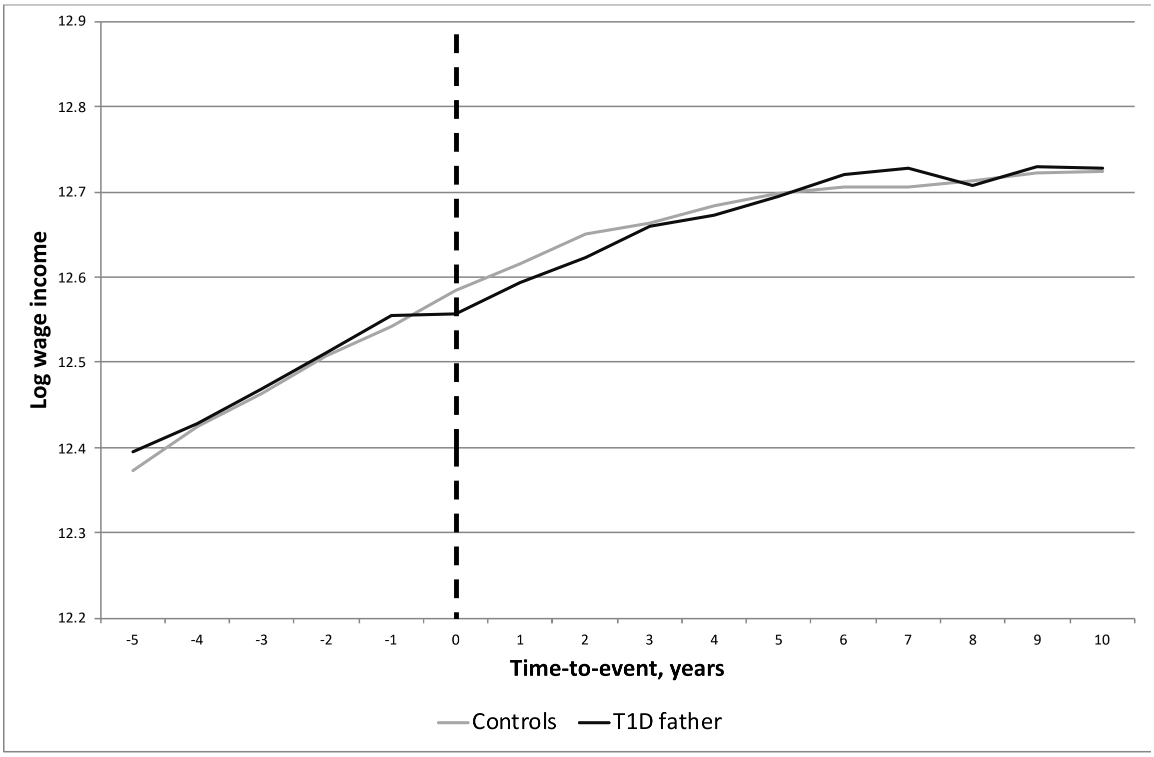
	Diabetes Group		Control Group			
Variable	Mean	SD	Mean	SD	% difference	p-value
<u>*Mothers*</u>						
Age	35.77	6.02	35.67	6.07	0.28%	0.251
# children	2.31	1.01	2.34	1.01	-1.25%	0.047
Immigrant	0.08	0.28	0.11	0.32	-34.20%	<0.001
Wage income (DKK 1,000)	227.90	166.63	225.66	170.34	0.99%	0.352
Drug expend., nervous system (DKK)	378.43	2093.19	399.04	2662.54	-5.45%	0.544
Academic education, share	0.07	0.25	0.08	0.26	-11.09%	0.039
Unskilled worker, share	0.23	0.42	0.23	0.42	-0.93%	0.723
Parents living together	0.72	0.45	0.72	0.45	1.04%	0.244
On social assistance, share	0.05	0.21	0.05	0.21	-0.24%	0.970
Working part-time	0.36	0.48	0.36	0.48	1.07%	0.639
Employed in public sector	0.55	0.50	0.54	0.50	1.29%	0.406
n =	5,779		28,671			
<u>*Fathers*</u>						
Age	38.53	6.74	38.38	6.73	0.39%	0.137
# children	2.34	1.07	2.38	1.07	-1.67%	0.014
Immigrant	0.08	0.28	0.12	0.32	-41.35%	<0.001
Wage income (DKK 1,000)	354.60	271.17	352.47	296.37	0.60%	0.605
Drug expend., nervous system (DKK)	284.80	2410.79	293.87	2528.89	-3.19%	0.815
Academic education, share	0.09	0.28	0.10	0.30	-16.39%	0.001
Unskilled worker, share	0.21	0.41	0.21	0.41	0.55%	0.849
On social assistance, share	0.03	0.16	0.03	0.17	-16.21%	0.079
Working part-time	0.23	0.42	0.24	0.42	-1.97%	0.515
Employed in public sector	0.21	0.40	0.20	0.40	1.56%	0.634
n =	5,427		26,681			

Figure 1: Mean log wage income of mothers with vs. without a child that develops diabetes at t=0



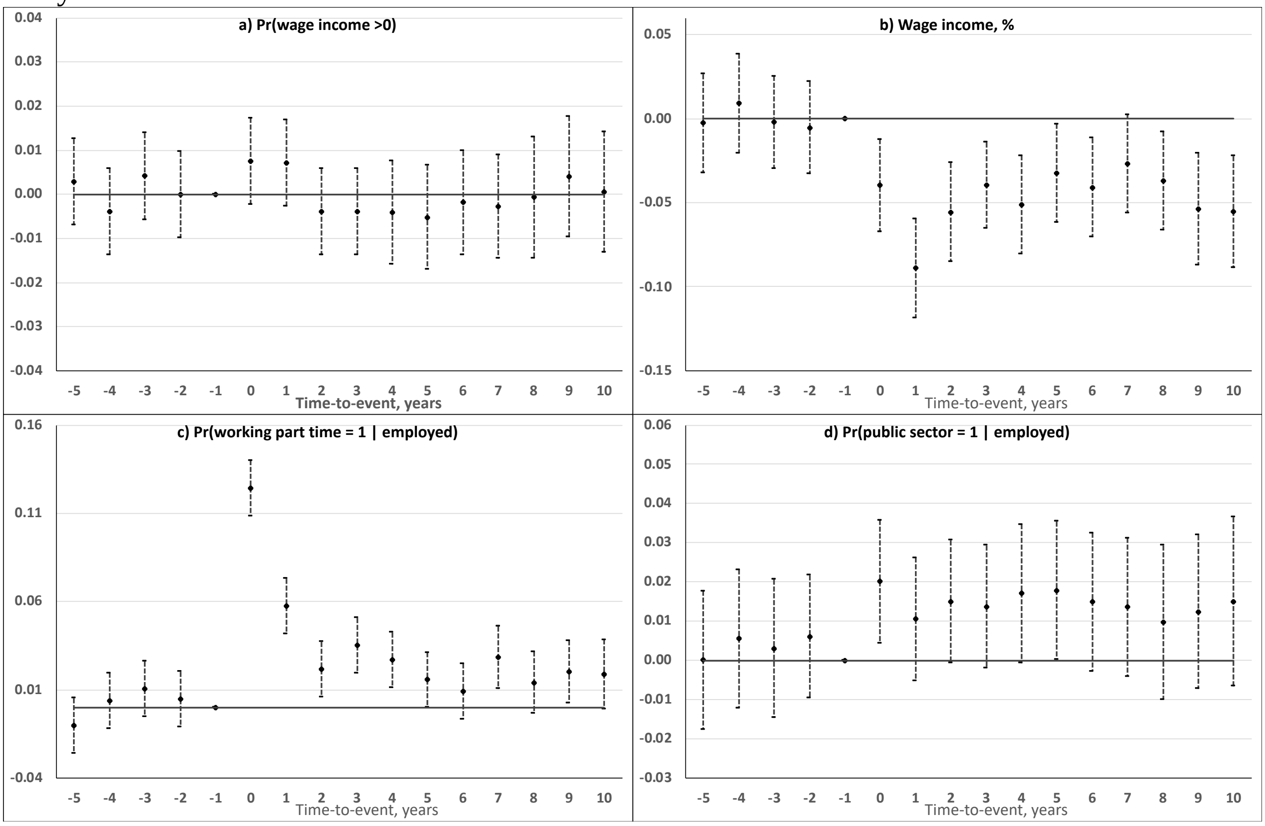
Note: Log wage income by year relative to onset year.

Figure 2: Mean log wage income of fathers with vs. without a child that develops diabetes at t=0



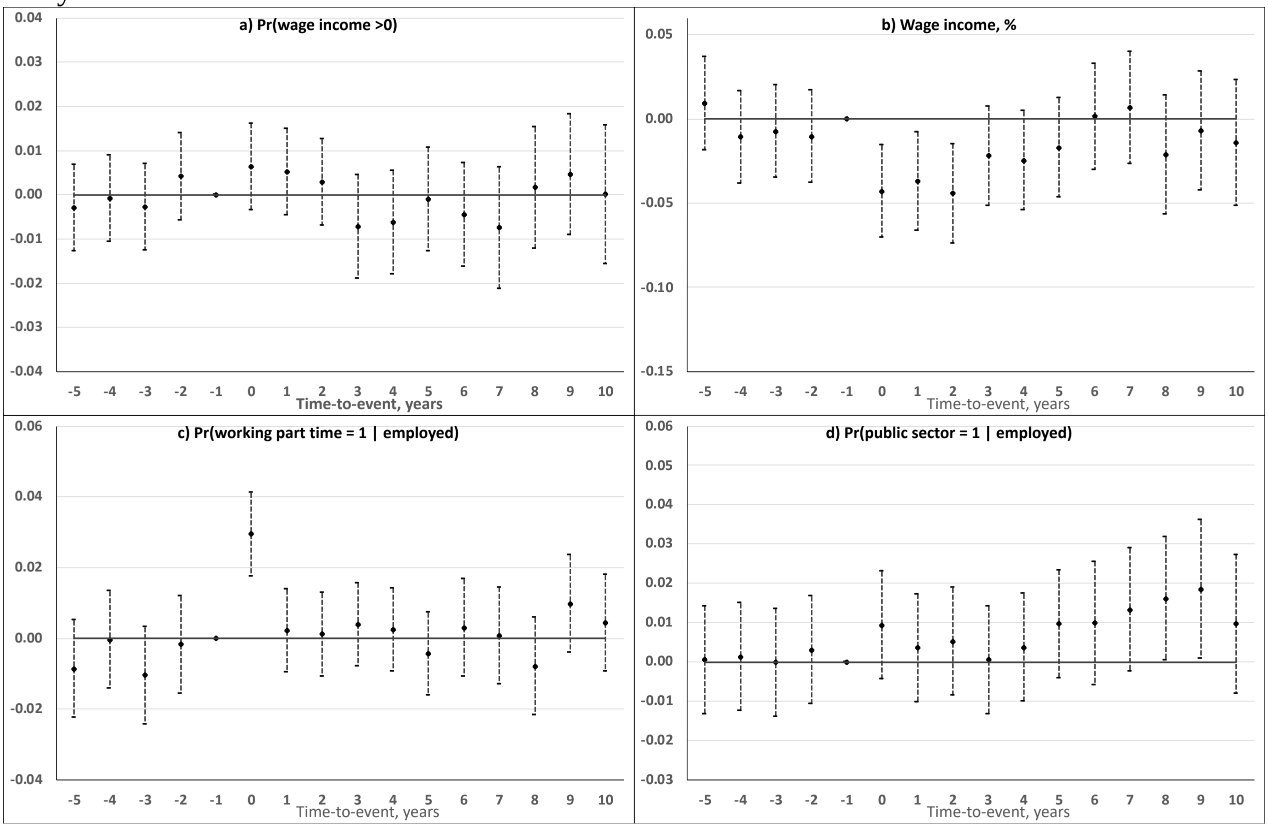
Note: Log wage income by year relative to onset year.

Figure 3: Differences in maternal labor market outcomes with vs without diabetes, event study



Note: Mean differences (and 95% CI) in outcomes between mothers with and without a child diagnosed with T1D in year t=0.

Figure 4: Differences in paternal labor market outcomes with vs without diabetes, event study



Note: Mean differences (and 95% CI) in outcomes between fathers with and without a child diagnosed with T1D in year t=0.

Table 2: Difference-in-differences estimation results

Panel A: Regression results for mothers

	(1)			(2)			(3)			(4)		
OUTCOME	Wage income > 0 (0/1)			Log wage			Working part time (0/1)			Public employment (0/1)		
Diabetes	-0.000			-0.002			0.000			0.000		
	[0.004]			[0.010]			[0.006]			[0.008]		
Post	0.013***	0.007***	0.008***	0.037***	0.009*	0.013**	-0.007**	0.008**	0.002	0.006**	-0.002	-0.004
	[0.002]	[0.002]	[0.002]	[0.005]	[0.005]	[0.005]	[0.003]	[0.003]	[0.004]	[0.003]	[0.002]	[0.003]
DiabetesXPost	0.000	-0.002	-0.003	-0.046***	-0.046***	-0.049***	0.037***	0.038***	0.028***	0.011*	0.009*	0.007
	[0.004]	[0.004]	[0.004]	[0.009]	[0.009]	[0.010]	[0.006]	[0.006]	[0.006]	[0.006]	[0.005]	[0.005]
Outcome mean:		0.82			12.11			0.32			0.54	
Observations	478,425	478,425	443,784	392,667	392,667	364,248	346,890	346,196	321,483	350,510	349,838	324,578
R-squared	0.079	0.611	0.611	0.128	0.580	0.581	0.066	0.442	0.445	0.003	0.785	0.785
Individual F.E.	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Onset yr included	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No

Panel B: Regression results for fathers

	(1)			(2)			(3)			(4)		
OUTCOME	Wage income > 0 (0/1)			Log wage			Working part time (0/1)			Public employment (0/1)		
Diabetes	-0.001			-0.004			-0.006			0.002		
	[0.004]			[0.011]			[0.004]			[0.007]		
Post	0.007***	0.003	0.003	0.034***	0.002	0.006	-0.016***	0.000	-0.001	0.001	-0.002	-0.002
	[0.002]	[0.002]	[0.002]	[0.005]	[0.004]	[0.005]	[0.002]	[0.002]	[0.003]	[0.002]	[0.002]	[0.002]
DiabetesXPost	0.001	0.000	-0.001	-0.019*	-0.018**	-0.018*	0.011**	0.011**	0.008	0.007	0.004	0.002
	[0.004]	[0.004]	[0.004]	[0.010]	[0.009]	[0.010]	[0.004]	[0.005]	[0.005]	[0.005]	[0.004]	[0.004]
Outcome mean:		0.84			12.59			0.20			0.21	
Observations	442,152	442,152	410,110	371,450	371,450	344,326	344,026	341,354	316,515	336,172	334,808	310,268
R-squared	0.054	0.651	0.650	0.093	0.670	0.670	0.099	0.393	0.395	0.003	0.822	0.821
Individual F.E.	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Onset yr included	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No

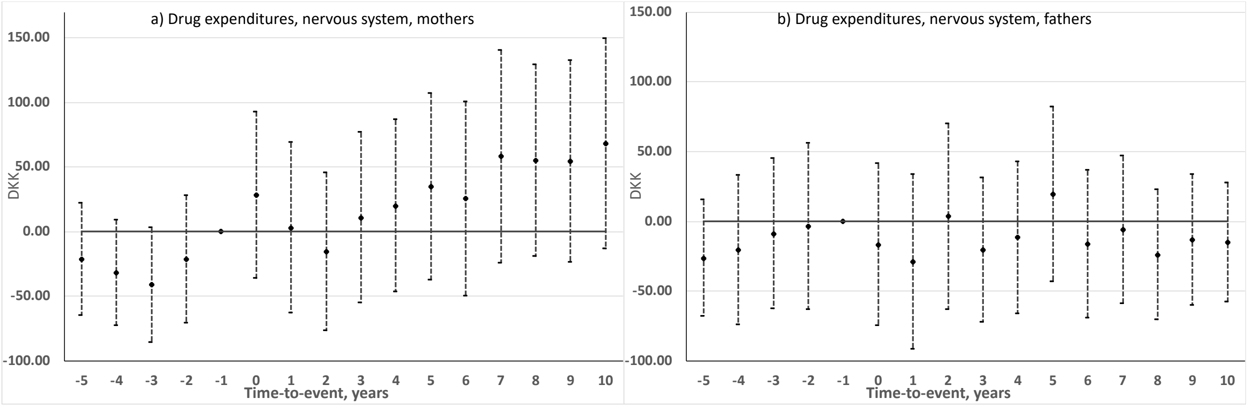
Notes: All regressions are adjusted for age and immigrant status. *** significance at 1% level, ** significance at 5% level, * significance at 10% level.

Table 3: Response heterogeneity by sub-group, mothers

	(1)	(2)	(4)	(5)
OUTCOME	Any wage income (0/1)	Log wage income	Working part time (0/1)	Public sector (0/1)
Panel A: Mother has Master's Degree or above				
(1) Diabetes X Post	-0.005	-0.047***	0.029***	0.006
	[0.004]	[0.010]	[0.007]	[0.006]
(2) Diabetes X Post X Master's degree	0.028*	0.030	-0.036*	0.012
	[0.015]	[0.035]	[0.020]	[0.017]
(1) + (2)	0.023*	-0.017	-0.007	0.018
	[0.014]	[0.033]	[0.020]	[0.016]
Panel B: Single mother in t-1				
Diabetes X Post	-0.001	-0.043***	0.026***	0.008
	[0.004]	[0.010]	[0.007]	[0.006]
Diabetes X Post X Single Mother	-0.017	-0.046	0.009	-0.012
	[0.013]	[0.033]	[0.019]	[0.019]
(1) + (2)	-0.018	-0.089***	0.036**	-0.004
	[0.013]	[0.032]	[0.018]	[0.018]
Panel C: Diabetes onset LE age 6				
Diabetes X Post	-0.004	-0.036***	0.027***	0.007
	[0.005]	[0.011]	[0.007]	[0.006]
Diabetes X Post X Early onset	0.003	-0.050**	0.001	-0.001
	[0.010]	[0.024]	[0.015]	[0.013]
(1) + (2)	-0,001	-0.086***	0.029***	0.004
	[0.008]	[0.021]	[0.013]	[0.011]
Panel D: Child is female				
Diabetes X Post	-0.001	-0.049***	0.029***	0.012
	[0.006]	[0.014]	[0.009]	[0.008]
Diabetes X Post X Female	-0.005	0.001	-0.003	-0.010
	[0.008]	[0.019]	[0.013]	[0.011]
(1) + (2)	-0.005	-0.049***	0.026***	0.001
	[0.006]	[0.014]	[0.009]	[0.008]
Outcome mean:	0.821	12.4	0.318	0.544
Observations	443,784	364,248	321,483	324,578

Notes: All regressions are adjusted for age and immigrant status. All specifications are with individual fixed effects. Diagnosis year left out. *** significance at 1% level, ** significance at 5% level, * significance at 10% level.

Figure 5: Differences in prescription drug expenditures targeting nervous system, mothers and fathers, time-to-event



Note: Differences in mean total prescription drug expenditures for drugs targeting the nervous system (with 95% CI). Mothers and fathers.

Table 4: Difference-in-differences estimates, prescription drug expenditures targeting nervous system

	(1) Mothers			(2) Fathers		
OUTCOME	Prescription drug expenditures, nervous system			Prescription drug expenditures, nervous system		
diabetes	-27.009			-20.157		
	[24.651]			[29.687]		
post	-3.997	-8.476	-3.761	2.551	1.215	7.190
	[14.468]	[15.538]	[18.215]	[14.255]	[14.124]	[16.731]
diabetesXpost	63.334**	25.221	23.258	7.681	-0.220	-1.697
	[30.336]	[26.419]	[28.496]	[28.671]	[25.729]	[27.671]
Outcome mean:		385.3			312.5	
Observations	473,302	473,302	440,943	437,804	437,804	407,887
R-squared	0.005	0.553	0.553	0.002	0.550	0.547
Individual F.E.	No	Yes	Yes	No	Yes	Yes
Onset yr included	Yes	Yes	No	Yes	Yes	No

Note: Total prescription drug expenditures on drugs targeting the nervous system. *** significance at 1% level, ** significance at 5% level, * significance at 10% level.

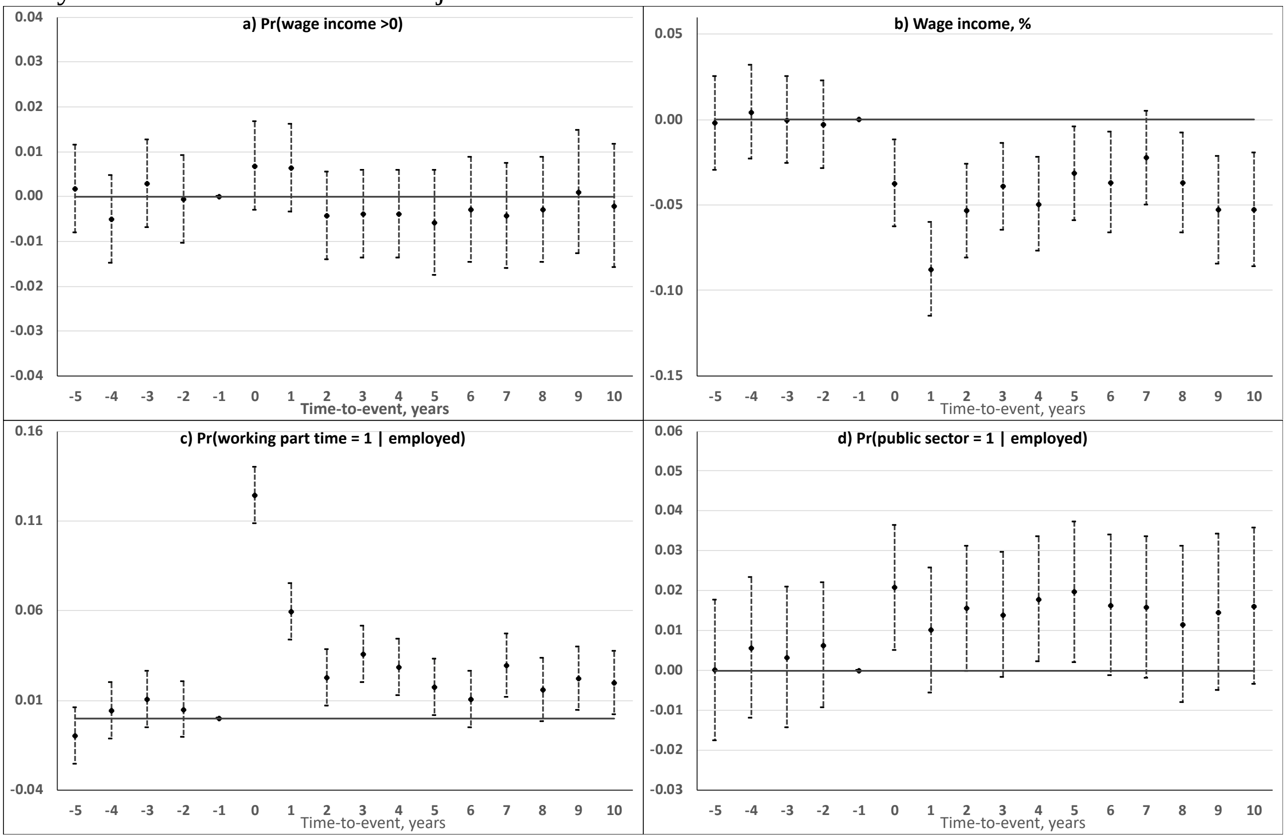
Appendix

Table A1: Probability of child developing diabetes in two years regressed on observable characteristics

VARIABLES	(1) Mothers	(1) Fathers
Age	0.000	0.001**
	[0.000]	[0.000]
# Children	-0.003	-0.004*
	[0.002]	[0.002]
Immigrant	-0.042***	-0.047***
	[0.007]	[0.007]
Wage income (DKK 100,000)	0.001	-0.000
	[0.002]	[0.001]
Drug expend., nervous system (DKK)	-0.000	0.000
	[0.000]	[0.000]
Academic degree	-0.018**	-0.025***
	[0.008]	[0.007]
Unskilled worker	0.000	0.001
	[0.005]	[0.005]
Both parents living together	0.007	0.005
	[0.005]	[0.005]
On social assistance	0.014	-0.005
	[0.011]	[0.015]
Working part time	0.005	-0.001
	[0.005]	[0.006]
Employed in public sector	0.004	0.005
	[0.005]	[0.006]
Constant	0.155***	0.156***
	[0.025]	[0.026]
Observations	34,450	32,108
R-squared	0.002	0.002

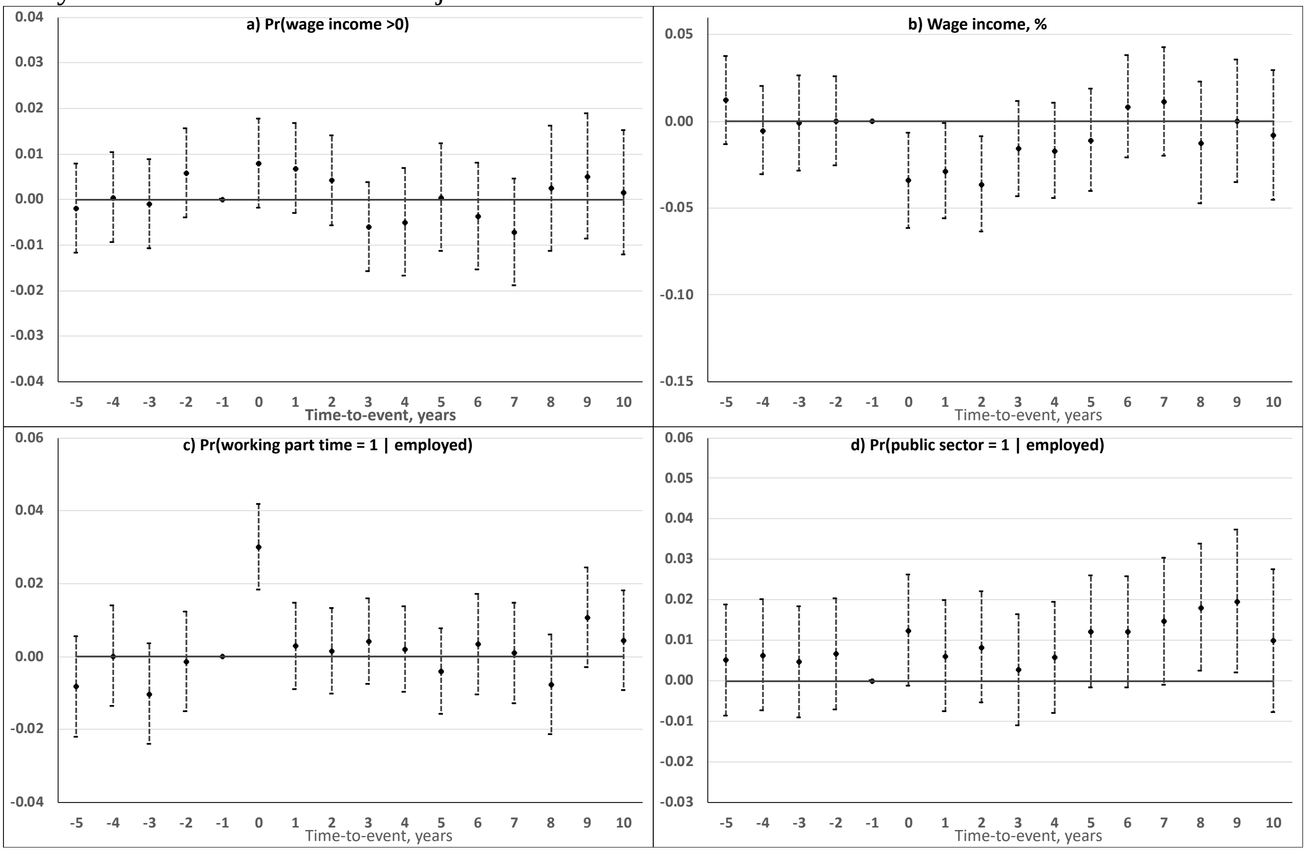
Notes: (0/1) outcome of child developing diabetes in 2 years regressed on observable characteristics separately for mothers and fathers.

Figure A1: Differences in maternal labor market outcomes with vs without diabetes, event study with additional covariate adjustment.



Note: Mean differences (and 95% CI) in outcomes between mothers with a child who are diagnosed in year t=0 compared to mothers in the control group. Adjusted for: Immigrant status, age, number of children, mother has an academic degree, mother is unskilled worker, and both parents living together.

Figure A2: Differences in paternal labor market outcomes with vs without diabetes, event study with additional covariate adjustment.



Note: Mean differences (and 95% CI) in outcomes between fathers to a child who are diagnosed in year t=0 compared to fathers in the control group. Adjusted for: Immigrant status, age, number of children, father has an academic degree, father is unskilled worker, and both parents living together.

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