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Double trouble: The burden of child rearing and working on maternal mortality[a]

by

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Abstract

We document increased old-age mortality rates among Swedish twin mothers compared to non-twin mothers. Results are based on administrative data on mortality for the years 1990 to 2010. We argue that twins are an unplanned shock to fertility in the cohorts of older women considered. Deaths due to lung cancer, chronic obstructive pulmonary disease and heart attacks, which are associated with stress during life, are significantly increased. Stratifying the sample by education and pension income shows the highest increase in mortality rates among highly educated mothers and those with above-median pension income. These results are consistent with the existence of a double burden from child rearing and working on mothers' health.

Keywords: Mortality, maternal health, fertility, twins
JEL-codes: I1, J13, J2

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1 Introduction

In times of demographic change and aging populations, policy makers in many countries are concerned about the development of the work force. In order to buffer the systematic aging and potential shrinking of the work force, policies that encourage an increase in female labour supply are often on the agenda. At the same time, family policies aiming at an increase in fertility rates are discussed (Jaumotte, 2004). However, for many mothers (and arguably fathers), it is challenging to actively raise children and pursue a career, because both are time consuming activities. Moreover, family life and careers may affect parental health through the stress that may occur from the double burden of working and caring for children at the same time. This paper studies this (potential) double burden and its effect on maternal health later in life. When designing public policies aimed at increased fertility rates and/or increased female labor supply, any negative health consequences of family and work have to be taken into account. In the United States and in many other developed countries work-family conflict and its potential negative effects are a public concern (see, e.g. Williams and Boushey, 2010).

Our analysis is based on administrative birth and death registries from Sweden. To study the effect of childbearing and labor force activity on maternal health, an ideal set-up would provide exogenous variation in both labor market activity and childbearing. In this paper, we use twin births as an unplanned fertility shock. Initially, we compare health outcomes of mothers who had twins at first birth (twin mothers) with those of mothers of singletons at first birth (non-twin mothers). The Swedish data allow us to follow mothers over a long time period, and we are the first to study old-age mortality. We find that twin mothers have a 3.8 percentage point (13%) higher all-cause mortality risk compared to mothers of singletons. This provides some initial evidence on the relationship between family, work and health.

However, while twinning is an exogenous shock[1], it can affect old-age health via mul-

[1] A potential threat to our empirical strategy is that twin births are not random. The probability of a twin birth increases with mothers' age at birth and the use of in-vitro fertilization. We argue that we can use this strategy nevertheless, because the cohorts examined in this study had their first children well before any major impact of fertility treatments on the number of twin births. Additionally, we condition on mothers' age at first birth in all our analyses.

tiple pathways. The twin mothers in our data have on average 0.68 more children five years after the first birth, but child spacing also changes (the spacing between the first and the last child is 3.8 years for twin mothers and 7.4 years for non-twin mothers). Twinning may also affect health risks during pregnancy, delivery and marital stability. Moreover, if women adjust their labor market choices depending on the children (Lundborg *et al.*, 2017), this may reduce any negative health impacts from the fertility shock due to twinning. Therefore, we examine the reduced form effect and do not use twin births as an instrumental variable for the number of children.

To understand potential mechanisms and to study a double burden effect of family and work, we pursue two strategies.[2] First, we stratify the sample along educational attainment and pension income. Both these measures are strongly related to labor force attachment. Level of education is an *ex ante* predictor of higher labor market activity, and pension income is a proxy for *ex post* realized labor market activity. Thus, if the double burden of working and caring for children is important, we expect to see larger health effects of a fertility shock (twin births) for women with high education and/or high pension income, because these women more often combine working and child rearing.[3] The second strategy to understand the mechanism behind the increased mortality of twin mothers is to analyze specific stress-related diseases. The underlying hypothesis is that the double burden of working and caring for children at the same time creates stress, which may particularly affect stress-related mortality. Here, one challenge is the measurement of lifetime stress. We analyze two specific groups of medical diagnoses related to stress during life: cardiovascular diseases (heart attacks and strokes) and smoking-related diseases (lung cancer and chronic obstructive pulmonary disease (COPD)) (Brotman *et al.*, 2007; Kouvonen *et al.*, 2005). The literature shows that strong predictors of cardiovascular dis-

[2] For both strategies, we do not assume that twin births do not affect mothers' labour market decisions. For instance, it may be the case that twin mothers reduce labor market participation, and this may have a positive effect on their health. This is one reason why we use these additional strategies and not only use the initial twin effect as evidence of a double burden effect.

[3] Note that we focus on mothers because women are traditionally more likely than men to find themselves in a situation where family and working life are in conflict. Additionally, due to the structure of the data set we can link children to their biological father and mother, but we do not know if parents are separated. However, we can safely assume that children of separated parents live with their mother.

eases are known to be elevated by chronic stress, e.g. due to care-giving.[4] Stress from work-family conflicts is also related to smoking behavior (Nelson *et al.*, 2012; Hurtado *et al.*, 2016), which in turn is strongly correlated with lung cancer and COPD. If these stress related causes of death are affected we take this as evidence of increased stress due to the double burden.

We acknowledge that level of education may interact with child rearing in other ways than through the stress caused by the double burden of family and work. For instance, higher educated mothers receive higher incomes which may allow them to better cope with the increased stress. At the same time, higher education is also associated with jobs with more flexible working hours and more control over work content, which may help to alleviate conflicts between children and jobs. In this paper, we will not attempt to disentangle these different mechanisms behind the relationship between level of education, labor supply, child rearing, and maternal health. One reason is that we lack data on important factors, such as work content and control over work time, because we do not know which jobs mothers in our sample held in the past. However, most of these alternative mechanisms, such as income and work conditions, suggest that highly educated mothers are better able to compensate for the twin burden. Thus, since we nevertheless see that highly educated mothers are more affected by twinning, this suggests that the double burden of family and work outweighs these other mechanisms, and we take this as evidence of a double burden effect of family and work. In robustness analyses, we will also use additional data to examine some of these alternative mechanisms.[5]

Since we compare twin and non-twin mothers, all women in our sample have at least one child, so that we are only able to study the effect of fertility at the intensive margin, i.e. having a singleton versus twins at first birth. A comparison at the extensive margin, i.e. having any children versus none, would be at least as interesting as the intensive

[4] Ridker *et al.* (2000) have shown that among markers of inflammation, C-reactive protein (CRP) and interleukin-6 (IL-6) are strong predictors of cardiovascular diseases in older women. At the same time, CRP and IL-6 are known to be elevated by chronic stress, such as care-giving (Kiecolt-Glaser *et al.*, 2003; Robles *et al.*, 2005).

[5] Another alternative mechanism is that higher education may induce more specialized jobs, so that higher educated women may move further away from their families and have different networks. We cannot rule out that this contributes to the more negative effects health effects for twin mothers with higher education.

margin comparison, because by definition, women without children do not experience the double burden of children and work. However, it is hard to find exogenous variation on the extensive margin effect. In fact, a lone exception is the contribution by Lundborg *et al.* (2017), in which the authors use the success of in-vitro fertilization treatments to obtain exogenous variation at the extensive margin. Interestingly, they find that the effects of fertility on earnings are larger at the extensive than at the intensive margin. Given this evidence, it seems reasonable to extrapolate that there also are important double burden effects at the extensive margin.

Our paper is linked to the literature on the interaction between fertility, working life, and maternal health. Kahn *et al.* (1964) were among the first to note that a conflict between work and non-work roles are a major source of stress. A large literature has researched the work-family conflict empirically. However, many early studies are based on small or highly selective samples (Greenhaus and Beutell, 1985). Studies based on large, representative or administrative data include Weatherall *et al.* (1994), Martikainen (1995) and Waldron *et al.* (1998). More specifically, related to our study, Nelson *et al.* (2012) find a strong relationship between work-family conflicts and smoking behavior in a sample of English long-term care workers. Similarly, Väänänen *et al.* (2005) document a negative association between conflicts due to paid and domestic work and health among men and women. Using retrospective data from the Health and Retirement Study, Sabbath *et al.* (2015) categorize mothers along their past marriage, fertility and working histories, and conclude that working single mothers experience the highest mortality rates in old age. Van Hedel *et al.* (2016) and Berkman *et al.* (2015) find that single working motherhood is associated with higher likelihood of stress-related heart diseases. While suggestive of a double burden effect, these studies and other related studies are not able to address self-selection of women into specific work-family profiles depending on their health and other unobserved related factors. By using twins at first birth as a fertility shock, we try to overcome this limitation.

A growing literature examines the relationship between family life and female careers. Several studies find negative effects of childbearing on female labor force participation, earnings and wages (Angrist and Evans, 1998; Lundborg *et al.*, 2017), and that male and female earnings diverge after the birth of the first child (Bertrand *et al.*, 2010; Angelov *et al.*, 2016; Kleven *et al.*, 2019a,b). Other studies examine how public policies, such as parental leave policies, affect labor force participation and childbearing (Del Boca, 2002; Lalive and Zweimüller, 2009; Schönberg and Ludsteck, 2014) or sickness absence from work (Guertzgen and Hank, 2018). We study a related aspect of family life and female careers; the double burden of working and caring for children at the same time.

Two closely related studies are Cáceres-Delpiano and Simonsen (2012) and Kruk and Reinhold (2014). Using multiple births as an instrumental variable, Cáceres-Delpiano and Simonsen (2012) find that a higher number of children implies worse health for mothers aged 20 to 45 in the United States. Based on data from the Survey of Health Aging and Retirement in Europe, Kruk and Reinhold (2014) show that an increase in the number of children has a negative impact on mental health of older women but no effect on older men. The authors use twin births and sibling sex composition as instruments for the number of children. We add to this literature by focusing on heterogeneity in the long-term effects of fertility on health. We are the first to study effects on (cause-specific) old-age mortality. Another difference compared to Cáceres-Delpiano and Simonsen (2012) and Kruk and Reinhold (2014) is that we rely on administrative rather than survey and census data. Another related study is Angelov *et al.* (2020). They use Swedish data to study how parenthood affects the within-couple gender gap in paid sick leave, and find that sick leave sharply increases among mothers after the birth of the first child.

We introduce the administrative data set in section 2. Section 3 lays out our empirical strategy, while section 4 shows the results. We conclude in section 5.

2 Data

We use the Swedish multi-generation register, which links all individuals to their biological mother (and father), even if they do not live in the same household or have died. It contains parental information for persons born in 1932 or later, including information on year and month of birth.[6] Twins are identified as being born to the same mother in the

[6]For further information about this register see Ekbom (2011).

same year and month as another sibling.

From the registry we identify 404,286 mothers that were 55-65 years old, alive and resident in Sweden in 1990. Of those, 2,684 mothers (0.66%) had twins at first birth. We exclude 14 mothers with higher order births than twins.[7] We follow these mothers for twenty years from 1991 to 2010. From the National Causes of Death Register we know if they died and the cause of death. We focus on two groups of diseases that may be related to stress during life: cardiovascular diseases and smoking-related diseases. For the former we study heart attacks and strokes and for the latter lung cancer and COPD. Here, we follow the strategy by Evans and Moore (2012) to classify the diagnoses into specific disease categories.[8]

Among all mothers born between 1925 and 1935 8.6% are not observed in 1990 because they either died (75%) or moved abroad (25%) before 1990. In Table *Table A-1* in the appendix we investigate whether twin and non-twin mothers differ in the probability to be included in our study sample (column 1) or in the probability to die before 1990 (column 2), but we find no significant differences. Thus, while the sample as a whole may suffer from survival/migration bias, our results are unlikely to be biased because twin and non-twin mothers are affected symmetrically.

We have a set of socio-economic characteristics from population registers. Table *Table 1* describes our variables for the full sample and stratified by mothers' educational attainment. Education is defined in three categories: primary schooling, upper secondary schooling and tertiary education. Primary schooling includes elementary schooling (Folkskola), which was seven years for most of the cohorts considered in the paper, and junior secondary schooling (Realskola). Upper secondary schooling means that mothers had some education beyond the primary level, but no tertiary education. This level also includes vocational training at the upper secondary level. Tertiary schooling indicates that mothers experienced some tertiary schooling, i.e. university education or hold a PhD.

[7] The overall twin rate, i.e. twins at any birth, is 2.1%.

[8] The ICD-9 is applied in the years 1979 to 1998, ICD-10 from 1999 onwards. The codes are: Lung Cancer (ICD9: 162.2-162.5, 162.8-162.9 and ICD10: C34), Heart Attack (ICD9: 410 and ICD19: I21), COPD (ICD9: 490-496 and ICD10: J40-J43, J44.0-J44.7, J44.9, J45-J48) and Stroke (ICD9: 430-439 and ICD10: I60-I69).

Table 1: Descriptive statistics by mothers' education

	Full sample	Primary schooling	Secondary schooling	Tertiary schooling
Age (1990)	60.03	60.34	59.74	59.24
	(3.16)	(3.13)	(3.16)	(3.06)
Age at first birth	24.56	23.92	24.81	27.13
	(4.67)	(4.55)	(4.62)	(4.43)
Number of children	2.40	2.45	2.32	2.36
	(1.21)	(1.30)	(1.11)	(1.00)
Twins at first birth (in %)	0.66	0.64	0.66	0.82
	(0.08)	(0.08)	(0.08)	(0.09)
Same-sex twins	0.44	0.42	0.44	0.55
at first birth (in %)	(0.07)	(0.06)	(0.07)	(0.07)
Employed (1990 in %)	66.00	57.08	74.82	88.74
	(0.47)	(0.50)	(0.43)	(0.32)
Died between 1991 and 2010 (in %)	28.72	31.81	26.16	19.48
	(0.45)	(0.47)	(0.44)	(0.40)
Died from lung cancer	4.46	5.02	4.15	2.40
or COPD (in %)	(0.21)	(0.22)	(0.20)	(0.15)
Died from heart attack	13.61	15.70	11.85	7.53
or stroke (in %)	(0.34)	(0.36)	(0.32)	(0.26)
N	404,286	237,558	120,340	46,388
in %	100.00	58.76	29.77	11.47
Pension income at age 72	817	676	871	1253
in 100 SEK	(471)	(429)	(410)	(468)
Pension income above median (in %)	50.00	39.15	53.48	80.96
	(0.50)	(0.48)	(0.49)	(0.39)
N	209,325	109,650	69,102	30,573

Note: For each variable the first line shows means with standard deviations below in parentheses. Primary schooling defined as education levels 1 and 2, upper secondary schooling as level 3 and 4, and tertiary schooling as 5, 6 and 7.

On average, the mothers are 60 years old in 1990. They had their first child at age 24.5 and have on average 2.4 children. The majority of the mothers completed primary education (59%), about 30% of them hold a secondary and around 11% hold a tertiary degree. The age at first birth is on average three years higher in the highly educated group as compared to the low educated group, while the average number of children is about the same.

Overall, about 66% of the women between age 55 and 65 are still active on the labor market (positive labor income) in 1990. However, the fraction of working women varies considerably by education. While 89% of the women with a tertiary degree receive labor income, only 57% of mothers with a primary schooling degree receive income from work at those ages. About 29% of the women in our sample died between 1991 and 2010 with large variation by education. While about one third of the low educated mothers died in the 20 year time window we consider, the fraction is only 26% (19%) among the medium (highly) educated mothers. We see similar patterns for the different causes of death.

From the population registers we also obtain information on pension income at age 72. Pension income is the best available proxy for life-time labor force participation in our data set.[9,10] Pension income at age 72 follows the expected pattern; the mean pension income of mothers with tertiary schooling is above 125,000 SEK and about 85% higher than the pension income of mothers with primary schooling or less. Note that 100,000 SEK correspond to roughly 10,800 EUR in 2002.

3 Empirical Strategy

To investigate differences between twin and non-twin mothers, we specify the following linear regression model:

$$y_i = \beta_0 + \beta_1 1\{\text{twins}_i = 1\} + x_i' \beta_x + u_i, \tag{1}$$

where y_i is the outcome variable and $1\{\text{twins}_i = 1\}$ is an indicator equal to one if mother i gave birth to twins at first birth. Depending on the specification, the outcome variables are indicators equal to one if the mother died from any cause between 1991 and 2010, if she died from a heart attack or stroke, or if she died from lung cancer or COPD between 1991 and 2010. The control variables, x_i, include dummy variables for seven different education levels, dummies for mothers' birth cohorts and a quadratic polynomial in age

[9] We use the earnings-related part of the pension income (*tilläggspension*) and do not include the basic pension (*folkpension*) in our pension income measure. Pension income is adjusted for inflation.

[10] We use pension income at age 72 as a proxy for life-time income due to data restrictions and selection issues. Specifically, pension income is only available for the years 2001 to 2008 and for individuals between age 65 and 74. Consequentially, for example, if we use pension income at age 65 we can only observe pension income for one of our cohorts. However, if we use pension income at higher ages, we only observe pension income for the survivors, which creates a selection problem if there are mortality differences between twin and non-twin mothers. To maximize the sample size and avoid selection, we use pension income at age 72, which we can observe for seven cohorts (aged 55–61) in 1990.

at first birth.[11,12]

One worry when comparing twin-mothers with non-twin mothers is that twinning may not be entirely random. For instance, Bhalotra and Clarke (2016) document that twin mothers are positively selected with respect to health and health behaviours. However, Farbmacher *et al.* (2018) show that this issue arises primarily due to dizygotic (fraternal) twins. Dizygotic twins become more likely with increasing age of the mother (Reddy *et al.*, 2005; Fauser *et al.*, 2005), and the use of in-vitro fertilization (IVF) treatments (Thurin *et al.*, 2004), and this creates a correlation between twin births and maternal health. Monozygotic twins on the other hand are considered to be truly random (Tong and Short, 1998; MacGillivray *et al.*, 1988).

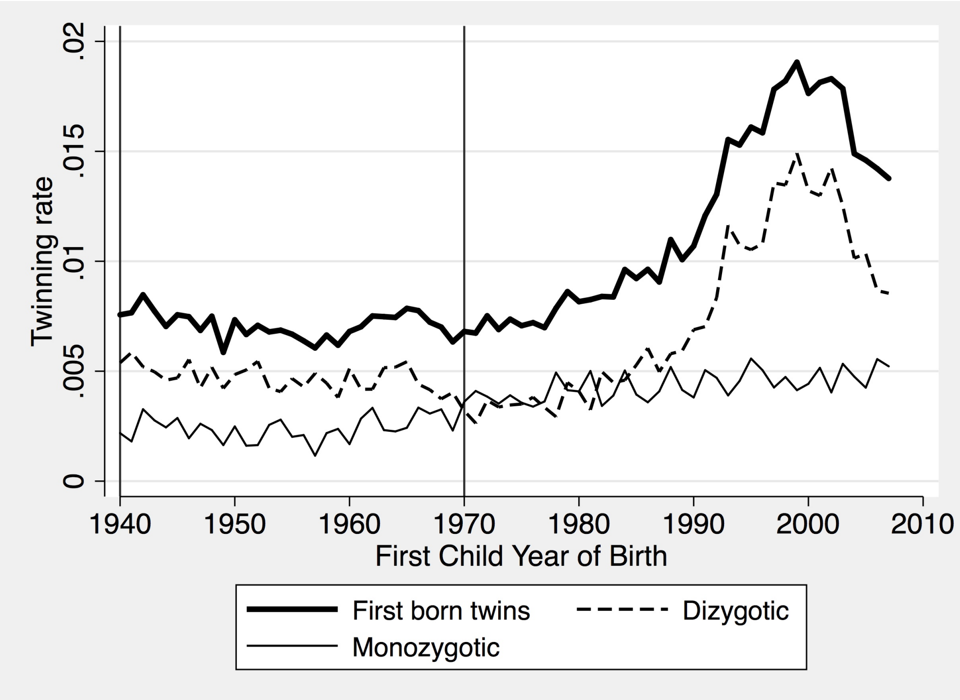
We have several strategies for dealing with these issues. First of all, as mentioned above, we control for age at first birth in all our analyses. Second, in order to investigate a possible selection bias stemming from dizygotic twins, we compare estimates between mothers of all twins and only same-sex twins (while also controlling for age at first birth). The reasoning is that since monozygotic twins necessarily have the same sex, their share must be higher among same-sex twins. This follows the arguments made by Black *et al.* (2007) and Figlio *et al.* (2014). Third, note that IVF is less of a concern in our data, since more than 99% of the mothers gave birth to their first child between 1940 and 1970, when IVF treatment was not yet available. This is illustrated by Figure *Figure 1*, which shows the twin rates in Sweden across the first child's year of birth. The share of twins remains fairly constant between 1940 and 1980 but increases strongly thereafter. While the steady but mild rise in the twin rate after 1980 can be attributed to delayed child bearing, the steep increase in the twin rate since 1990 mainly follows the availability of IVF. The vertical lines in the graph indicate the cohorts included in our analysis by birth year of the first child/children.

Twinning affects the number of children the mother has over a specific period of time

[11] Note that the levels of education we include in the regression model are finer than the three strata we use to condition our sample: 1=only elementary schooling, 2=junior secondary schooling, 3=upper secondary schooling of at most 2 years, 4=longer upper secondary schooling, 5=tertiary education of less than 3 years, 6=tertiary education of 3 years or more, 7=PhD.

[12] Farbmacher *et al.* (2018) demonstrate that the probability to give birth to twins follows an inverted U-shape across age at birth.

Figure 1: Twin rate in Sweden for first born children



Note: Statistics based on the Swedish register data. To compute the mono- and dizygotic twinning rates, we apply Weinberg (1901)'s rule. The vertical lines indicate the time period in which more than 99% of the mothers in our sample gave birth to their first child.

and after completed fertility. However, while many previous studies used the birth of twins as an instrumental variable for fertility, we study the so-called reduced form effects of twinning. That is, we estimate differences between twin and non-twin mothers, which capture all mechanisms through which twinning affects mortality. Next to the main mechanism, the increase in the number of children, other effects may exist, too. First, twin pregnancies and delivery are on average of a greater health risk to the mother than are singleton births, which may translate into higher old-age mortality rates (Buhling *et al.*, 2003; Rauh-Hain *et al.*, 2009). Second, twins are extremely close-spaced and twins may influence the spacing of further children, which in turn might have a direct effect on mother's health. Third, twinning may affect the probability of divorce, which may act as an additional channel of stress. Fourth, mothers may adjust their labor market choices if they have twins (Lundborg *et al.*, 2017), perhaps by decreased labor force participation, which in turn may have health effects. We, therefore, focus on the overall effect of twinning, and interpret any effects as a general effect of child rearing. As a background, we also show how twinning affects completed fertility and birth spacing.

To analyze the double burden effect, we study the effect of twinning for sub-samples defined by level of education and pension income. Education is an important predictor of labor force participation, working hours and earnings, since highly educated mothers are more prone to pursue careers. Therefore, we expect that, given the same unplanned fertility shock, higher educated mothers are more likely to experience a double burden of working life and child rearing. Thus, if the health effects of twinning are larger for highly educated mothers this is evidence of a double burden effect. Note that we can use education for stratifying the analysis, since most of the mothers in our sample have completed their education before giving birth to their first child, i.e. the education level is less influenced by fertility than labor force participation itself.[13]

We use twinning as a fertility shock, and assume that highly educated mothers experience more stress because they are more likely to work. However, level of education is also correlated with other factors that may influence the effect of twinning on maternal health. First, the Grossman (1972) model predicts that higher educated individuals are better at using medical care goods, and therefore more able to mitigate negative health effects. Second, higher educated mothers receive higher incomes, which may allow them to better cope with the increased stress due to twinning. Third, higher education is also associated with jobs with more flexible working hours and more control over the work content, and this may also help to alleviate conflicts between children and jobs. Fourth, due to educational homogamy, fathers involvement may differ between high and low educated mothers. Fifth, higher education induces more specialized jobs and thus higher educated women might move further away from their families and have different networks. However, most of these alternative mechanisms indicate that highly educated mothers should be less affected by twinning. In other words, if we find that highly educated mothers

[13] We still checked if we have a sample selection bias by comparing twin births and schooling outcomes. To this end, we estimate an ordered logit model for level of education (with seven education levels) using twins at first birth, cohort fixed effects and a quadratic polynomial in age at first birth as explanatory variables. The results in Column 3 of Table *Table A-1* in the appendix show that twin births are not a significant predictor of mothers' level of education.

are more affected by twinning, this suggests that the double burden of family and work outweighs these other mechanisms. Thus, even if we are not able to completely disentangle the different mechanisms behind the relationship between level of education, labor supply, child rearing and maternal health, we can provide some evidence on the double burden of family and work.

While higher education only holds the *ex-ante* potential to a higher labor force attachment, pension income is a proxy for life-time income and is thus an *ex-post* realization of the former. Note that pension income in Sweden is independent of the partner's income. Our hypothesis is that there exists a higher potential double burden effect on mothers with a higher pension income. We, therefore, stratify the sample at the median pension income, where an income above the median implies more labor market attachment. Note that pension income is a direct result of labor market participation, which could be adjusted due to child birth. Thus, pension income is an endogenous outcome. However, pension income is also the best available proxy for life-time labor force participation in our dataset and we believe that splitting the dataset based on it reveals valuable insights. One caveat of the split by pension income is that a specific level of pension income can result from working many hours at a medium or low wage as well as working few hours at a high wage. Usually, the number of hours worked creates the conflict with child rearing and thus the double burden. However, if this were the case, we should see no differences in the effect of having twins by pension income. Additionally, twin births could have a direct effect on survival and retirement until age 72. This may create selective sorting. Table *Table A-1* in the appendix (columns 4–5) shows no differences between twin and non-twin mothers with respect to whether the pension income at age 72 is missing or the amount of pension income at age 72.

Our results are derived for the cohorts of mothers born between 1925 and 1935 who had their first children between 1940 and 1970. In order get an idea how these cohorts differ from younger cohorts in terms of mother's age at first birth, the number of children, and birth spacing we plot the main differences by mothers' birth cohorts in the Appendix (Figure A.1-A.4). For the cohorts born between 1925 and 1935 age at first birth declines from around 25 years to just about 24 years. It remained around age 24 for the birth cohorts born until the late 1940s and increased continuously thereafter (Figure A.1). The number of children per mother fluctuated between just over 2.4 and 2.2 children per mother for all cohorts, with the highest average number of children among women born in the early 1930ies and the lowest for women born around 1945 (Figure A.2). Birth spacing between the first and the second as well as the first and the last child declined continuously for mothers until the cohorts born around 1940. It increased slightly for mothers born until 1950 but continues to decrease thereafter (Figure A.3 and A.4).

4 Results

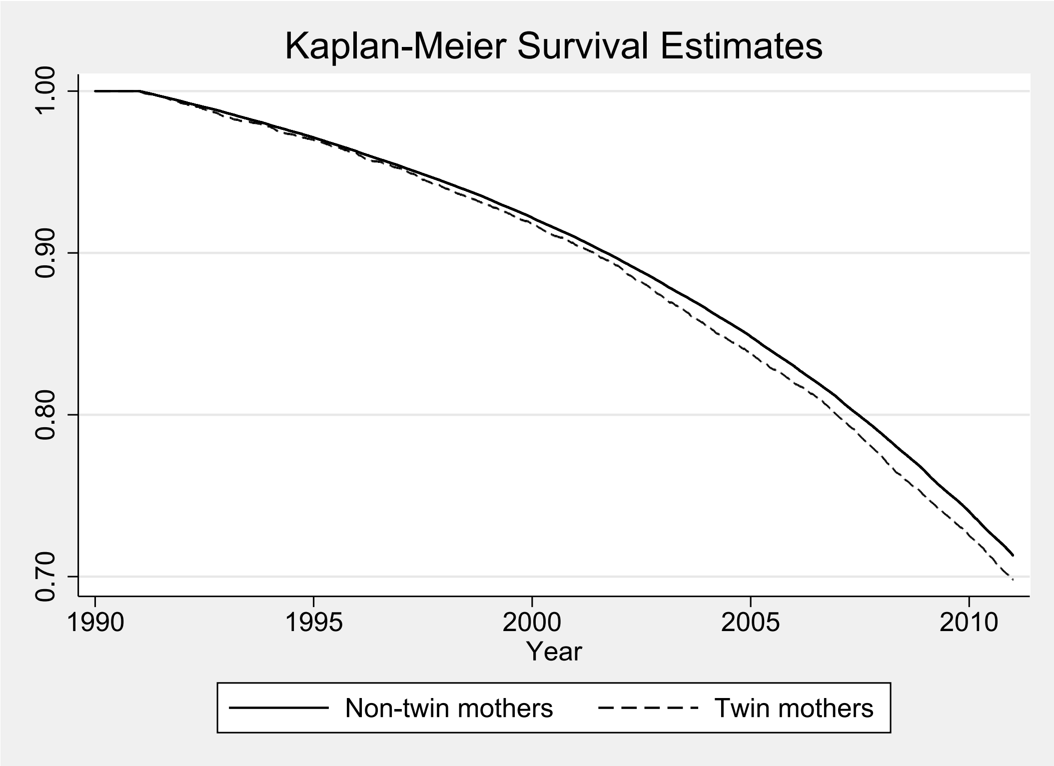
4.1 Twins and Old Age Mortality

We now turn to our main analysis. Figure *Figure 2* presents Kaplan-Meier survival curves for mothers with and without twins. A clear gap in the survival probabilities emerges between the two groups over the 20-year period. Twin mothers are dying at a higher rate compared to their peers who only had one child at first birth. The gap becomes larger around the year 2002, i.e. when the women in our sample are on average 72 years old.

Panel A of Table *Table 2* contains estimates for the effect of having twins at first birth based on the regression model from equation 1. Having twins at first birth increases the probability of dying by 3.7 percentage points over a 20 year period. Related to a baseline probability of dying of 28.7%, this means that twin mothers have a 13% higher mortality rate than non-twin mothers. Looking into specific causes of death the pattern is confirmed (see columns 2 and 3). Twin mothers are 1.3 percentage points (or 20%) more likely to die of lung cancer or COPD compared to other mothers. Their likelihood of dying from a heart attack or stroke is 1.8 percentage points or 13% higher during the period of observation.

As robustness checks, Panel A of Table *Table 2* also contains the estimates from a placebo regression (see column 4). Here we look at femur fractures, which are unlikely to be affected by stress during working life. Fracture of femur is usually caused by severe accidents or for older adults occurs due to a fall because their bones tend to be weaker. The placebo outcome is equal to 1 if the mother had a femur fracture in the period from

Figure 2: Survival rates for mothers with and without twins at first birth



1991-2005. We can see that the prevalence of femur fracture is indeed not significantly higher among twin mothers. Moreover, Panel B of Table *Table 2* contains estimates when using only same-sex twins as treatment, excluding potentially non-random opposite-sex (dizygotic) twins from the treated group. The estimates are very similar to the estimates in Panel A. Both robustness checks suggest that our results are not driven by direct effects of twinning on health or non-random selection into twinning.[14]

To provide a background to these estimates Tables *Table A-2* and *Table A-3* in the appendix report statistics on the number of children and child spacing for twin and non-twin mothers. Table *Table A-2* shows that twins at first birth lead to a substantially larger number of children in the short run as well as in the long run. Five years after the first birth, twin mothers have 0.68 more children than non-twin mothers, and 15 years after the first birth this difference is 0.59 children, on average. As expected, twinning also affects child spacing. From Table *Table A-3* we see that the average time between the first and the second child is around 4 years for non-twin mothers (zero by construction for twin

[14] We find similar patterns when we consider twin births at any birth (not reported).

Table 2: Main results

	(1) Died between 1991 and 2010	(2) Death due to Lung cancer/ COPD	(3) Death due to Heart attack/ stroke	(4) Death due to Femur/ Fracture
Panel A				
Twins	0.037***	0.013***	0.018***	0.005
	(0.009)	(0.004)	(0.007)	(0.004)
Panel B				
Same-sex twins	0.038***	0.013**	0.020**	0.005
	(0.011)	(0.005)	(0.008)	(0.005)
Unconditional mean	0.287	0.044	0.136	0.047
Observations	404,286	404,286	404,286	404,286

Note: Table displays linear probability models controlling for education, cohort dummies and a quadratic polynomial in age at first birth. In panel A the reference group are mothers with a singleton first birth, and in panel B mothers with singletons or opposite sex twins at first birth. Robust standard errors in parentheses below. ***,**,* indicate significance at the 1%, 5%, and 10% level, respectively.

mothers). Twinning also affects the spacing between the first and the last child, which is 3.8 years for twin mothers and 7.4 years for other mothers. Our twinning estimates thus capture the combined effects of the increased number of children, the reduced spacing, and potentially other effects that we discussed above.

4.2 Results by Educational Level and Pension Income

To investigate the interaction of fertility and labor market attachment, we now split the sample by education and pension income. Table *Table 3* displays our results stratified by maternal education. Panel A shows that the effect of having twins at first birth for mothers with at most primary schooling is slightly smaller compared to the effect estimated for the full sample (reported in Table *Table 2*). However, the probability of dying from lung cancer, COPD or heart diseases is slightly higher among the mothers with a primary schooling degree compared to the overall effects. For mothers with a secondary school degree, we find a similar effect of twins on overall mothers' mortality compared to the full sample (Panel B). However, there are no elevated levels of lung cancer and COPD or cardiovascular diseases for these mothers. Interestingly, the largest effect sizes in absolute and relative terms are experienced by mothers within the highest education group (Panel C). For twin mothers compared to non-twin mothers, all-cause mortality is increased by

8.4 percentage points or 43%, and death due to lung cancer and COPD is increased by 2.2 percentage points, which corresponds to an almost 100% increase. Death due to a heart attack or stroke is 4.1 percentage points or 55% higher.[15] Reassuringly, we also find that effect sizes for the estimates based on all and same-sex twins are quite similar for all specifications.

Table 3: Results by education

	(1) Died between 1991 and 2010	(2) Lung cancer/ COPD	(3) Heart attack/ stroke
Panel A: Primary schooling			
Twins	0.028**	0.018***	0.021**
	(0.012)	(0.006)	(0.010)
Same-sex twins	0.027*	0.020**	0.023*
	(0.015)	(0.008)	(0.012)
Unconditional mean	0.318	0.050	0.157
Observations	237,558	237,558	237,558
Panel B: Upper secondary schooling			
Twins	0.032**	-0.003	0.001
	(0.016)	(0.007)	(0.011)
Same-sex twins	0.028	-0.005	-0.002
	(0.020)	(0.008)	(0.014)
Unconditional mean	0.262	0.042	0.119
Observations	120,340	120,340	120,340
Panel C: Tertiary schooling			
Twins	0.084***	0.022**	0.041**
	(0.023)	(0.011)	(0.017)
Same-sex twins	0.099***	0.020	0.055***
	(0.028)	(0.013)	(0.021)
Unconditional mean	0.195	0.024	0.075
Observations	46,388	46,388	46,388

Note: Each coefficient-standard error pair comes from a separate regression of a linear probability model controlling for the subcategories of education, cohort dummies and a quadratic polynomial in age at first birth. Robust standard errors in parentheses below. ***,**,* indicate significance at the 1%, 5%, and 10% level, respectively.

We next split the sample at the median by pension income. As described in Section 3, pension income is only observed for a sub-sample of mothers in our sample. Therefore, we first report the overall twinning effects for this reduced sample (Panel A, Table *Table 4*). Here, the health effects are slightly smaller than estimates for the full sample in

[15]We tested the statistical significance of the differences in the effects between educational groups. We find that the difference in the absolute effect of twinning between low and high educated mothers is significant at the 5% level for overall mortality, but not significant for the stress related diseases. Differences in the effect of twinning between middle and high educated mothers are significant for all outcomes.

Table *Table 2*, but still sizable and significant. Panels B and C of Table *Table 4* show the effects of twins for mothers below and above the median pension income, respectively. Again, the pattern is consistent with the double burden hypothesis. We find no significant effects of twins for mothers with below median pension income, whereas for mothers with above median pension income there are sizable mortality effects. This holds for both overall and cause specific mortality. For instance, for mothers with a pension income above the median, having twins increases the probability of dying over a 20 year time period by 4.6 percentage points or almost 40%.[16,17]

As a robustness check, we have also re-estimated the above models by using interaction terms between the twin birth indicator and education levels instead of splitting the sample. The results in Columns 1–3 of Table *Table A-4* are very similar to those from the split-sample analyses. The same holds if we use an interaction model for the below and above median pension income analyses (Table *Table A-5*).

We next split the sample by education and pension income into six cells. The results of this exercise are presented in Table *Table 5*. Due to the lower sample size in each cell, the difference between twin and non-twin mothers is not significant most of the time, but the sign and magnitude of the coefficients are consistent with the results presented above. In particular, the effect of twins on overall mortality is the largest for highly educated mothers with above median pension income.

We interpret these results as evidence of a double burden of family and work. However, we already mentioned that the level of education is also correlated with other factors that may influence the effect of twinning on maternal health. One factor is that higher educated mothers receive higher incomes, which may help to alleviate some stress and give access to better health care. To test for the importance of this channel, we adjust for income in our regressions. Specifically, we control for a quadratic polynomial of log-labor income in 1985.[18] The results presented in columns 4–6 of Table *Table A-4*, are very

[16] As a robustness check we ran the same analysis for the pension income at age 71 for the cohorts age 55 to 60 in 1990 and the results are very similar.

[17] The difference in effect sizes between mothers with above and below-median pension incomes is highly significant for all cause mortality.

[18] We use labor income in 1985, because this is the earliest year for which we observe income. Mothers with zero labor income in this year are assigned zero log-labor income.

Table 4: Results by pension income

	(1) Died between 1991 and 2010	(2) Lung cancer/ COPD	(3) Heart attack/ stroke
Panel A: All – cond. on pension inc. observed			
Twins	0.028***	0.009**	0.013*
	(0.009)	(0.005)	(0.007)
Same-sex twins	0.034***	0.010*	0.020**
	(0.012)	(0.008)	(0.009)
Unconditional mean	0.122	0.022	0.058
Observations	209,325	209,325	209,325
Panel B: Below median pension inc.			
Twins	0.010	0.002	0.006
	(0.012)	(0.005)	(0.009)
Same-sex twins	0.020	0.006	0.004
	(0.016)	(0.007)	(0.011)
Unconditional mean	0.124	0.020	0.061
Observations	104,682	104,682	104,682
Panel C: Above median pension inc.			
Twins	0.046***	0.017**	0.020**
	(0.014)	(0.008)	(0.010)
Same-sex twins	0.049***	0.014	0.038***
	(0.018)	(0.009)	(0.014)
Unconditional mean	0.120	0.024	0.056
Observations	104,643	104,643	104,643

Note: Each coefficient-standard error pair comes from a separate regression of a linear probability model controlling for education, cohort dummies and a quadratic polynomial in age at first birth. Low (high) pension sample are individuals with below (above) median pension income at age 72 corrected for inflation. Robust standard errors in parentheses below. ***,**,* indicate significance at the 1%, 5%, and 10% level, respectively.

similar to the results from the main analyses, where we do not control for past income. This suggests that income is not the main mechanism behind our results.s

5 Discussion and Conclusions

In summary, we find that having twins increases all-cause mortality significantly for women older than 55. Twin mothers also have a higher probability of dying from lung cancer/COPD and heart attacks/strokes. The effects of twins on maternal health are the strongest for high-educated mothers and mothers with above median pension income.

Our results fit into a recent line of epidemiological and sociological literature on the adverse effects of the work-family strain. The general theoretical considerations in that lit-

Table 5: Results by pension income and education

	(1) Primary schooling	(2) Upper secondary schooling	(3) Tertiary schooling
Panel A: Below median pension inc.			
Twins	-0.000	0.034	0.001
	(0.015)	(0.024)	(0.045)
Same-sex twins	0.005	0.050	0.039
	(0.019)	(0.032)	(0.066)
Unconditional mean	0.134	0.111	0.086
Observations	66,719	31,143	5,820
Panel B: Above median pension inc.			
Twins	0.026	0.034	0.085***
	(0.023)	(0.024)	(0.027)
Same-sex twins	0.037	0.036	0.081**
	(0.018)	(0.030)	(0.033)
Unconditional mean	0.143	0.120	0.082
Observations	42,931	36,959	24,753

Note: The outcome variable is death between 1991 and 2010 due to all causes. Each coefficient-standard error pair comes from a separate regression of a linear probability model controlling for finer subcategories of education, cohort dummies and a quadratic polynomial in age at first birth. Low (high) pension sample are individuals with below (above) median pension income at age 72 corrected for inflation. Robust standard errors in parentheses below. ***,**,* indicate significance at the 1%, 5%, and 10% level, respectively.

erature are the following. First, there are selection effects, i.e. women who are employed, married, and have children are healthier than their childless, unmarried and unemployed counterparts. Second, according to the role accumulation theory, combining family and work is beneficial for women's health. Third, multiple role theory states that combining work and family roles leads to stress with negative consequences for health (Kahn *et al.*, 1964).

In this paper, we have used twins at first birth as a shock to fertility. This allows us to overcome part of the selection problems arising in this literature. We find that all-cause mortality as well as dying from lung-cancer and heart diseases are significantly elevated among mothers who give birth to twins. The higher probability of death due to lung-cancer and heart diseases indicates that at least part of the effect is stress related, since the medical literature strongly associates these causes of death with stress from work-family conflicts and care-giving. That is, the additional burden on women due to having two instead of one child at their first birth takes its toll on their health later in life.

We also find strong mortality effects among mothers with higher education and above median pension income. We argue that this can be taken as evidence of a double burden effect. High-educated mothers have a higher likelihood of pursuing careers despite having kids, and higher pension income indicates that women worked more. In other words, higher education is an *ex ante* predictor of higher labor market attachment, and pension income is a proxy for *ex post* realized labor market activity. Thus, higher all-cause and stress-related mortality rates among mothers with higher education and above median pension income point in the direction of a double burden from child rearing and working on maternal health in old age.

The specific mechanisms behind these findings deserve further research. Especially, since women of younger generations are increasingly more likely to stay attached to the labor force and raise children at the same time (Goldin and Mitchell, 2017). Fathers' roles in supporting their families both financially and by taking a more active role in raising children changes as well. Changes in family planning, changes in family benefits, supply of child care as well as the family friendliness of workplaces have to be taken into account when it comes to the external validity of our results for younger generations. We shed some light on this issue by depicting the averages of age at first birth, number of children, and birth spacing for younger and older generations in Sweden. In any case, more research is necessary to find policies that can protect mothers from the double burden of family and work. The recent study by Avendano *et al.* (2015), for example, shows that more generous parental leave policies reduce maternal depression in old age. This is particularly relevant in times of demographic change, when many countries aim at increasing female labor supply, and, at the same time, higher birth rates are on the policy agenda.

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Appendix

Table A-1: Selection into different samples

Outcome	(1) Resident in 1990	(2) Died betw. 1961–1990	(3) Education (ordered logit)	(4) Pension at age 72 missing	(5) Pension at age 72 in 100 SEK
twins	0.005	-0.004	-0.014	0.006	-0.716
	(0.005)	(0.004)	(0.037)	(0.005)	(9.627)
same-sex twins	0.005	-0.005	0.046	0.006	-10.162
	(0.006)	(0.005)	(0.046)	(0.006)	(11.632)
Unconditional mean	0.914	0.065	2.224	0.446	817.846
Observations	444,197	444,197	404,286	404,286	209,325

In columns 1,2,4 and 5, each coefficient-standard error pair comes from a single regression of a linear probability model controlling for education, cohort dummies and a quadratic polynomial in age at first birth. Column 3 uses education in seven levels as outcome, is estimated using an ordered logit model and controls for cohort dummies and a quadratic polynomial in age at first birth. Robust standard errors in parentheses below. ***,**,* indicate significance at the 1%, 5%, and 10% level, respectively.

Table A-2: Twin births and the number of children

	(1) All twins	(2) Same-sex twins
# children 5 years after first birth	0.68***	0.69***
	(0.012)	(0.015)
# children 10 years after first birth	0.61***	0.61***
	(0.017)	(0.021)
# children 15 years after first birth	0.59***	0.59***
	(0.019)	(0.023)
Total # children	0.59***	0.59***
	(0.020)	(0.025)

Note: Table displays linear probability models controlling for education, cohort dummies and a quadratic polynomial in age at first birth. Robust standard errors in parentheses below. ***,**,* indicate significance at the 1%, 5%, and 10% level, respectively.

Table A-3: Twin births and child spacing (averages in years)

	(1) Twin parents	(2) Non-twin parents
Spacing between first and second child	0	4.00
Spacing between first and last child	3.80	7.38
Spacing between second and last child	3.80	3.37

Note: Twin parents defined by twinning at first birth. Sample statistics for the sample as described in Section 2.

Table A-4: Interaction model for education

	(1) Died between 1991 and 2010	(2) Lung cancer/ COPD	(3) Heart attack/ stroke	(4) Died between 1991 and 2010	(5) Lung cancer/ COPD	(6) Heart attack/ stroke
Panel A: All twins						
Twins	0.027**	0.018***	0.021**	0.027**	0.018***	0.020**
	(0.012)	(0.006)	(0.010)	(0.012)	(0.006)	(0.010)
Twins	0.004	-0.021**	-0.021	0.006	-0.021**	-0.019
× upper secondary schooling	(0.020)	(0.009)	(0.015)	(0.020)	(0.009)	(0.015)
Twins	0.057**	0.004	0.020	0.054**	0.004	0.021
× tertiary schooling	(0.026)	(0.012)	(0.019)	(0.026)	(0.012)	(0.019)
Panel B: Same-sex twins						
Same-sex twins	0.027*	0.019**	0.023*	0.027*	0.020**	0.022*
	(0.015)	(0.008)	(0.012)	(0.015)	(0.008)	(0.012)
Same-sex twins	0.000	-0.024**	-0.026	0.024	-0.024**	-0.024
× upper secondary schooling	(0.024)	(0.011)	(0.018)	(0.024)	(0.011)	(0.018)
Same-sex twins	0.072**	0.001	0.032	0.067**	0.000	0.032
× tertiary schooling	(0.032)	(0.015)	(0.024)	(0.032)	(0.015)	(0.024)
Control for income	no	no	no	yes	yes	yes
Unconditional mean	0.287	0.044	0.136	0.287	0.044	0.136
Observations	404,286	404,286	404,286	404,286	404,286	404,286

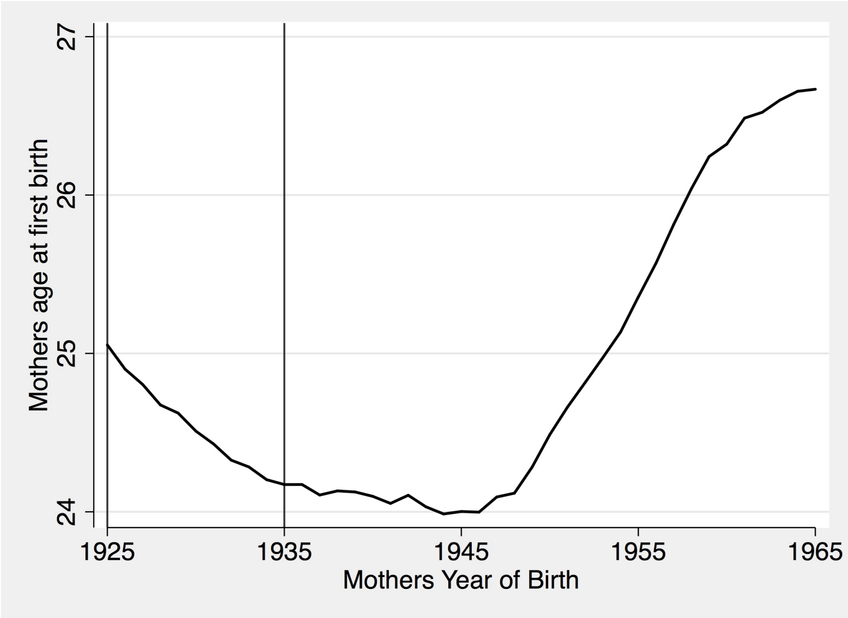
Note: Table displays linear probability models controlling for finer levels of education, cohort dummies and a quadratic polynomial in age at first birth. Columns 4 to 6 additionally control for a quadratic polynomial in log-labor market income in 1985. Individuals with zero income in 1985 are assigned a value of zero. The reference group are mothers with primary education. Robust standard errors in parentheses below. ***,**,* indicate significance at the 1%, 5%, and 10% level, respectively.

Table A-5: Interaction model for pension income

	(1) Died between 1991 and 2010	(2) Lung cancer/ COPD	(3) Heart attack/ stroke
Panel A: All twins			
Twins	0.010	0.002	0.005
	(0.012)	(0.005)	(0.010)
Twins × above median pension income	0.037*	0.015*	0.015
	(0.009)	(0.009)	(0.014)
Panel B: Same-sex twins			
Same-sex twins	0.019	0.006	0.004
	(0.016)	(0.007)	(0.011)
Same-sex twins × above median pension income	0.031	0.009	0.034*
	(0.024)	(0.012)	(0.018)
Unconditional mean	0.287	0.044	0.136
Observations	404,286	404,286	404,286

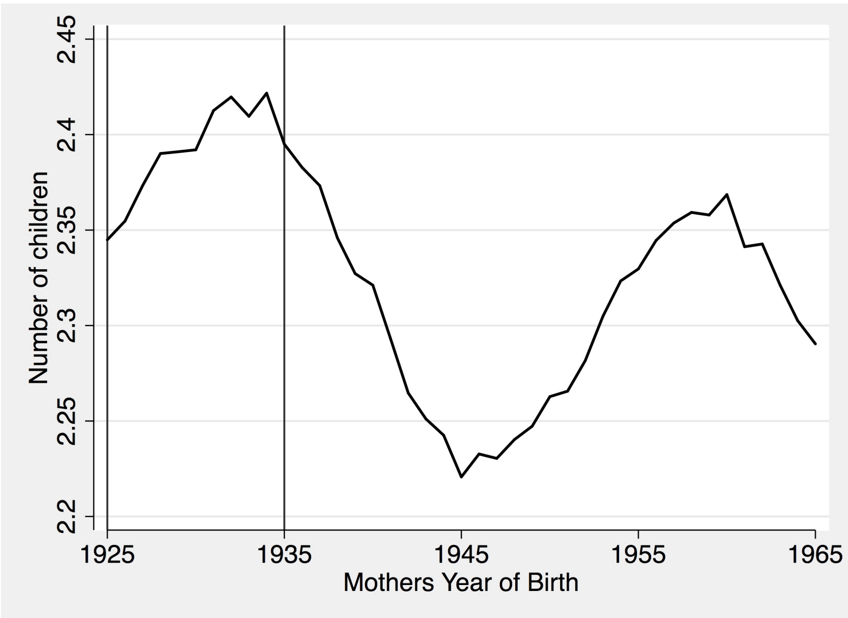
Note: Table displays linear probability models controlling for finer levels of education, cohort dummies and a quadratic polynomial in age at first birth. The reference group are mothers with primary education. Robust standard errors in parentheses below. ***,**,* indicate significance at the 1%, 5%, and 10% level, respectively.

Figure A-1: Average age of a mother at first birth



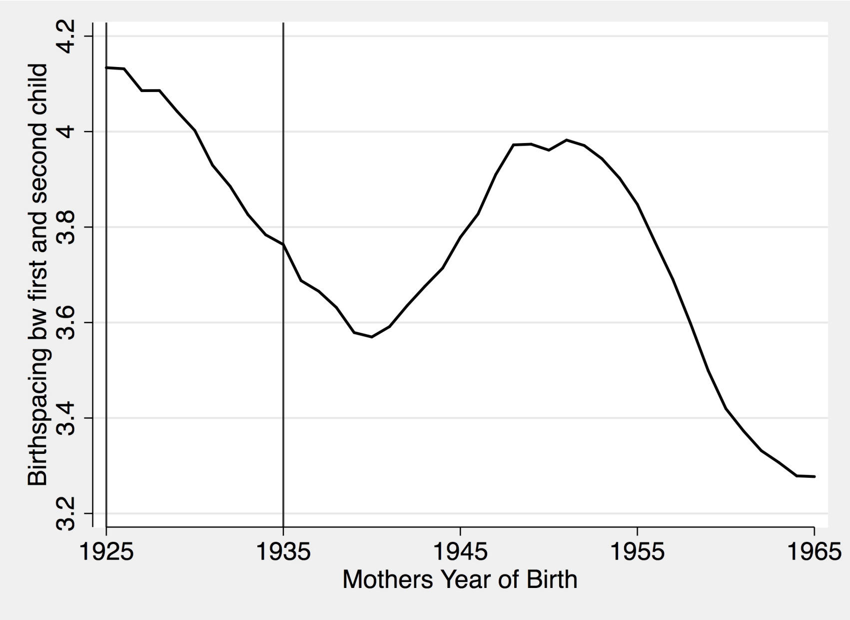
Note: The vertical lines indicate the mothers in our sample.

Figure A-2: Number of children per woman



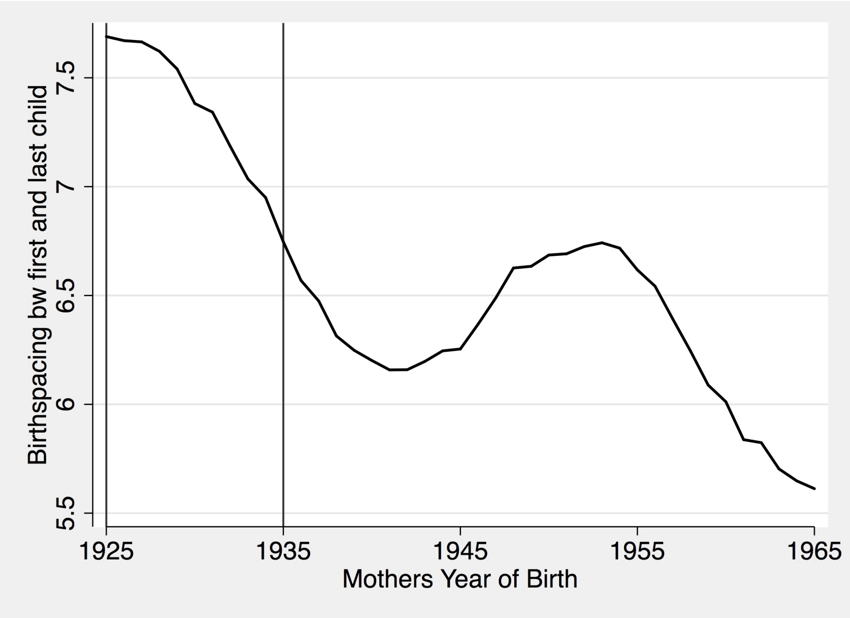
Note: The vertical lines indicate the mothers in our sample.

Figure A-3: Birth spacing (in years) between first and second child



Note: The vertical lines indicate the mothers in our sample.

Figure A-4: Birth spacing (in years) between first and last child



Note: The vertical lines indicate the mothers in our sample.