Double trouble: The burden of child rearing and working on maternal mortality*

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Abstract

We study the consequences of actively raising children and simultaneously pursuing a career for mothers' health. Based on Swedish administrative data, we document strongly increased old-age mortality rates among twin mothers compared to non-twin mothers. We use twins as an unplanned shock to fertility and proxy labor force attachment by stratifying the sample by education and pension income. The effect of having twins is largest among highly educated mothers and those with above-median pension income. Deaths due to lung cancer, chronic obstructive pulmonary disease and heart attacks, which are strongly associated with stress during life, are over-proportionally increased. These results are in line with the existence of a double burden on mothers' health.

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

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1 Introduction

In times of increasing female labor market participation and policy efforts to combine work and family life, it is important to understand the consequences of actively raising children and simultaneously pursuing a career for mothers' health. 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). Other studies examine how public policies, such as parental leave polices, affect labor force participation and childbearing (Del Boca, 2002; Lalive and Zweimüller, 2009; Schönberg and Ludsteck, 2014). An important aspect in the context of family life and female careers is the stress that could occur from the double burden of working and caring for children at the same time. However, up to this point, there exists very little evidence on this double burden and the consequences of such a burden for maternal health. This paper aims at filling this gap by studying the effects of past fertility shocks and their interaction with labor force activity on health later in life.

In order to study the combined effect of childbearing and labor force activity on maternal health, an ideal set-up would provide exogenous variation in both labor market participation and having and raising children. In this paper we use twins at first birth as an unplanned shock to fertility. Our analysis is based on detailed administrative birth and death registries from Sweden. The analysis sample includes more than 400,000 mothers that were between 55 and 65 years old in 1990. We follow these women over 20 years and study the effects of twinning on all-cause mortality and stress-related mortality. We focus on mothers because women are significantly more likely than men to find themselves in a situation where family and working life are in conflict—at least for the cohorts of women examined here. We find some striking results. Women who had twins at first birth have a 3.8 percentage point (13%) higher all-cause mortality risk and they have a substantially higher risk of dying from a stress-related disease.

To study the interaction of child rearing and work life we then stratify the sample along educational attainment and pension income. Both these measure 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 child rearing are important we expect to see larger health effects of a fertility shock (twin births) for women with higher education and high pension income, since these women more often combine work and child rearing. This is also what we find. The effects of twin births on old age mortality and stress-related mortality are distinctly larger among mothers with university education and for those with above-median pension income. These findings are in line with the medical literature that studies the relation between stress, diseases, and mortality. Specifically, our evidence concurs with the argument that the double burden of working and raising children increases life-time stress and takes its toll on mothers' health later in life.

One challenge in the context of our research question is the measurement of stress. We cannot directly measure life-time stress, but we can analyze two specific groups of medical diagnoses that have been related to stress during life in the literature: cardiovascular diseases, specifically heart attacks and strokes, and smoking-related diseases, specifically lung cancer and chronic obstructive pulmonary disease (COPD). The literature shows that strong predictors of cardiovascular diseases are known to be elevated by chronic stress.[1] Stress from work-family conflicts is strongly predictive of smoking behavior (Nelson *et al.*, 2012; Hurtado *et al.*, 2016) and smoking behavior in turn is strongly correlated with a higher risk of dying from lung cancer and COPD. In the paper we analyze overall mortality and these two specific causes of death that have been linked to stress during life.

In our analyses we use twinning as an unplanned fertility shock. Two potential threats to this approach are that twin births increase with mothers' age at birth and the availability of in-vitro fertilization. We can use this strategy nevertheless, because the cohorts examined in this study had their first children between 1940 and 1970, which is 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.

Our paper is linked to past research on the interacting effects of fertility, working life, and maternal health. Using retrospective data from the Health and Retirement Study (HRS), 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) investigate the association of work-family profiles and find that single working motherhood is associated with higher likelihood of stress-related heart diseases, see also Berkman *et al.* (2015). While suggestive of a double burden effect, these studies are not able to control for selection of women into specific work-family profiles depending on their health. By using twins at first birth as a fertility shock, we aim to provide more

[1] 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).

reliable evidence.

Closest to our study 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 long-term effects of fertility on health. Furthermore, we do not use twins as instrumental variable as giving birth to twins might have direct effects on maternal health. In contrast to Cáceres-Delpiano and Simonsen (2012) and Kruk and Reinhold (2014), we rely on administrative rather than survey and census data.

This paper proceeds as follows. The administrative data set is introduced 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.[2] Twins are identified as being born to the same mother in the 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 mothers with higher order births than twins. 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.[3]

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

[3] 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).

Note that 8.6% of all mothers born between 1925 and 1935 are not observed in 1990 because they either died (75%) or moved abroad (25%) before 1990. In 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) and 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 also have a rich set of socio-economic characteristics from population registers. Table 1 describes our variables for the full sample and stratified by mothers' educational attainment. Education is defined in three categories. Primary schooling means that mothers completed compulsory education of nine years. Secondary schooling means that mothers had at least some years of secondary schooling. Tertiary schooling indicates that mothers experienced some tertiary schooling, i.e. some university education or even hold a PhD.

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.[4] 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.

[4] 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.

	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, Secondary schooling as level 3 and 4, and tertiary schooling as 5, 6 and 7.

Table 1: Descriptive statistics by mothers' education

3 Empirical Strategy

We start by documenting all-cause and stress related mortality rates by the number of children a mother gave birth to in her life. While being purely descriptive, this analysis helps to understand the relationship between completed fertility and old-age mortality. One reason for providing these estimates is that previous studies have been inconclusive on the direction of this correlation (Hurt *et al.*, 2006). Here, our basic linear regression model is:

$$y_i = \alpha_0 + \sum_{k=2}^{K} \alpha_k \mathbb{1}\{\#kids_i = k\} + x_i' \alpha_x + \epsilon_i, \tag{1}$$

where y_i is the outcome variable. 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. $\mathbb{1}\{\#kids_i = k\}$ is an indicator equal to one if mother i gave birth to k children in her life. Here, we group mothers who gave birth to eight or more children into one category. The control variables, x_i, include dummy variables for seven different education levels, dummies for mothers' birth cohorts and a quadratic polynomial in age at first birth.[5,6]

We then turn to the causal effect of having twins at first birth on mothers' health later in life. We specify the following regression model:

$$y_i = \beta_0 + \beta_1 \, \mathbb{1}\{\text{twins}_i = 1\} + x_i' \beta_x + u_i, \tag{2}$$

where $\mathbb{1}\{\text{twins}_i = 1\}$ is an indicator equal to one if mother i gave birth to twins at first birth. One worry when comparing twin-mothers with non-twin mothers is that twinning might not be entirely random. For instance, Bhalotra and Clarke (2016) document that twin mothers are positively selected with respect to health and health behaviours. 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).

[5] 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=less then compulsory schooling of 9 years, 2=compulsory schooling of 9 years, 3=secondary schooling of at most 2 years, 4=secondary schooling of three years, 5=tertiary education of less than 3 years, 6=tertiary education of 3 years or more, 7=PhD.

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

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), who obtain similar results when using all and only same-sex twins. 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 important, as the preference for IVF may be correlated with other health-related outcomes which we cannot control for. Figure 1 shows the twin rates in Sweden across the first child's year of birth. The overall share of twins remains fairly constant between 1930 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.

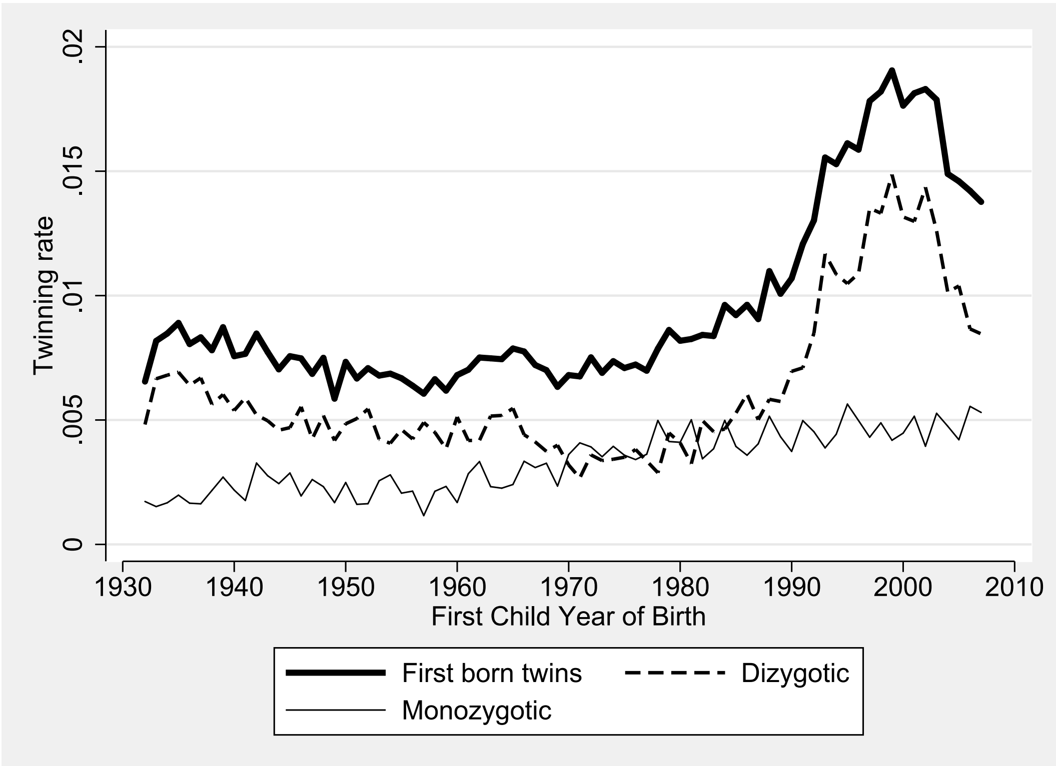

Figure 1: Twin rate in Sweden (firstborn children) between 1930 and 2007.

Note: Statistics based on the Swedish register data. To compute the mono- and dizygotic twinning rates, we apply Weinberg (1901)'s rule.

Twinning affects the number of children the mother has over a specific period of time and completed fertility. However, while many previous studies used the birth of twins as an instrumental variable (4) for fertility, we study the reduced form effects of twinning. There are two main reasons for this. 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 themselves 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. We, therefore, focus on the reduced form effect of twinning and interpret any effects as a general effect of child rearing. In addition to our reduced form analyses we show how twin births affect completed fertility and birth spacing.

In order to analyze the potential 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. 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.[7]

We have the following hypotheses with respect to education and fertility. While in principle the birth of twins lowers labor market activities of mothers of all educational levels, it is likely that highly educated mothers are more prone to pursue careers because of higher opportunity costs. We thus 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. However, while highly educated mothers might be more likely to work and thus experience more stress, the Grossman (1972) model predicts that higher educated individuals are better at using medical care and might thus be more able to mitigate possible negative effects on their health. Thus, the overall potential double burden on the health of highly educated mothers compared to those of lower levels of education is not entirely clear. Additionally, low educated mothers may also experience a double burden effect as they might need to work more hours due to lower hourly wages compared to mothers with higher educational degrees and higher hourly wages.

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.[8] Note that pension income in Sweden is independent of

[7] 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 A.1 in the appendix show that twin births are not a significant predictor of mothers' level of education.

[8] We use pension income at age 72 as a proxy for life-time income due to data restrictions on the one

the partners' 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. One caveat of this 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.

Again, one could worry about selective sorting when splitting the sample in this way. Twins at first birth could directly affect pension income or survival and retirement until age 72. In Table A.1 (columns four and five) in the Appendix we show that there are 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.

4 Results

4.1 Completed Fertility and Old Age Mortality

As explained above, we first investigate the correlation between the number of children and mothers' health later in life using mothers who gave birth to one child as the reference group. These OLS estimates of equation 1 are reported in Panel A of Table 2. We find that overall mortality rates (Column 1) are significantly lower for mothers who have up to five children compared to those with only one child. Mortality rates are about equal between mothers with one and six children, but rise for mothers with more than six children. Thus, there exists a U-shaped relationship between the number of children and overall mortality. These patterns are in line with results by Grundy and Kravdal (2010) based on Norwegian register data. For heart attack and strokes (Column 3) we find a similar U-shaped pattern with lower mortality rates for mothers with up to four children and higher mortality rates for mothers with more than four children. For lung cancer or COPD (Column 2) the pattern is slightly different. Here, the mortality rate is lower for mothers with two

hand, and selection problems on the other hand. 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, thus mortality differences between twin and non-twin mothers might cause biased results. In order to maximize the sample size and avoid selection we use pension income at age 72, which we can observe for seven cohorts, those aged between 55 and 61 in 1990. We checked if pension income at age 72 is systematically missing between twin and non-twin mothers and find no significant differences (see Table A.1 columns four and five in the appendix).

to four children but the mortality rate is not higher among mothers with more than five children.

4.2 Twins and Old Age Mortality

We now turn to our main analysis. 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.

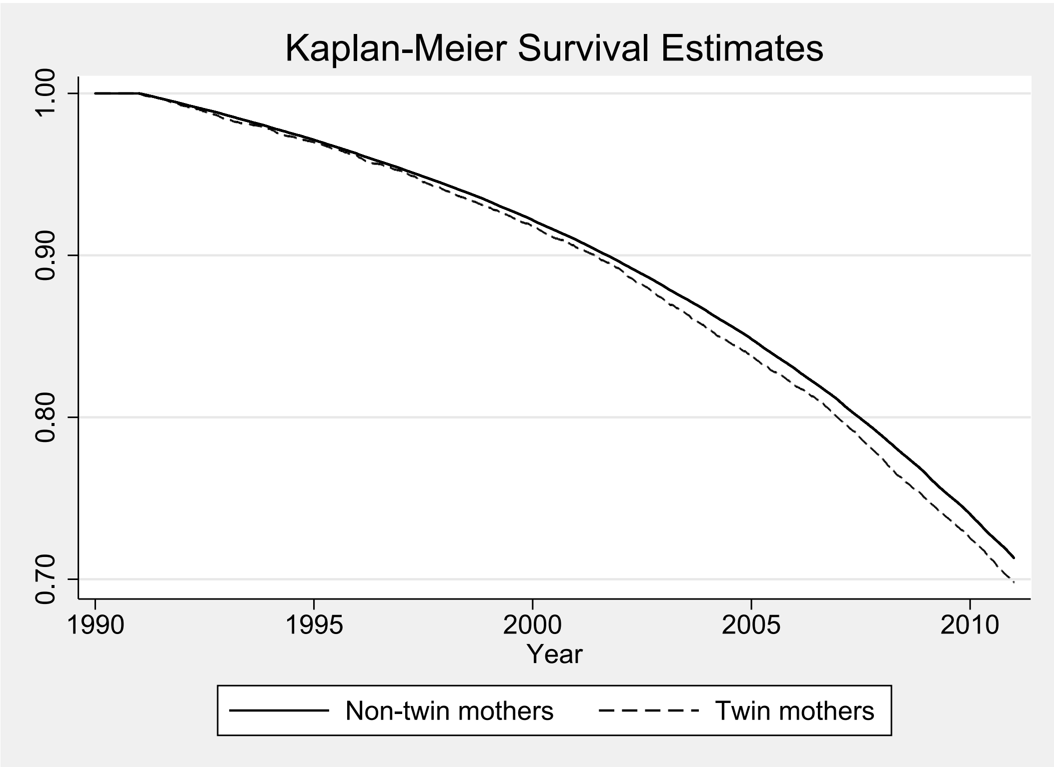

Figure 2: Survival rates for mothers with and without twins at first birth.

Panel B of Table 2 contains estimates for the effect of having twins at first birth based on the regression model from equation 2. 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 compared to mothers of singletons during the period of observation. Looking into specific causes of death the pattern is confirmed. 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.

	(1) Died between 1991 and 2010	(ii) Lung cancer/ COPD	(3) Heart attack/ stroke
Panel A			
Mothers with			
2 children	-0.042***	-0.010***	-0.022***
	(0.002)	(0.001)	(0.001)
3 children	-0.043***	-0.009***	-0.020***
	(0.002)	(0.001)	(0.002)
4 children	-0.030***	-0.004***	-0.009***
	(0.003)	(0.001)	(0.002)
5 children	-0.012***	0.000	0.007*
	(0.004)	(0.002)	(0.003)
6 children	0.005	0.002	0.020***
	(0.007)	(0.004)	(0.006)
7 children	0.032***	0.006	0.052***
	(0.011)	(0.006)	(0.009)
$\geq$ 8 children	0.041***	-0.000	0.058***
	(0.013)	(0.007)	(0.011)
Panel B			
Twins	0.037***	0.013***	0.018***
	(0.009)	(0.004)	(0.007)
Panel C			
Same-sex twins	0.038***	0.013**	0.020**
	(0.011)	(0.005)	(0.008)
Unconditional mean	0.287	0.044	0.136
Observations	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 one child, in panel B the reference group are mothers without twins at first birth and in panel C mothers without same-sex twins at first birth. Robust standard errors in parentheses below. ***,**,* indicate significance at the 1%, 5%, and 10% level, respectively.

Table 2: Mortality by number of children and twinning

As a robustness check, Panel C of 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 effects do not differ by much from the results presented in Panel B of Table 2. This suggests that our results are not driven by non-random selection into twinning.

Table 2 reports the reduced form effect of having twins at first birth. To provide a background to these estimates Tables A.2 and A.3 in the appendix report statistics on the number of children and child spacing for twin and non-twin mothers. From Table A.2 we see that twins at first birth lead to a substantially larger number of children in the short-run and in the long-run. Five years after first birth twin mothers on average have 0.68 more children than non-twin mothers and 15 years after first birth this difference is 0.59 children. As expected, twinning also affects child spacing. From 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 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 reduced form estimates capture the combined effects of the increased number of children and the reduced spacing, i.e. we capture a general health effect of child rearing.

4.3 Results by Educational Level and Pension Income

In order to investigate the interaction of fertility and labor market attachment, we now split the sample by education and pension income. 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 whole sample (see table 2 Panel B). 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. The largest effect sizes in absolute and relative terms are experienced by mothers within the highest education group (Panel C). For twin 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.[9] Reassuringly, we also find that effect sizes for

[9] We tested the statistical significance of the differences in the effects between educational groups using regression models with interaction terms. We find that the difference in the absolute effect of

the estimates based on all and same-sex twins are quite similar for all specifications.

We next split the sample at the median of the pension income at age 72. As described in section 3, we only observe pension income for a subsample of mothers between 55 and 61 years of age in 1990. In order to compare the results by pension income to the baseline estimates for the full sample, we rerun our original baseline results on the reduced sample (see Table 4 Panel A). The point estimates are slightly smaller compared to the estimates reported in Panel B and C of Table 2 but still sizable and highly significant. This is not surprising, given that the mortality differences become larger at older ages (see Figure 2), and the subsample is younger than our original sample. In Panel B and Panel C of Table 4 we show the effects of giving birth to twins for mothers below and above the median pension income, respectively. The observed pattern is in line with the double burden hypothesis. We do not find a significant effect of twins (or same-sex twins) on overall and cause specific mortality for individuals with below median pension income. In contrast to that for mothers with above median pension income twins (and same-sex twins) clearly increase overall and cause-specific mortality rates. Among 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. Compared to a baseline probability of 12% this translates into an almost 40% higher mortality. The estimated effect of twinning for mothers with below median pension income is not significant and much smaller in magnitude.[10] [11] Similar results are found for stress related diseases in columns 2 and 3 of Table 4. An interesting point in this analysis is that the baseline death rates by pension income are rather similar. This was not the case for the split by education. Thus, while for example in the context of death by COPD for highly educated mothers an additional death has a higher impact in relative terms compared to an additional death among the low educated, this problem does not occur in the context of pension income.

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. These results are based on tests on interaction terms between the twin birth indicator and education levels estimated in linear models using the full sample with control variables included.

[10] 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.

[11] The difference in effect sizes between mothers with above and below-median pension incomes is highly significant for all cause mortality. Results are based on tests on interaction terms between the twin birth indicator and a pension income indicator estimated in linear models using the full sample with control variables included.

	(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: 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.

Table 3: Results by education

	(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.

Table 4: Results by pension income

5 Discussion and Conclusion

In summary, we find evidence of a U-shaped relationship between the number of children and mothers' mortality. This appears to be in line with healthy mothers having more children. However, after a certain point more children take their toll on mothers' health either due to stress or because of the direct negative effects of giving birth to a large number of children on mothers' health. While this pattern cannot be interpreted causally, we also estimate the effect of having twins at first birth on mothers' mortality later in life. We find that having (same-sex) twins increases all-cause morality significantly for women older than 55. We also find substantial effects on cause-specific death rates. In particular, twin mothers have a higher probability of dying from lung cancer and COPD and heart attacks or strokes. The effects are stronger among women with higher educational degrees and higher pension income.

Our results fit into a recent line of epidemiological and sociological literature that tries to determine the adverse effects of work-family strain on women's later life health. The general theoretical considerations in that literature 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.

Using twins at first birth as a shock to fertility, we can overcome part of the endogeneity problem plaguing this literature. All-cause mortality as well as dying from lung-cancer and heart diseases are significantly elevated among mothers who give birth to twins. We take the higher probability of death due to lung cancer and COPD as well as the higher death rates due to heart attacks and strokes as indication that at least part of the effect is stress related. As argued in the introduction, the medical literature strongly associates these causes of death with stress from work-family conflicts, care-giving, and multiple role requirements of women. Thus, our results indicate that 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.

In addition to overall higher levels of all-cause and stress-specific mortality among twin mothers we find particularly strong effects among mothers with tertiary education and above median pension income. These results come as a surprise, as these mothers are a socio-economic advantaged group that due to their higher levels of education, ability, income and savings should be more able to stay healthy and mitigate negative shocks (Smith, 1999). However, the fact that effects among those mothers are particularly high, can be taken as an indication of a double burden effect. Women with tertiary education have a higher likelihood of following their career despite having kids and higher pension income is an indicator that women worked more during their life-time. In other words, we use tertiary education as an *ex ante* predictor of higher labor market attachment and pension income as a proxy for *ex post* realized labor market activity. Higher all-cause and stress-related death rates among women with tertiary education and above median pension income point to the existence of a double burden from simultaneous child rearing and working on maternal health in old age. Women who have worked more during their life have higher mortality rates from the same fertility shock than others.

The particular mechanisms behind these findings deserve further research. However, it is important to note that we make these observations in Sweden, a country famous for its generous parental leave and child support policies that attempts to make labor market and fertility decisions as compatible as possible. What is more, our findings are particularly important in the light of the fact that 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). Also, fathers' roles in supporting their families both financially and by taking a more active role in raising children are changing, too. Thus, more research is necessary in order to find adequate policies that buffer the negative consequences of a potential double burden from parents. This seems particularly relevant in times of demographic change and a decreasing work force, were policy makers in many developed countries aim at increasing female labor supply in order to better tap into hidden reserves. At the same time, preventing birth rates from declining further or even increasing them is on the agenda.

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Appendix

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.1: Selection into different samples.

	(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.2: Twin births and the number of children

	(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.3: Twin births and child spacing