Maternal Age and the Risk of Low Birth Weight and Preterm Delivery: a Pan-Nordic Comparison

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Introduction

In recent decades, the postponement of childbearing has been one of the most prominent demographic developments in high-income countries. In 2016, the mean maternal age at childbearing was above 30 in several highly developed countries (Human Fertility Database 2016). Since advanced maternal age at birth may reflect multiple biological, health, and social processes that influence the birth outcomes of children, there has been increased concern that this trend may be associated with increasing negative health consequences among children (Jacobsson et al. 2004; Liu et al. 2011). This study investigates the relationship between maternal age and the risk of low birth weight (LBW) and preterm delivery in Denmark, Finland, Norway, and Sweden.

Low birth weight and preterm birth are not only important measures of health at the time of birth, but are also linked to long-term outcomes in terms of socioeconomic status and health. In both the United States and Norway, low birth weight has been linked to lower cognitive ability scores, lower educational attainment, poorer labor market outcomes, and worse health in adulthood (Bharadwaj et al. 2018; Black et al. 2007; Conley and Bennett 2000; Moster et al. 2008; Swamy et al. 2008). Given the poor long-term outcomes associated with LBW and preterm birth, the secular increase in the mean age at childbearing in high-income countries could have important population-level consequences both in terms of health and economic development. As a result it is crucial to identify the extent to which advanced maternal age at the time of birth really is associated with poor perinatal outcomes, and to what extent.

A large literature investigating the relationship between advanced maternal age and pregnancy and perinatal health outcomes has consistently shown that older mothers are at a higher risk of experiencing complications during pregnancy and labor (Hemminki and Gissler 1996; Laopaiboon et al. 2014; Lisonkova et al. 2017; Schimmel et al. 2015). Similarly, children born to older mothers have also been found to experience an elevated risk of negative perinatal health outcomes such as preterm birth, low birth weight, stillbirth and perinatal mortality (e.g., Aldous and Edmonson 1993; Carolan and Frankowska 2011; Hemminki and Gissler 1996; Laopaiboon et al. 2014; Odibo et al. 2006). The latter may be driven by declines in oocyte quality amongst older mothers, making maternal age an independent risk factor for poor perinatal outcomes in children (Cimadomo et al. 2018; Jacobsson et al. 2004; Odibo et al. 2006). Although this literature is large and consistent, a recent study has brought into question the extent to which maternal age is causally related to adverse perinatal health outcomes of children (Goisis et al. 2017).

Goisis et al. (2017) examine the relationship between maternal age and LBW and preterm delivery in Finland using population registers. This study found that the results from standard regression models comparing children across different families corroborate the conventional story that the children of

older mothers have an elevated risk of experiencing poor birth outcomes; however, when examining within-family variation in maternal age at birth, the effects are statistically and substantively negligible. Thus, the authors conclude that the effects of maternal age on perinatal health outcomes are largely driven by unobserved confounding. The present study builds upon this by testing this relationship in Sweden, Denmark, and Norway using total-population register data (results for Norway are not presented here, but will be ready by the time of the conference). The main contribution of this study is to examine the extent to which the patterns identified in Finland are also found in other Nordic countries. Since the results from Goisis et al. (2017) stand in contrast to what is found in other studies, it is necessary to test this relationship in similar contexts.

Data

In this study we intend to use full population data from Sweden, Denmark, Norway, and Finland. At present we only include the results for Sweden and Denmark, but the results for Norway and Finland will be added to prior to the 2019 PAA meeting. Below we detail the characteristics of the Swedish and Danish register data used for our analyses:

Sweden

The data for this study comes from the Swedish Interdisciplinary Panel (SIP) administered by the Centre for Economic Demography, Lund University. The SIP is constructed by linking individual level data across administrative registers using unique identification numbers assigned to all individuals registered in Sweden. In this study, we rely primarily on information from the Medical Birth Register (SMBR) for birth cohorts 1973-2012 (n=3,780,885). The MBR contains birthweight information on approximately 99% of all births that have occurred in Sweden during this period (Cnattingius et al. 1990). Maternal information for the children included in the analysis is linked to the MBR from several other register data sources using the biological mother's unique identification number which is recorded in the MBR. As a result, we are able to identify every child born in Sweden to each mother.

Denmark

The Danish Medical Birth Register (DMBR) is available from the Danish Health Data Authority through Statistics Denmark and is a valuable source with information on all births in Denmark since 1997. In this study, we focus on birth cohorts 1997-2016 (n=1,234,027). Individual-level information on the mother is linked through the Danish Civil Registration System and the individual identifiers (CPR-number). Information vital for this study such as mother's age, gestational age and weight of the child has been deemed of very high quality from various evaluations made since 1997 (Bliddal et al. 2018).

Norway

The Norwegian Medical Birth Register (NMBR) is administered by the Norwegian Institute of Public Health and includes coverage for all births in Norway from 1967 onward. Similar to the other Nordic register data sources, unique identification numbers allow for linkages to made across registers.

Finland

The Finnish Medical Birth Register (FMBR) is administered by the National Institute for Health and Welfare and includes coverage for all births in Finland from 1987 onward. Similar to the other Nordic register data sources, unique identification numbers allow for linkages to made across registers.

Methods

Birth outcomes

We study two birth outcomes: whether a child was born with LBW (less than 2500 grams at birth) and whether the child was delivered preterm (less than 37 weeks of gestation).

Statistical Analysis

We compared the association between advanced maternal age and birth outcomes using two approaches. The first set of analyses applies linear regression to our binary outcome variables, meaning that we implement linear probability models. We refer to these models as between-family models as they compare the outcomes of children across different families. This is the standard approach in the literature, but these models do not account for potential unobserved factors that may be correlated with both maternal age at birth as well as child birth outcomes. In these analyses we control for birth order (1, 2, 3, 4+), sex, family size (1, 2, 3, 4, 5+), and year of birth. In the second step of the analysis, we employ linear regression with fixed effects specified at the level of the sibling group. That is, we compare siblings born to the same mother at different ages. The advantage of this approach is that we are able to account for all unobservable maternal factors that are shared between siblings, such as social background, health behaviors, unobserved aspects of maternal health, and genetic factors. In this set of analyses we also adjust for factors that vary between siblings, such as birth order and sex.

Results

Table 1 and table 2 present the results for Sweden and Denmark, respectively. Model 1 in table 1 and model 5 in table 2 correspond to the estimates of the association between maternal age and the risk of LBW in the between-family analysis. Here, the results corroborate the larger literature suggesting that the risk of a child being born LBW displays a U-shaped relationship with maternal age. Specifically, maternal age of 15-19 years is associated with a 1-percentage-point and a 1.7-percentage-point increase in the probability of LBW relative to the reference group (maternal age 25-29) in Sweden and Denmark, respectively. The risk of LBW also increased with maternal age. For example, the maternal age category of 40 or older is associated with a 2.1-percentage-point and 3.2-percentage-point increase in the risk of LBW relative to the reference group in Sweden and Denmark, respectively.

Model 3 in table 1 and model 7 in table 2 display the estimates for the association between maternal age and the risk of preterm delivery in the between-family analysis for Sweden and Denmark, respectively. Similar to the aforementioned analysis, the results also indicate a U-shaped relationship. Maternal age of 15-19 years is associated with a 2.1-percentage-point and 1-percentage point increase in the risk of preterm delivery relative to the reference category (maternal age 25-29) in Sweden and Denmark, respectively. The risk of preterm delivery also increased with maternal age. The maternal age category of 40 or older displayed an increase of 3.2-percentage-points and 2.6-percentage-points relative to the reference category in Sweden and Denmark, respectively. Although the results from the between-family analyses were qualitatively consistent between Sweden and Denmark, they are confounded by unobserved characteristics that are correlated with both maternal age at the time of birth and perinatal outcomes. In order to account for this, we use within-family analyses to exploit sibling differences in maternal age at birth.

Table 1. Sweden: The risk of LBW and preterm delivery by maternal age

	LBW		Preterm Delivery	
	Model 1[a] Between-family	**Model 2**[b] Within-family	**Model 3**[a] Between-family	**Model 4**[b] Within-family
Mother's age				
Less than 20	0.010***	-0.004***	0.021***	-0.016***
	[0.009, 0.012]	[-0.006, -0.003]	[0.018, 0.023	[-0.019, -0.013]
20-24	0.001***	-0.004***	0.004***	-0.009***
	[0.0005, 0.002]	[-0.005, -0.003]	[0.003, 0.005]	[-0.010, -0.007]
25-29	Ref.	Ref.	Ref.	Ref.
30-34	0.004***	0.0055***	0.002***	0.009***
	[0.004, 0.005]	[0.005,0.006]	[0.001, 0.003]	[0.007, 0.010]
35-39	0.012***	0.014***	0.015***	0.027***
	[0.012, 0.013]	[0.013, 0.015]	[0.014, 0.016]	[0.025, 0.029]
40+	0.021***	0.026***	0.032***	0.055***
	[0.019, 0.022]	[0.024, 0.028]	[0.029, 0.034]	[0.052, 0.058]
Maternal FE		X		X
Observations	3,780,885	3,780,885	3,780,885	3,780,885
R^2	0.003	0.002	0.006	0.003

95% confidence intervals in brackets. *(**)[***] denotes significance at the 5(1)[.1] % level.
[a] Models include controls for birth order, sex, family size, and year of birth
[b] Models include controls for birth order and sex

Table 2. Denmark: The risk of LBW and preterm delivery by maternal age

	LBW		Preterm Delivery	
	Model 5[a] Between-family	**Model 6**[b] Within-family	**Model 7**[a] Between-family	**Model 8**[b] Within-family
Mother's age				
Less than 20	0.017***	-0.006**	0.010***	0.005*
	[0.014, 0.020]	[-0.002, -0.010]	[0.006, 0.013]	[0.001, 0.009]
20-24	0.000	-0.001	0.001	0.005***
	[-0.001, 0.001]	[-0.001, -0.002]	[-0.001, 0.002]	[0.003, 0.007]
25-29	Ref.	Ref.	Ref.	Ref.
30-34	0.006***	-0.004***	0.003***	-0.008***
	[0.005, 0.006]	[-0.005, -0.002]	[0.001, 0.004]	[-0.009, -0.007]
35-39	0.018***	0.000	0.014***	-0.005***
	[0.017, 0.020]	[-0.003, 0.002]	[0.013, 0.016]	[-0.008, -0.003]
40+	0.032***	0.007**	0.026***	0.001
	[0.030, 0.035]	[0.002, 0.011]	[0.023, 0.029]	[-0.004, 0.006]
Maternal FE		X		X
Observations	1,234,027	1,234,027	1,234,027	1,234,027
R^2	0.003	0.001	0.003	0.001

95% confidence intervals in brackets. *(**)[***] denotes significance at the 5(1)[.1] % level.
[a] Models include controls for birth order, sex, family size, and year of birth
[b] Models include controls for birth order and sex

Model 2 in table 1 and model 6 in table 2 display the results for the association between maternal age and the risk of LBW, including maternal fixed effects, for Sweden and Denmark, respectively. In the Swedish case, the results from model 2 indicate that there is a linear relationship between maternal age and the risk of LBW. The risk of LBW increases linearly with maternal age, with mothers age 40 or older display a 2.6-percentage-point increase in the risk of LBW relative to the reference category. The results for Denmark, however, display an entirely different relationship. In the within-family analysis,

there seems to be no substantive or statistically significant difference in the incidence of LBW by maternal age. Figure 1 presents the relative probability of LBW by maternal age from the within-family analyses.

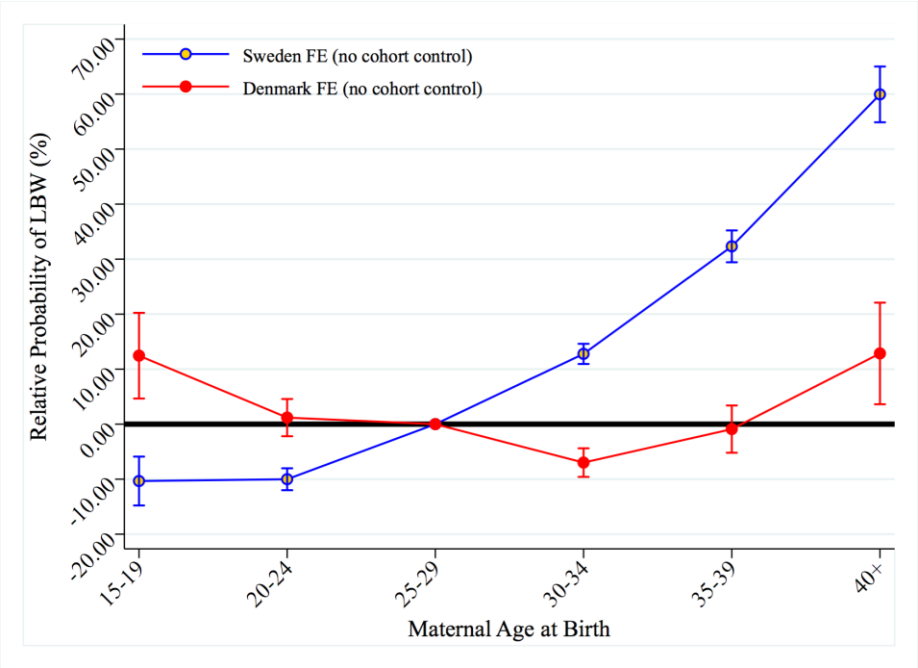

Figure 1. Relative probability of LBW from within-family analyses for Sweden and Denmark. For more detail, see results for Sweden in model 2 in table 1 and for Denmark in model 6 in table 2.

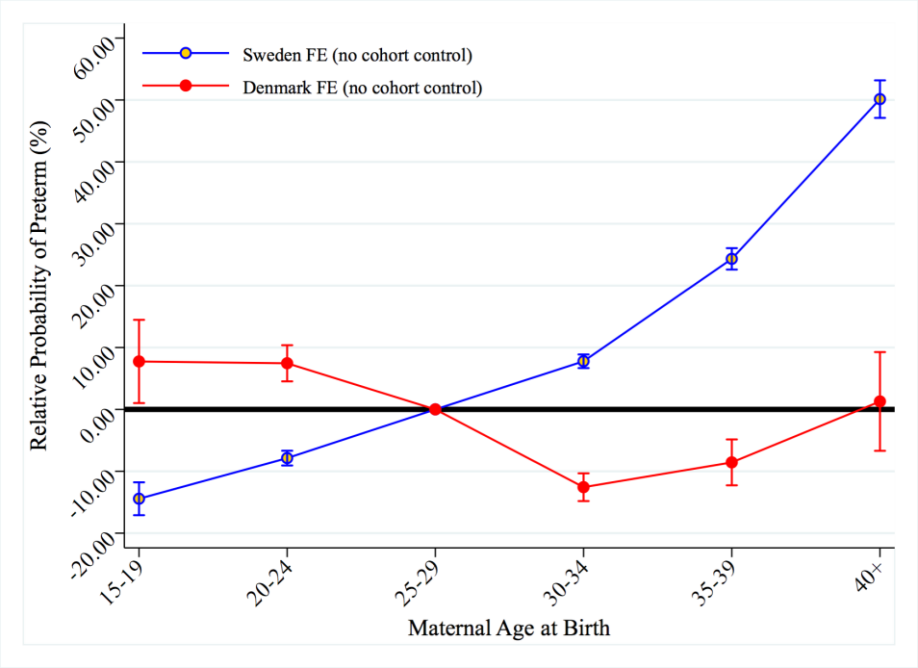

Figure 2. Relative probability of preterm delivery from within-family analyses for Sweden and Denmark. For more detail, see results for Sweden in model 4 in table 1 and for Denmark in model 8 in table 2.

A similar pattern is observed in the results from the within-family models for preterm delivery. Specifically, the within-family models suggest that maternal age is associated with the risk of preterm births in Sweden; however, in Denmark the association between maternal age and the probability of preterm delivery displays no clear association. Figure 2 illustrates these results.

In the within-family analyses, we are able to minimize residual confounding and come closer to the true association between maternal age and the two perinatal health outcomes that we study. This empirical strategy seems to yield similar results between Denmark and Finland, as identified in Goisis (2017); however, Sweden stands out with the association remaining robust to this model specification. We will add Norway and Finland to this analysis by the time of the conference, and aim to investigate the mechanisms driving these disparate results in more detail.

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