



## Socioeconomic inequality in birth weight and gestational age in Denmark 1996–2007: Using a family-based approach to explore alternative explanations

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### ABSTRACT

A large body of literature has reported associations between socioeconomic position and adverse pregnancy outcomes even in affluent egalitarian welfare states. This study explored the nature of this relationship by examining women who changed socioeconomic position between pregnancies and women who were siblings but were different in terms of socioeconomic position. Data consisted of 471,215 live born singletons born in Denmark 1997–2007 with at least one sibling or one first cousin. We examined parental educational attainment and household income in relation to preterm birth and small for gestational age using Cox regression. Household income was only weakly related to these outcomes. Paternal education was strongly associated with the outcomes only in the cohort analyses. Maternal education was inversely associated with preterm birth only in the cohort analyses, where the least educated women had the highest risk. Maternal education was inversely associated with the risk of small for gestational age in cohort analyses, attenuated between mothers who were siblings, and not present between children who were siblings. For example, the hazard ratio of preterm birth of women with a college/university degree when compared to women with only mandatory education was 0.64 (95% confidence interval: 0.60–0.67) in the cohort analysis, 0.90 (0.78–1.04) between mothers who were siblings, and 1.01 (0.82–1.24) between children who were siblings. The corresponding hazard ratios of small for gestational age were 0.54 (0.52–0.56), 0.72 (0.63–0.83), and 1.02 (0.84–1.24). This suggests that the associations were partly explained by factors shared between mothers who are siblings. In conclusion, the early life circumstances of mothers appear to be important in understanding the association between education, preterm birth and small for gestational age.

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### Introduction

Children whose parents have short educations or low incomes are at increased risk of being born preterm or with a low birth weight. This association has been observed in numerous populations (Kramer, Seguin, Lydon, & Goulet, 2000; Spencer, 2003). This has also been observed in the Nordic welfare states, where educational inequalities in birth outcomes are persisting and have perhaps even grown stronger over recent years (Mortensen et al., 2008; Petersen et al., 2009).

It is not well understood why there is an association between parental socioeconomic position and pregnancy outcomes. Several studies have sought to explain the association by examining whether a set of explanatory variables can account for the association between parental socioeconomic position and health in early

life (Dowd, 2007; Hafeman & Schwartz, 2009; Jansen et al., 2009; Reime et al., 2006). For example, two recent cohort studies have suggested that factors like maternal anthropometrics and smoking account for a major part of association between maternal education and birth weight (Mortensen, Diderichsen, Smith, & Andersen, 2009; Silva et al., 2010). In these studies the explanatory variables are not described as confounders, but as mediators, i.e. variables that act as intermediaries on the causal pathway from parental socioeconomic position to birth outcomes (Rothman, Greenland, & Lash, 2008). The use of the concept of mediation implicitly involves a causal claim, namely that socioeconomic position causally affects the level of the intermediary factors. But this assertion is potentially problematic. For instance, getting a college degree is something that takes place in early adulthood, whereas smoking initiation and the establishment of growth trajectories occur earlier in life. More often than not the putative intermediary variables are measured at the same point in time as socioeconomic position, which means that there is nothing that by design ensures that one precedes the other (Adair, 2008; Kraemer, Wilson, Fairburn, & Agras, 2002;

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National Cancer Institute, 2011; Nonnemaker, Morgan-Lopez, Pais, & Finkelstein, 2009). This does not invalidate mediational analyses, but it highlights the need for careful consideration of the alternative explanation that there may be confounding influences from antecedents of educational attainment and birth outcomes. For example, educational attainment is known to be strongly associated with parental educational attainment, even in the Nordic welfare states where equality in educational opportunities have been heavily promoted through policy (Jonsson & Erikson, 2007). It may be that early life circumstances of relevance to later-life reproductive outcomes vary according to the socioeconomic characteristics of the parental household, which may explain the educational differences in birth outcomes. One approach to this problem of confounding from early life factors would be to collect information on relevant early life circumstances, but this complicates the analyses because information on these factors may not be available or may be measured with considerable error.

Following a seminal paper by Krieger et al. the influence of early life circumstances on the relationship between socioeconomic position and health in adulthood has been studied in a number of studies of twins and non-twin siblings (Krieger, Chen, Coull, & Selby, 2005; Madsen, Andersen, Christensen, Andersen, & Osler, 2010; Søndergaard et al., 2012). Studies of monozygotic twins have shown that differences in health according to education exists even among individuals who are genetically identical and partly/fully share early life social and material circumstances. The attraction of sibling comparisons is that when siblings that are discordantly exposed (i.e. have different socioeconomic positions) are compared, all factors shared between them are matched out. In life course epidemiology, which takes it as a premise that early life circumstances may affect health later in life, this design has been strongly advocated (Strully & Mishra, 2009). An attractive characteristic of the sibling control design is that the factors that are matched out need not be directly measured: By design all that is shared is matched out. In social epidemiology the (non-twin) sibling design has been used to show that a substantial proportion of the association between education and cigarette smoking in adulthood is explained by factors shared by siblings (Gilman et al., 2008). It has also been used to show that increased risk of low birth weight and preterm birth among young mother is explained by factors shared by siblings, suggesting that the excess risk is not a 'biological' consequence of young maternal age, but is explained by the early life circumstances of the pregnant women (Lawlor, Mortensen, & Nybo Andersen, 2011). Differing opinions on the utility of these types of family designs exist: some have argued that siblings generally are as (dis)similar as unrelated individuals once shared genes are accounted for (Plomin & Daniels, 2011; Smith, 2011). According to this point of view the sibling design (when the genetic contribution is negligible) is bound to give similar results as a study of unrelated individuals, but at the cost of having to collect family data, strongly reduced statistical power and potentially other added assumptions (Kaufman, 2008). Others have argued that while this may be true siblings designs still provide the opportunity to actually test the influence of shared early life circumstance (Strully & Mishra, 2009).

The sibling design allows for control for shared early life circumstances, which may help explain the association between socioeconomic position and birth outcomes, but if the shared component is limited the results may remain confounded. Another approach would be to examine changes in socioeconomic factors in relation to changes in birth outcomes between pregnancies. This is possible because pregnancy is something that most often happens more than once to each woman. Such an analysis can be considered be an instance of the case crossover design, where the exposure for

a given person at a time where an event occurred is compared with the exposure for the same person at a different time (Maclure & Mittleman, 2000). The strength of this design is that all characteristics of an individual that do not vary over pregnancies are matched out. The two family-based designs used here have been promoted as methods to improve causal inference from observational data (McGue, Osler, & Christensen, 2010; Rutter, 2007), but it is important to keep in mind that the case crossover and sibling control designs are observational designs that will only allow the analyst to identify causal effects under special circumstances. Our study is based on relatively crude analyses of whether the associations between parental socioeconomic position and birth outcomes persist when the children compared are siblings or have mothers who are siblings. The type of explanations that can this study can offer is from the onset limited to either factors shared between children who are siblings or factors shared between children whose mothers are siblings. This present study is not genetically informative and no inference on the role of genes can be drawn from this study.

The objective of this study is to examine the association between parental socioeconomic position, preterm birth and small for gestational age in three different designs: cohort, sibling control, and case-crossover. The aim is not to show that socioeconomic inequality in birth outcomes do not exist because it does. The aim is to increase the understanding of the origins of the association.

## Methods

### Population

From the Danish Medical Birth Registry we selected all live born children born in Denmark 1996–2007 ( $n = 794,239$ ). The selection of the data is illustrated in Fig. 1. We excluded multiple pregnancies ( $n = 37,140$ ) and stillbirths ( $n = 2281$ ). Children whose grandmothers were born outside Denmark were excluded because their identity was not very likely to be recorded in Danish registries, which meant that family relations could not be reconstructed ( $n = 92,691$ ). The population with linked data on the grandmother's identity consisted of 645,933 children. We excluded a further 23,062 children with missing or implausible information on variables of interest, leaving a population of 622,871 children (Alexander, Himes, Kaufman, Mor, & Kogan, 1996). Of these 151,656 were singletons with no maternal cousins in the cohort, and were not thus informative for any of the family-based analyses. The population that formed the bases of the analyses consisted of 471,215 children.

### Variables

We used two measures of socioeconomic position: household income and parental education. Household income was included as an indicator of current material resources available to the family. Parental education was included a measure of knowledge assets. We chose these two measures because they have been used frequently in previous research. From the Registry of Tax-Related Income Statistics we obtained the household market income in the year before the birth of the offspring, which we then size-equivalised (using the OECD-modified scale method) and corrected for changes in consumer prices (Haagenars, de Vos, & Zaidi, 1994; Statistics Denmark, 2011). The majority of all income reported directly to the tax authorities by the employer, and the registry information generally thought to be valid and accurate (Baadsgaard & Quitzau, 2011). Education in the year preceding birth of the offspring was taken from the Integrated Database of Labour

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