



# Fetal malnutrition and academic success: Evidence from Muslim immigrants in Denmark<sup>☆</sup>



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## ABSTRACT

This paper examines the impact of potential fetal malnutrition on the academic test scores of Muslim students in Denmark. We account for the endogeneity of fetal malnutrition by using exposure to the month of Ramadan as a natural experiment under the assumption that mothers of some of the Muslim students might have fasted during Ramadan when they were pregnant. We also complement our Muslim sample with a control group comprised of immigrant children from predominantly non-Muslim countries in a difference-in-differences framework. Our outcome measures are the standardized test scores from the national exams on the subjects of Danish, English, Mathematics, and Science administered by the Danish Ministry of Education. Our results indicate that fetal exposure to Ramadan is likely to have a negative impact on the achievement scores of Muslim students, especially among females. Our analysis further reveals that the estimated relationship is stronger among children with a relatively low socio-economic background. Our findings lend support for the importance of interventions designed to assist economically disadvantaged women during pregnancy.

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## 1. Introduction

A well-established body of research demonstrates that early years of life is a profoundly important period, during which external shocks can have significant and long-lasting impacts on future outcomes in health, education, crime, and labor market (e.g., Carneiro & Ginja, 2014; Chetty et al., 2011; Currie, 2001; Heckman, Moon, Pinto, Savelyev, & Yavitz, 2010; Ludwig & Miller, 2007; Ludwig & Phillips, 2008; Muennig et al., 2011). One implication of this finding is that early childhood investments are likely to produce substantial benefits for those who receive them as well as the society at large (Almond & Currie, 2011a,b; Heckman, 2006).

This literature is also complemented by a growing body of research, which reveals the importance of environments and condi-

tions that individuals encounter during their period in utero. In particular, these studies demonstrate that the risk of poor outcomes in education, labor market, and health may actually originate from individuals' exposure to adverse conditions such as air pollution, inadequate nutrition, maternal smoking, stress and alcohol abuse when they were in utero (e.g., Almond & Mazumder, 2011; Almond, Mazumder, & Ewijk, 2015; Black et al., 2014; Cesur et al., 2017; Scholder, Wehby, Lewis, & Zuccolo, 2014; Hoynes, Miller, & David, 2015; Schultz-Nielsen, Tekin, & Greve, 2016; Yeung, Van den Berg, Lindeboom, & Portrait, 2014; Persson and Rossin-Slater). An important lesson learned from this research is that the prenatal period should not be overlooked when making decisions about policy interventions aimed at promoting the future well-being of individuals (Almond & Currie, 2011a; Shonkoff & Phillips, 2000). To the extent that human development, skill formation in particular, is a dynamic process, in which early inputs are strongly linked to the productivity of later inputs, interventions targeting pregnant women as well as those at childbearing age may actually be more cost-effective than those interventions implemented later in life (Almond & Currie, 2011a,b).

The foundations of the literature on the long-term consequences of fetal conditions on the well-being of individuals date

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back to the pioneering work by Stein in 1970s, when she and her colleagues discovered that exposure to the 1944–45 Dutch “Hunger Winter” in specific periods of gestation had been associated with a myriad of health problems later in life (e.g., Stein, Susser, Saenger, & Marolla, 1972; Stein, Susser, Saenger, & Marolla, 1975). Since then, the most commonly used approach in this literature has become to exploit some extreme and negative event such as famines (e.g., the Dutch Hunger Winter, the Bangladeshi famine of 1974, and the Chinese famine of 1959–61) or disease outbreaks (e.g., the 1918 influenza epidemic) as natural experiments and compare the outcomes of cohorts of individuals who are exposed to these events with those who are not.<sup>1</sup>

While the majority of the studies focused on health outcomes initially, there has been a recent shift in interest towards exploring the potential impact of intrauterine shocks on non-health endpoints (e.g., Almond, 2006; Almond & Mazumder, 2011; Almond et al., 2015; Field, Robles, & Torero, 2009; Majid, 2015; Neelsen & Stratmann, 2011; Scholte, Van den Berg, & Lindeboom, 2015; Schultz-Nielsen et al., 2016). The finding in these investigations is that exposure to disease environments or malnutrition during the period of gestational development has detrimental impacts on outcomes such as educational attainment, employment, and earnings.

In this paper, we provide fresh insights into the relationship between potential malnutrition experienced by individuals during the critical period of fetal development and their subsequent academic proficiency. In order to address this question, we exploit the Islamic calendar in a natural experiment framework and examine the academic test scores of children to Muslim immigrants in relation to their exposure to the month of Ramadan in utero. The underlying assumption in this approach is that at least some Muslim parents might have fasted during the month of Ramadan while they were pregnant. Our Muslim population is comprised of immigrants in Denmark whose country of origin are predominantly from Muslim countries. The outcomes that we consider include national standard test scores administered at the end of the ninth grade on the subjects of Danish, English, Mathematics, and Science. In addition to comparing Muslim children based on their exposure to Ramadan in utero, we also utilize a sample of children born to immigrant parents from predominantly non-Muslim countries as an additional control group to eliminate any confounding influences due to potential seasonality in the school achievement outcomes associated with the time of birth. In a supplementary analysis, we also make use of Danish students as a control group.

Our paper is in the same vein as a series of recent studies, which rely on the overlap between pregnancy and the month of Ramadan for the purpose of identification (e.g., Almond & Mazumder, 2011; Almond et al., 2015; Jürges, 2015; Majid, 2015; Schultz-Nielsen et al., 2016; van Ewijk, 2011).<sup>2</sup> However, with the exceptions of a few recent examples (e.g., Almond et al., 2015; Schultz-Nielsen et al., 2016), these studies use survey data, which are more likely to suffer from attrition and measurement problems. Furthermore, the majority of the studies in the literature focus on outcomes related to either employment or health outcomes. An important exception to this is Almond et al. (2015), which use school register data from England to examine the impact of Ramadan’s overlap with pregnancy on academic outcomes of immigrant children with Pakistani and Bangladeshi origins at the of age

seven. In addition to comparing Muslim students who were exposed to Ramadan with those who were not exposed, the authors also make use of a sample of students born in the Caribbean as an additional control group in a difference-in-differences framework. Their results indicate that Muslim children who were exposed to Ramadan in utero during the first trimester of pregnancy score significantly lower on test scores in mathematics, reading, and writing.

We believe it is important to assess whether the findings in Almond et al. (2015) can be generalized to immigrant populations in another developed country like Denmark. Furthermore, the Muslim population considered in Almond et al. (2015) includes only those with Bangladeshi and Pakistani origins. Since we have register data on the entire Danish population, the Muslim children in our sample come from a much more diverse set of countries, including Turkey, Iraq, Pakistan, Afghanistan, and Somalia. Accordingly, it is less likely that our findings are driven by any particular religious, cultural, or traditional practices that are unique to a particular Muslim group. Almond et al. (2015) rely on one’s birth date and assume a normal gestation length of 266 days when they determine overlap between Ramadan and specific periods of gestation. In contrast, we use data from the Danish birth registry, which includes exact information on gestation length and birth date for every individual in our sample. Therefore, the possibility of misclassification in the assignment of exposure to Ramadan in utero is minimal in our sample. Finally, Almond et al. (2015) examine the test scores of children at age seven, while the children in our sample are around age 16 at the time the national exams are administered.

Aside from these differences, we also extend Almond et al. (2015) by exploring whether the impact of fetal exposure to Ramadan on academic achievement is heterogeneous along various characteristics of Muslim students, including gender and socio-economic status (SES). There is a sizeable body of literature documenting large differences by SES in both the quality and quantity of time parents spend with school-age children (e.g., Guryan, Hurst, & Kearney, 2008; Kalil, Ryan, & Corey, 2012). Then it is possible that low-SES Muslim parents may lack the resources necessary to mitigate some of the adverse influences experienced by their children. Therefore, it would be interesting to assess whether exposure to malnutrition in utero exacerbate the pre-existing disparities in academic achievement between children from various socio-economic backgrounds.

There is also evidence of male vulnerability to in utero shocks demonstrated by studies showing that exposure to Ramadan affects sex-ratio in favor of females (e.g. Almond & Mazumder, 2011).<sup>3</sup> On the one hand, there may be positive selection (culling) at work if those in relatively poor health do not survive fetal insults. On the other hand, there may be negative selection (scarring) if the survivors are permanently damaged in accordance with the fetal origins hypothesis. Additionally, both health shocks and subsequent interventions can have different long-term effects on males and females (Almond & Currie, 2011b; Currie and Yelowitz, 2000; Orr et al., 2003) due to biological differences between males and females in adapting to these problems or to the roles that they are assigned to in the society. To support this notion, several studies in health sciences document that fetal under-nutrition has more deleterious effects on the health of females than males (e.g., Mu & Zhang, 2008; Chen, Nembhard, & Stockwell, 2014; Lv et al., 2015; Sugden & Holnes, 2002). Despite these potential mechanisms, the empirical investigations of the impact of fetal malnutri-

<sup>1</sup> See Currie (2009) and Almond and Currie (2011ab) for extensive reviews of this literature.

<sup>2</sup> For example, Almond and Mazumder (2011) use data from multiple sources including vital records and health statistics from Michigan and Census data from Iraq and Uganda and find that the exposure to Ramadan in utero results in lower birthweight, reduced employment, and increased disability. Majid (2015) uses survey data from Indonesia and shows that individuals exposed to Ramadan perform more child labor, score lower on cognitive and math tests as children, and work less as adults.

<sup>3</sup> However, Jürges (2015) finds no effect of Ramadan exposure on the fraction of male births and birthweight using a data set of one million births to Muslim mothers in Germany.

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