The effect of prenatal Ramadan exposure on child health in Indonesia: a longitudinal perspective

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Abstract
Although they are permitted to skip fasting, many pregnant Muslim women continue to fast during the holy month of Ramadan. Evidence on the effect of such practice for the health of the conceived child is a topic of debate. Previous cross-sectional studies showed compromised adult health. However, others were against the results. The basis of their argument is insignificant differences in birth weight of relatively younger cohort. Unlike previous studies, we contribute to the debate by presenting the first evidence from a longitudinal panel data analysis. We exploit longitudinal panel structure of the Indonesian Family Life Survey to analyse consequences of being exposed to Ramadan during pregnancy on health in early childhood to late adolescence. By using fixed effect regression model, we find a retarded height growth of those who experienced Ramadan while *in utero*. Compared to the unexposed, the height growth of boys and girls who were exposed to Ramadan in early pregnancy are 1.33 cm and 1.25 cm less respectively in late adolescence. However, we are unable to find any evidence of negative effects on weight and BMI. Our findings conclude that the effect of prenatal Ramadan exposure develops through age and is not cohort dependent.

Keywords: prenatal, Ramadan, fasting, health, childhood, adolescence

Highlight
- Prenatal Ramadan exposure caused a retarded height growth
- No evidence of negative effects of the exposure on weight and BMI
- Negative effect of the exposure develops through age and is not cohort dependent

1. Introduction

The fetal origins hypothesis suggests prenatal period as an important life stage that has long-term consequences for the well-being of conceived child (Almond & Currie, 2011; Godfrey & Barker, 2001). From this point of view, mothers' dietary during pregnancy becomes a dominant factor that will determine life outcomes of the child later in life. Medical studies showed that restrictive food intake may halt maternal weight gain and may reduce in-body fatty acid reserve required for a healthy pregnancy (Almond & Mazumder, 2011). This condition is harmful for the conceived child and may compromise their optimal health development throughout life.

In Muslims community, food intake restriction in the form of fasting has strong religious root. Every year, millions of Muslim observe the holy month of Ramadan by consuming neither food nor drink during the daytime. Muslims consider Ramadan as a special occasion where people share a full month of spiritual and social experiences with their family. Therefore, although most interpretation in Islam allows pregnant women to skip fasting for health reason, many of them continue to fast during Ramadan (R. J. van Ewijk, Painter, & Roseboom, 2013). Furthermore, some Muslim women believe that it is safe to fast during pregnancy (Joosoph, Abu, & Yu, 2004). A number of studies reported that around 70%-90% of Muslim pregnant women around the globe remain fasting during Ramadan (R. van Ewijk, 2011). These facts suggest that Ramadan may imprint life of million individuals. Thus, studies to examine consequences of being exposed to Ramadan during pregnancy become important.

Previous studies have documented negative consequences of being exposed to Ramadan during pregnancy on multiple health indicators at different life stages. At birth, those who were prenatally exposed to Ramadan were lighter. This adverse effect is found across nations comprising of that from the USA (Almond & Mazumder, 2011), the Netherlands (Savitri et al., 2014), and Indonesia (Majid, 2013). Evidence from Indonesia showed not only General Health Status (GHS) is compromised but also symptoms of coronary heart problem and type 2 diabetes arise particularly in the older cohort (R. van Ewijk, 2011). A smaller and thinner stature at adulthood also add the evidence (R. J. van Ewijk et al., 2013).

Those who found negative consequences of being exposed to Ramadan while *in utero* suggest the lower birth weight may indicate the brain and other vital organ were not well-developed. Thus, becomes the pathway through which ill-health develops at later life stages. However, recent studies were against this hypothesis and suggested the birth weight and other neonatal health indicators of those who were exposed to Ramadan are not affected. Except for descriptive analysis of that Cross, Eminson, & Wharton (1990), the claim is mainly based on analysis of relatively younger cohort in Iran (Makvandi, Nematy, & Karimi, 2013; Sarafraz, Kafaei Atrian, Abbaszadeh, & Bagheri, 2014), the UK (Petherick, Tuffnell, & Wright, 2014), and Germany (Jürges, 2015). For these evidence, they argue prenatal Ramadan exposure fasting has no negative effect.

Debate on the compromised health of the conceived child due to maternal fasting during Ramadan is still inconclusive. While the pro camp has rather solid evidence at adulthood, the contra camp showed the birth weight of those who were exposed is not necessarily lower. Both the pro and the contra studies used cross-sectional design and therefore, the two opposing camps potentially overlooked longitudinal dimensions that may explain their results further.

Our study contributes to the debate by presenting the first evidence from a longitudinal panel data analysis. We exploit longitudinal panel structure of the Indonesian Family Life Survey (IFLS): a national representative survey from the largest country of Muslims majority. The aim is to analyse consequences of being exposed to Ramadan during pregnancy on consistent health indicators in early childhood to late adolescence. In this study, we show the seemed contradictive evidence of previous studies does not mean that prenatal Ramadan exposure has no effect for the conceived child. Moreover, although we do not find negative effects on weight and BMI, we find a slightly retarded height growth of those who were exposed to Ramadan while *in utero*. We show that our finding is relatively robust to any age specification and is not cohort dependent. Therefore, we firmly conclude that the negative effect of prenatal Ramadan exposure develops through age and not necessarily manifest on health problems of early childhood.

We structure our article as follow. In section 2, we discuss what Ramadan is and how the Muslims observe fasting during this holy month. We present additional details on the contextual setting of Ramadan in Indonesia. Section 3 reviews medical literature related to maternal fasting and its long-term consequences for the conceived children. The brief review introduces necessary knowledge of possible mechanisms linking the prenatal condition and later health outcomes of the children. We describe our data and analytical strategy in section 4. Section 5 presents the results. We show effects of being exposed to Ramadan fasting while *in utero* on three anthropometric measurements consist of height-for-age (HAZ), weight-for-age (WAZ), and BMI-for-age (BMIZ). In this section, we further present several age specifications to demonstrate the robustness of our results. A graph of linear age specification is also plotted to give an illustration of retarded height growth in early childhood to late adolescence. Section 6 concludes this article with a discussion on the implication of our study.

2. Background

Ramadan, the ninth month of Hijri calendar, is the Muslims' holiest month. During this holy month, every adult Muslims are obligated to fast from dawn to sunset. Consuming food and drink is not allowed during the daylight. Smoking, sexual intercourse, and according to some interpretation, taking oral medicine during fasting are also forbidden. After sunset, family and friends come together to break the fast with sweet drinks and snacks before dinner. If a Muslim unable to make the fasting, the person should fast on a later day and should give a donation to feed the poor. Certain people are exempted from this religious fasting. These are women in their monthly cycle, women in their *nifas* month, those who are in long traveling, those who are too old, and the sick. Pregnant women and the breastfeed are allowed to skip fasting if they have concerns about their health or the health of their children. However, they have to fast the moment health concerns are relaxed. Many feel it is uneasy to fast on a later day by their own and therefore choose to continue fasting during Ramadan (Mirghani, Weerasinghe, Ezimokhai, & Smith, 2003; Robinson & Raisler, 2005).

Since Hijri is a lunar calendar, Ramadan shifts around 11 days ahead of Gregorian calendar every year. Consequently, those who live in far southern and northern hemisphere experienced variable daylight duration respective to the month of which Ramadan falls in Gregorian calendar. Any statistical estimation becomes complicated because each cohort was exposed to a different fasting duration. For this reason, Indonesia is an appropriate site to study the effect of Ramadan. Indonesia situated near the equator. It means that daylight duration and thus, the length of fasting is constantly last for about 13 hours each day. Furthermore, Indonesia is the biggest country of Muslims majority. The latest census registered 87% of 237 million Indonesian are Muslims (Statistik, 2011). Therefore, results of this study have a great social relevance.

The rhythm of life in Indonesia changes considerably during Ramadan. Many restaurant and food stalls open only near sunset until just before sunrise (Abe, 2010). Office hours usually shift to early morning and close early to allow Muslims prepare the break in the evening. At the time of Ramadan, inflation and temporal food price hike are not unusual (ANTARA, 2016). However, the annual bonus locally known as *Tunjangan Hari Raya* eases the Muslims and enables them to have proper Eid celebration held the day after Ramadan.

During the long national holiday of Eid celebration, the Muslims mark the joy and happiness following a full month of spiritual and social experiences of Ramadan. They gather with family and friends to pray and celebrate with many food and drink. The non-Muslims receive *Tunjangan Hari Raya* as well but not during Ramadan. They receive this annual bonus before their own religious day celebration (Menteri Tenaga Kerja, 1994).

3. Medical theory on maternal fasting and the health of the conceived child

Almond & Mazumder (2011) and R. van Ewijk (2011) have discussed medical theories linking maternal fasting and possible consequences to the health of the conceived child extensively. At least three notable interrelated mechanisms can be summarised from their papers. These are accelerated starvation, fetal programming theory, and epigenetic adaptations.

Perhaps the most prevalent mechanism among the three is the accelerated starvation. The term is used to describe abnormal metabolic and hormonal condition when pregnant women skip breakfast after a night without food (Metzger, Vileisis, Ravnikar, & Freinkel, 1982). The abnormality occurs more rapidly when fasting takes place during the daytime because the body requires more energy to remain active (Meis, Rose, & Swain, 1984). Under normal conditions, human body produce energy from nutrition intake of food and drink. In lack of metabolic fuel, the body have to compensate low blood sugar with fat metabolism process. This process is very demanding for pregnant women as they have to sustain energy not only for them but also for the conceived child. The ketone body which is a side product of fat metabolism can lead to low blood pH that potentially destroy the much-required protein for the child procreation. Several studies indicate accelerated starvation occurs among pregnant women during Ramadan including those who live in West Africa (Prentice, Prentice, Lamb, Lunn, & Austin, 1983), the UK (Malhotra, Scott, Scott, Gee, & Wharton, 1989), and Iran (Arab, 2004). Arab (2004) found that before breaking their fast, 61% of the Iranian pregnant women in the sample had low blood sugar and 31% had ketone body. The study documented 92% of those who fast during Ramadan experienced calorie deficit of at least 500 kcal.

The fetal programming theory explains long-term consequences of metabolic fuel lack on health problem of the conceived child in later life stage. Fetal adaptation to harsh environment is the foremost of this theory. Nutritional shortage during pregnancy causes fetal adaptation to use scarce energy more to sustain the development of vital organs, in particular, the brain. The process is at expenses of other organs, muscles, and limbs. Thus, affecting general fetal growth and slowed down development of non-vital organs undergoing their critical period. Birth length and weight may be compromised as the immediate results (James, 1997). However, the most important matter is how the fetal adaptation may lead to adult chronic diseases such as coronary heart disease and its biological risk factor including hypertension and type 2 diabetes (Godfrey & Barker, 2000; Roseboom et al., 2000). The adult chronic disease is due to organs degeneration process occurring much later in life. Hypertension, for example, is because in many cases, the kidneys unable to function properly due to decreases number of already low quantity nephrons sustained from fetal adaptation to undernutrition (Barker, 2002).

Fetal experiences of undernutrition may contribute to epigenetic adaptations. The process sets genes to express the phenotypes that best fits the expected environment. This predictive adaptive response prepares the body optimally for its later life (Gluckman & Hanson, 2004). For example, poor prenatal nutrition may suggest the fetal body that it will encounter malnutrition in later life. As the result, the conceived child may express a tendency to store fat more in preparation to be born into a malnourish environment. The adaptation is beneficial if malnutrition after birth follow, but will be maladaptive once the conceived child exposed to better postnatal nutrition. This situation may lead to excessive weight gain that may create problems such as overweight in adulthood. Ramadan may create such maladaptive condition because the conceived child was prepared to encounter a harsh environment that it will not exactly follow after birth (R. van Ewijk, 2011).

4. Data and Analytical Strategy

The Indonesian Family Life Survey (IFLS) is a broad setup survey carried out by the RAND corporation (Strauss, Witoelar, & Sikoki, 2016). The survey collects wide array of information on economic, health, and social life conditions of the Indonesian population. This longitudinal panel design survey collects multiple waves of data by following the same individual within the household. Currently, five waves of IFLS have been completed. The first IFLS was fielded in 1993/1994 and the following IFLS 2, 3, 4, and 5 were fielded in 1997/1998, 2000, 2007/2008, and 2014/2015 successively. The sampling scheme consists of 13 most densely populated provinces in Indonesia representing 83% of the 1993 Indonesian population. Thus, the survey has a high level of representativeness of the Indonesian population.

Multiple health indicators are available in the IFLS. However, for the health indicators in our study, we decide to use anthropometric measurement because these measurements are available in all IFLS waves. Thus, allowing us to analyse consistent health indicators from early childhood to late adolescence. Trained nurses were assigned to measure height (cm) and weight (kg) up to a single digit decimal. We standardise these two measurements to the World Health Organization (WHO) growth reference (De Onis, 2006; Onis et al., 2007). Three anthropometric z-scores were constructed. These are height-for-age (HAZ), weight-for-age (WAZ), and BMI-for-age (BMIZ). The standardisation has two advantages. First, it produces a more linear specification of human biological growth. Second, the standardisation enables us to simplify identification of outliers which is difficult to detect due to curvilinear biological growth during childhood and adolescence.

This study exploits the IFLS longitudinal panel structure design to examine the effect of maternal fasting during Ramadan for the health of the conceived child. We construct our sample from those who participate at least once in the IFLS. With a thorough sample selection, our final sample consists of 44,861 anthropometric data of that 19,186 age 0 to 19 years old individuals from 9,260 families. About 88.56% individuals in our final sample were born to a Muslim mother. Details on the construction of the final sample are described in section 5.

We use R. van Ewijk's (2011) approach to identify those who were prenatally exposed to Ramadan. On average, a full-term pregnancy lasts 266 days after the conception. An individual is considered prenatally exposed to Ramadan if born to a Muslim mother and Ramadan overlapped with a period of 266 days before birth. We retrieve Ramadan dates from The Umm al-Qura Calendar of Saudi Arabia. This calendar is accessible from http://www.phys.uu.nl/~vgent/islam/ummalqura.htm. To examine the effect further, we classify the exposed children into: a) those who were conceived during Ramadan, b) those for whom Ramadan began during early pregnancy (days 1-89 of pregnancy), c) those for whom Ramadan began during mid-pregnancy (days 90-178), d) those for whom Ramadan began during late pregnancy (days 176-266), and e) those who were born during Ramadan. Group b, c, and d experienced an entire Ramadan while *in utero*. Those who were not exposed to Ramadan become the reference group. We exclude children who were conceived less than 21 days after the end of Ramadan because their classification as the unexposed may introduce estimation bias due to a possibility of post-term birth. The above procedure is applied to children of a non-Muslim mother as well to create control groups.

Our basic model is:

$$y_{im} = \beta_1 exposure_{im} + \beta_2 age_{im} + \beta_3 cohort_{im} + \beta_4 exposure_{im} + \varepsilon_{im} \quad (1)$$

We use mother fixed-effects regression to estimate our model specifications. The use of mother fixed-effect regression restricts any statistical estimation to within-siblings comparisons only and therefore, cancels out any systematic differences between families *m* including differences in nutritional intake and genetic variability that may bias our results. Since a child may have several anthropometric data *y* measured at a different age, we cluster the standard errors by children *i*. The *exposure* is a set of dummies correspond to when during pregnancy a child was exposed to Ramadan. Further, we create several *age* specifications to be tested in our analysis. The main specification is a set of dummies correspond to early childhood (0-4 years old), late childhood (5-9 years old), early adolescence (10-14 years old), and late adolescence (15-19 years old). For other specifications, we divide age in days with 365.25 to form age in years. We then create continuous variables of age, age^2, and age^3 as alternatives to the previous age specification. We also create *cohort* dummies to classify those who were born before 1986, between 1986-1990, 1991-1995, 1996-2000, and after 2000. Previous studies showed that sex (Macintyre, Hunt, & Sweeting, 1996), birth month (Doblhammer & Vaupel, 2001), and birth order (Black, Devereux, & Salvanes, 2015) may have significant effects on health. Therefore, it is important to control these possible confounders with X_{im} comprises of dummy variables for sex, birth month, and birth order. Since we do not know which mothers actually did fast during Ramadan, our results should be seen as intention to treat estimates. There is no statistics on how many Indonesian pregnant women actually fast during Ramadan and for how many days. Thus, if the number of pregnant mothers who did fast is small or they observed fasting only for a short period, then our results would heavily bias towards zero.

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References

Abe, B. (2010, August). The Ramadan tradition in Indonesia. The Jakarta Post. Retrieved from http://www.thejakartapost.com/news/2010/08/11/the-ramadan-tradition-indonesia.html

Almond, D., & Currie, J. (2011). Killing me softly: The fetal origins hypothesis. *The journal of economic perspectives: a journal of the American Economic Association*, *25*(3), 153.

Almond, D., & Mazumder, B. (2011). Health capital and the prenatal environment: the effect of Ramadan observance during pregnancy. *American Economic Journal: Applied Economics*, 56–85.

ANTARA. (2016). BPS: Harga Komoditas Pangan Naik Menjelang Akhir Mei 2016. tempo.co. Retrieved from https://m.tempo.co/read/news/2016/05/25/090773806/bps-harga-komoditas-pangan-naik-menjelang-akhir-mei-2016

Arab, M. (2004). Ketonuria and serum glucose of fasting pregnant women at the end of a day in Ramadan. *Acta Medica Iranica*, *42*(3), 209–212.

Barker, D. J. (2002). Fetal programming of coronary heart disease. *TRENDS in Endocrinology & Metabolism*, *13*(9), 364–368.

Black, S. E., Devereux, P. J., & Salvanes, K. G. (2015). *Healthy (?), Wealthy and Wise: Birth Order and Adult Health*. National Bureau of Economic Research.

Cross, J., Eminson, J., & Wharton, B. (1990). Ramadan and birth weight at full term in Asian Moslem pregnant women in Birmingham. *Archives of disease in childhood*, *65*(10 Spec No), 1053–1056.

De Onis, M. (2006). *WHO child growth standards: length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age*. WHO.

Doblhammer, G., & Vaupel, J. W. (2001). Lifespan depends on month of birth. *Proceedings of the National Academy of Sciences*, *98*(5), 2934–2939.

Ewijk, R. van. (2011). Long-term health effects on the next generation of Ramadan fasting during pregnancy. *Journal of health economics*, *30*(6), 1246–1260.

Ewijk, R. J. van, Painter, R. C., & Roseboom, T. J. (2013). Associations of prenatal exposure to Ramadan with small stature and thinness in adulthood: results from a large Indonesian population–based study. *American journal of epidemiology*, *177*(8), 729–736.

Gluckman, P. D., & Hanson, M. A. (2004). *The fetal matrix: evolution, development and disease*. Cambridge University Press.

Godfrey, K. M., & Barker, D. J. (2000). Fetal nutrition and adult disease. *The American journal of clinical nutrition*, *71*(5), 1344s–1352s.

Godfrey, K. M., & Barker, D. J. (2001). Fetal programming and adult health. *Public Health Nutrition*, *4*(2b), 611–624. doi:10.1079/PHN2001145

James, W. P. T. (1997). Long-Term Fetal Programming of Body Composition and Longevity. *Nutrition Reviews*, *55*(1), S31–S41. doi:10.1111/j.1753-4887.1997.tb06097.x

Joosoph, J., Abu, J., & Yu, S. (2004). A survey of fasting during pregnancy. *Singapore medical journal*, *45*(12), 583–586.

Jürges, H. (2015). Ramadan fasting, sex-ratio at birth, and birth weight: No effects on Muslim infants born in Germany. *Economics Letters*, *137*, 13–16. doi:http://dx.doi.org/10.1016/j.econlet.2015.10.015

Macintyre, S., Hunt, K., & Sweeting, H. (1996). Gender differences in health: are things really as simple as they seem? *Social science & medicine*, *42*(4), 617–624.

Majid, M. F. (2013). The Persistent Eff ects of in Utero Nutrition Shocks Over the Life Cycle: Evidence From Ramadan Fasting.

Makvandi, S., Nematy, M., & Karimi, L. (2013). Effects of Ramadan fasting on neonatal anthropometric measurements in the third trimester of pregnancy. *Journal of Fasting and Health*, *1*(2), 53–57.

Malhotra, A., Scott, P., Scott, J., Gee, H., & Wharton, B. (1989). Metabolic changes in Asian Muslim pregnant mothers observing the Ramadan fast in Britain. *British Journal of Nutrition*, *61*(03), 663–672.

Meis, P. J., Rose, J. C., & Swain, M. (1984). Pregnancy alters diurnal variation of plasma glucose concentration. *Chronobiology international*, *1*(2), 145–149.

Menteri Tenaga Kerja. (1994). Peraturan Menteri Tenaga Kerja Republik Indonesia Nomor Per-04/MEN/1994 tentang Tunjangan Hari Raya Keagamaan Bagi Pekerja di Perusahaan. Jakarta: Per-04/MEN.

Metzger, B., Vileisis, R., Ravnikar, V., & Freinkel, N. (1982). Accelerated starvation" and the skipped breakfast in late normal pregnancy. *The Lancet*, *319*(8272), 588–592.

Mirghani, H., Weerasinghe, D., Ezimokhai, M., & Smith, J. (2003). The effect of maternal fasting on the fetal biophysical profile. *International Journal of Gynecology & Obstetrics*, *81*(1), 17–21.

Onis, M. de, Onyango, A. W., Borghi, E., Siyam, A., Nishida, C., & Siekmann, J. (2007). Development of a WHO growth reference for school-aged children and adolescents. *Bulletin of the World Health Organization*, *85*(9), 660–667.

Petherick, E. S., Tuffnell, D., & Wright, J. (2014). Experiences and outcomes of maternal Ramadan fasting during pregnancy: results from a sub-cohort of the Born in Bradford birth cohort study. *BMC pregnancy and childbirth*, *14*(1), 1.

Prentice, A., Prentice, A., Lamb, W., Lunn, P., & Austin, S. (1983). Metabolic consequences of fasting during Ramadan in pregnant and lactating women. *Human nutrition. Clinical nutrition*, *37*(4), 283–294.

Robinson, T., & Raisler, J. (2005). Each one is a doctor for herself": Ramadan fasting among pregnant Muslim women in the United States. *Ethn Dis*, *15*(1 Suppl 1), 1–99.

Roseboom, T. J., Meulen, J. H. van der, Osmond, C., Barker, D. J., Ravelli, A. C., Schroeder-Tanka, J. M., Montfrans, G. A. van, et al. (2000). Coronary heart disease after prenatal exposure to the Dutch famine, 1944–45. *Heart*, *84*(6), 595–598.

Sarafraz, N., Kafaei Atrian, M., Abbaszadeh, F., & Bagheri, A. (2014). Effect of Ramadan fasting during pregnancy on neonatal birth weight. *Journal of Fasting and Health*, *2*(1), 37–40.

Savitri, A. I., Yadegari, N., Bakker, J., Ewijk, R. J. G. van, Grobbee, D. E., Painter, R. C., Uiterwaal, C. S. P. M., et al. (2014). Ramadan fasting and newborn's birth weight in pregnant Muslim women in The Netherlands. *British Journal of Nutrition*, *112*(09), 1503–1509. doi:10.1017/S0007114514002219

Statistik, B. P. (2011). Kewarganegaraan, Suku Bangsa, Agama, dan Bahasa Sehari-hari Penduduk Indonesia: Hasil Sensus Penduduk 2010. *Jakarta: Badan Pusat Statistik*. Retrieved from http://sp2010.bps.go.id/files/ebook/kewarganegaraan%20penduduk%20indonesia/

Strauss, J., Witoelar, F., & Sikoki, B. (2016). *The fifth wave of the Indonesian Family Life Survey (IFLS5): overview and field report,*. WR-1143/1-NIA/NICHD.