Network for Studies on Pensions, Aging and Retirement

Netspar DISCUSSION PAPERS

Reyn van Ewijk

Long-Term Health Effects on the Next Generation of Ramadan Fasting during Pregnancy

Discussion Paper 07/2010-040

Long-term health effects on the next generation of Ramadan fasting during pregnancy

Reyn van Ewijk*

July 9, 2010

Abstract

Each year, many pregnant Muslim women fast during Ramadan. Using Indonesian cross-sectional data and building upon work of Almond & Mazumder (2009), I show that people who were prenatally exposed to Ramadan fasting have a poorer general health than others. As predicted by medical theory, this effect is especially pronounced among older people, who also more often report symptoms indicative of coronary heart problems and type 2 diabetes. Among exposed Muslims the share of males is lower, which is most likely caused by death before birth. I show that these effects are unlikely the result of common health shocks correlated to the occurrence of Ramadan, or of fasting mainly occurring among women who would have had unhealthier children anyway.

JEL Classification: I1, I12, J1, J14
Keywords: Health, Ramadan, pregnancy, nutrition, Indonesia

*VU University Amsterdam, De Boelelaan 1105, 1081 HV, Amsterdam, The Netherlands; rewijk@feweb.vu.nl; tel. + 31 (0) 20 59 83616. I would like to thank Douglas Almond, David Barker, Monique de Haan, Bhashkar Mazumder, Sandra McNally, Hessel Oosterbeek and Erik Plug for their helpful comments and suggestions. I gratefully acknowledge comments from seminar participants at the National Islamic University (UIN) in Jakarta, Indonesia, the London School of Economics, the Chicago Federal Reserve Bank, the Centre for European Economic Research (ZEW), and the University of Amsterdam Medical Center (AMC). I thank my Indonesian hosts, particularly the people from UIN and Dwi Tyastuti for their great help in organizing the interviews and visits I made during Ramadan 2008. Tessa Roseboom, who leads the "Fetal origins of adult disease" research programme at the University of Amsterdam Medical Center (AMC), I thank for her expert advice on the medical theory described in this paper.

1 Introduction

Mothers' behavior during pregnancy, such as smoking and alcohol and coffee consumption, is known to have long-term effects on their children's health. Medical studies show that fasting during pregnancy in the form of skipping breakfast and other meals is another aspect of mothers' consumption and behavior that may have a negative effect on the health of their children, which may last into adulthood. Each year, many pregnant women fast during daylight hours during the Islamic holy month of Ramadan. They do this, even though they are exempted from the religious obligation to fast if they are worrying about their own health, or the health of their fetus. This paper shows that the health of people is negatively affected if their mother fasted during a Ramadan while they themselves were still *in utero*. This effect gets stronger as these people get older. Although effects on pregnant women and newborn babies with respect to Ramadan fasting have been measured in previous studies, very little research exists on the long-term effects of having a mother who observed Ramadan during pregnancy, and no research has yet examined effects on the serious health problems that are specifically predicted by medical theory, such as coronary heart disease and type 2 diabetes.

Almond & Mazumder (2009) are the first to systematically examine long-term effects of pre-birth Ramadan exposure. Using Michigan data, they first focus on short-term effects and demonstrate that exposure in utero is associated with lower birth weights and a lower share of male births. Next, they show that prenatally exposed Ugandan adults have higher probabilities of having sensory or mental disabilities and less wealth. Iraqi and US data corroborate these long-run effects. This paper differs from Almond & Mazumder's paper on four notable aspects. First, compared to Almond & Mazumder's analyses on long-term health effects which rely on rather crude measures of disabilities, the rich dataset I use contains better and more detailed measures of people's general health, and adds indicators for high-prevalence serious health problems, including coronary heart disease, hypertension and type 2 diabetes. Second, I am able to determine prenatal Ramadan exposure more precisely since I can use exact date of birth instead of only month or quarter of birth. And my data contain the respondents' religion, whereas in their American data, Almond & Mazumder use immigrants from predominantly Muslim countries to proxy for Muslims. As they report, however, a large share of these immigrants in the United States, are non-Muslims. This induces considerable noise. Third, I show that selection on observables and unobservables do not drive my results, by comparing parents of exposed and not exposed children and by using a family fixed effects approach. Almond and Mazumder only rely on testing for selection on observables for one of their datasets (Michigan). Fourth, my analyses on different symptoms and age groups closely follow, and confirm, specific predictions made by medical theory.

The data I use consist of a cross-sectional sample of the population of Indonesia, which is the country with the largest Muslim population in the world. After showing that general health, especially that of older people, is negatively affected by exposure, I examine which aspects of health are affected. I find evidence that exposure leads to a higher likelihood of developing symptoms that are indicatory for coronary heart disease, type 2 diabetes and kidney problems at older age. A point of overlap with Almond & Mazumder is that I also find a lower share of males among the exposed. This fits with medical theory, because in utero, males are more vulnerable to adverse conditions. Importantly, I investigate whether there are alternative explanations for these effects. I show that they are most probably not artifacts of selective timing of pregnancies: perhaps Muslims who care a lot about their offspring's health may avoid pregnancy during Ramadan. Using family fixed effects and by comparing the characteristics of parents whose child was, versus was not, in utero during a Ramadan, I refute this alternative explanation. Also, throughout this paper, to rule out that effects of Ramadan during pregnancy are caused by correlated common shocks to birth cohorts, I show that no effects of timing of Ramadan are found on non-Muslims.

The paper is structured as follows: section two gives background information on Ramadan and explores Muslims' beliefs on observing the Ramadan fast during pregnancy. Section three discusses medical theory on how maternal fasting during pregnancy may exert a long-term effect on the health of her offspring. Section four describes the data used. Section five presents the results. It starts with effects on general health and some checks on the robustness of the results found. It next deals with effects on the sex ratio and then focuses on specific diseases, including coronary heart disease, diabetes, hypertension and anemia. Section six discusses the implications of this research. Throughout this paper, I will complement the analyses with information obtained from interviews I held in Indonesia during Ramadan 2008 with doctors, midwifes, health workers and others. These interviews and the observations made in hospitals and health clinics during my visits are not representative for a complete Indonesian population, nor do they serve to replace any quantitative analyses, but they do often shed more light on the local situation and the believes and experiences of Indonesians.

2 Background

Ramadan is the holiest month of Islam. It is one of the five "pillars" of Islam that Muslims have to fast during this month. No food and drinks are to be taken from dawn to sunset. Smoking, sexual intercourse and, according to some interpretations, the taking of oral medicine are also forbidden during these hours. In the evening, the fast is broken with sweet drinks and snacks. This is a very social happening, in which family and friends come together. If a Muslim misses a day of fasting, (s)he has to make up for it on a later day and often pay a penalty that is used to feed the poor. The timing of the Ramadan follows the Islamic calendar. This is a lunar calendar and since, depending on the exact moon cycle, the year is about 11 days shorter than the commonly used Gregorian calendar, each year Ramadan starts about 11 days earlier. After a bit more than 33 years, Ramadan will start around the same Gregorian date again. This "shifting over the years" makes it possible to separate effects of Ramadan from seasonal effects, a strategy similar to the one applied in Almond & Mazumder (2009), which I exploit in this paper.

Ramadan lasts about 30 days, but both the exact start and end date depend on moon sightings and cannot be predicted exactly in advance. Because Indonesia lies on the equator, daylight times and thus length of fasting, are about the same each year (about 13 $\frac{1}{2}$ hours), irrespective of the Gregorian month in which Ramadan falls. This makes Indonesia very well suited for the study of these effects, because the effect of fasting (which can be assumed to depend on the length of fasting) will be the same for each cohort. Hence, my results are not biased by correlation between length of Ramadan in utero and age.

Certain people are excluded from the religious obligation to fast, including children under 12, the sick, the traveling, women who are breastfeeding young babies and women in their period. Pregnant women are allowed to skip fasting if they are afraid that fasting may harm their own health or the health of their fetus. According to most people, they then have to do the fasting later and often pay a compensation in food or money that will go to the poor. Some Muslims explain this regulation as an obligation for all pregnant women to fast, unless there are specific reasons for abandoning fasting. These reasons, according to Indonesian doctors I interviewed who adhered to this interpretation, include pregnancy complications and maternal health problems that existed already before pregnancy. Other Muslims have the interpretation that pregnant women in any case have a dispensation from fasting. Even women adhering to the latter interpretation often do choose to fast. Reasons include having to make up for the fast later on their own, instead of fasting together with the whole community and family, a loss of the feeling of Ramadan and not actively deciding to fast: it is just the normal thing to do (Robinson & Raisler, 2005; Mirghani et al., 2003). For poor Indonesians, the obligation to pay a compensation may play a role, and in orthodox areas negative reactions from other people may do the same. Also, many women think that fasting during pregnancy is not harmful (Joosoph, Abu & Yu, 2004) and some believe it even to be beneficial. This follows the general conviction among Muslims that Ramadan fasting is good for health and beneficial in general, as it is the wish of God that they fast. The belief that fasting during pregnancy is not harmful plays an important role in decisions to fast, since many Muslims believe that it is a sin to fast if this is harmful (Robinson & Raisler, 2005). On the other hand, some women I talked to who believed fasting to be obligatory during pregnancy, gave up fasting because they found it too hard to continue. A great majority of 70 to 90% of pregnant Muslim women do fast, as is evidenced by research from around the world, from Iran (Arab & Nasrollahi, 2001), to Singapore (Joosoph, Abu & Yu, 2004), rural West Africa (Prentice et al., 1983) and the UK (Malhotra et al., 1989). For Indonesia, no survey data on this are available, but there is no reason to assume that the picture will be different.

3 Medical theory and evidence of the effects of Ramadan fasting during pregnancy on offspring's health

Medical theory on how Ramadan fasting during pregnancy affects the offspring, is highly related to medical theory on fasting, skipping meals, and hunger during pregnancy in general. Long-term effects are mainly expected to arise because a shortage in nutrition hampers fetal growth and causes damage to the fetal body, while at the same time such a nutritional shortage arises relatively quickly in a pregnant woman because the fetus growing inside of her increases her energy demands.

The fasting person's body experiences a reduced supply of metabolic fuel. Under normal circumstances, glucose is one of the body's main sources of energy. When fasting, a lack of glucose arises (hypoglycemia or "low blood sugar"). The body may be able to at least partially compensate for this by stepping up the, otherwise sparsely used, process of fat metabolism. Although a shortage in nutrition probably causes the greatest problems to the fetus, an increased fat metabolism is also potentially dangerous: high concentrations of its byproduct ketones can lead the blood pH to drop. This destroys proteins in the body, leading to tissue damage, organ failure, and eventually death. Pregnant women in many countries are regularly tested for elevated ketone levels, since ketoacidosis is a major cause of intrauterine death. Pregnant women are at an increased risk of reaching states of hypoglycemia and ketoacidosis because their own body's demand for energy is augmented by that of both placenta and fetus. This increased energy demand means that glucose-levels for pregnant women are lower in general already, so that there is much less leeway for any restriction in food intake before the body gets into problems (Hobel & Culhane, 2003). Metzger et al. (1982) coined the term "accelerated starvation" for the increased speed with which the pregnant body reaches states, as measured by blood levels of metabolic fuels and hormones, otherwise only seen in starvation. Accelerated starvation can occur when the woman skips breakfast after a night without food, but happens even more rapidly when fasting takes place during daytime, as daytime activities increase the pregnant woman's already high glucose demand even further (Meis, Rose & Swain, 1984).

The most important medical theory explaining how adverse conditions in utero like these can lead to negative long-term health effects, is fetal programming theory. It states that fetuses adapt themselves to hostile environments, which is beneficial in that it helps them to survive, but has as a downside that the adaptations may lead to serious problems in the long run, including an increased risk later in life of coronary heart disease and its biological risk factors, such as hypertension and type 2 diabetes (Godfrey & Barker, 2000; Roseboom et al., 2000). One important adaptation by the fetus to nutritional shortage is that it will use most of the scarce energy for the most vital organs (particularly the brain) and their metabolism, so that they will be protected against the lack of fuel (Godfrey & Barker, 2001). This "brain-sparing" goes at the expense of energy devoted to other organs, muscles and limbs. As a result, cell division in these body parts may be slowed. Apart from affecting general fetal growth, this especially affects organs undergoing their critical growth period: the period in which they are formed or go through a phase of important growth. Even short periods of undernutrition can cause damage to these organs (Barker, 1997). Often, such damage does not create problems immediately, but only much later in life, as degeneration sustained during the lifetime has taken its own toll. A good example for this are the kidneys: undernutrition leads to a reduced number of nephrons (the functional units of the kidney). Initially, this does not cause great problems, but when ageing further decreases the number of nephrons, it may result in hypertension and consequent further damage to the kidneys (Barker, 2002).

Other fetal adaptations arise because nutritional shortage raises maternal concentrations of the stress hormone CRH (corticotropin-releasing hormone). This prepares the fetus for an expected preterm delivery: fetal growth is reduced while tissue maturation is speeded up (Hermann et al., 2001; Hobel & Culhane, 2003). Prenatal exposure to stress hormones may also program the hypothalamic-pituitary-adrenal axis (a system that controls much of the hormonal system, including reactions to stress) and lead to higher blood pressure and type 2 diabetes (Seckl & Holmes, 2007). And pre-birth circumstances, including famine, can evoke epigenetic changes, i.e. as a result of fetal programming, the same set of genes may lead to different outcomes (phenotypes) (Seckl & Holmes, 2007; Heijmans et al., 2008).

According to fetal programming theory, the adaptations of the fetal body to nutritional shortage may serve not only to minimize damage, but also to prepare for a life in an environment characterized by this same shortage. For example, it acquires a heightened tendency to store fat, which is beneficial if there is indeed often a shortage of nutrition. If not, however, this is only maladaptive. The initially small child will then gain weight fast, and fast weight gain is, even more than the final body weight reached, predictive of coronary heart disease (Barker, 2002). The chances of developing serious health problems later in life seem higher if there is a "mismatch" between the environment experienced in utero and the environment experienced during post-natal life (Seckl & Holmes, 2007). Ramadan may create such a mismatch, as the fetus gets "programmed" for a hostile environment that it will in reality not encounter.

From an evolutionary viewpoint, if negative health effects from a shortage of nutrition are unavoidable, the best way to minimize damage, is if the body manages to postpone these negative effects till after the person has procreated. The body's adaptational strategy is hence theorized to be such that it tries to stay vital until the reproductive age. After that, it pays the price for the adaptations made. The evolutionary goal of procreation will be achieved in this way, but the early onset of adult diseases is the side-effect (Godfrey & Barker, 2000; Metcalfe & Monaghan, 2001). Thus, although prenatal Ramadan exposure may negatively affect the health of people of all ages, the strongest effects are expected on people who are after their reproductive age.

Beside the long-term health consequences emanating from fetal adaptations during Ramadan, other potential negative effects may come from higher incidences of hyperemesis gravidarum (excessive vomiting during pregnancy) (Rabinerson et al., 2000) and from a refusal to take prescribed drugs during daytime (Leiper, Molla & Molla, 2003). Potentially, peaks in the blood glucose level caused by the consumption of large amounts of sweet products in the evening, may lead to congenital anomalies in the offspring (cf. Schaefer et al., 1997). Furthermore, dehydration caused by restricted fluid intake may cause a low amniotic fluid level. This, in turn, has been linked to perinatal death, fetal malformations, preterm birth, low birth weight and poor health at birth (Brace, 1997; Casey et al., 2000).

Several studies show that pregnant women in Ramadan do indeed exhibit symptoms indicating accelerated starvation. Arab (2004) found that 61% of the Iranian pregnant women in their sample had hypoglycemia and 31% had ketonuria before breaking their fast. Prentice et al. (1983) and Malhotra et al. (1989) demonstrated accelerated starvation in Ramadan fasting women in respectively West Africa and the UK. It is thinkable that Ramadan fasting does not lead to a decreased total energy consumption as women do eat during the evening and in the early morning, and hence only causes a series of temporary shortages of nutrition, each day during daylight hours. But Arab (2004) found that also the total amount of energy consumed over a 24-hour time span is often too low: in his sample, 92% of Ramadan fasting pregnant women had a calorie deficit of at least 500 Kcal.

A lack of metabolic fuel in fetuses has been demonstrated by Mirghani and colleagues, who found that breathing movements and heart rate accelerations and decelerations were altered in fetuses of Ramadan fasting women (Mirghani et al. 2004; 2005). Almond & Mazumder (2009) show that prenatally exposed children have lower average birth weights. Birth weight is a rough measure for fetal development and may proxy for more precise measures such as changes to organs, that are hard to obtain for newborns (Harding, 2001).

The Indonesian doctors I interviewed did not separately register problems during pregnancy related to Ramadan. A few obstetricians nevertheless noticed an increased incidence of pregnancy problems during Ramadan: more cesarean sections, cases in which there was a decrease in amniotic fluid or fetal heart rate accelerations and, in the first trimester, a higher incidence of hyperemesis. Insufficient weight gain of mother or fetus was the reason that most often prompted the doctors to advise a woman to stop fasting. They also had to regularly advise women to keep drinking enough and to eat variedly, healthily and a sufficient quantity.

4 The data

The Indonesian Family Life Survey (IFLS) is a broadly set up longitudinal survey carried out by the RAND corporation (Strauss et al., 2004). It consists of 3 waves: IFLS 1 (1993/4); IFLS 2 (1997/8) and IFLS 3 (2000). For most analyses, I will use data from the last wave, as this wave has the largest sample size, contains the most complete birthdate information and contains more information of interest for the purposes of this research than the other two waves. IFLS collects a great amount of information at individual, household and community level on a large array of economic, health and social indicators for a cross-section of the population in 13 of the (then) 26 provinces of Indonesia, which in total represent 83% of the Indonesian population. The provinces that are not included, are mainly the decentrally located, less densely populated ones. Sampling took place at the household level. In IFLS 3, the sample size was 43,649 persons in 10,435 households, about 85% of whom were measured and/or interviewed in person. Some people did not know their exact birthdate: of about 20% of the remaining sample, the month and/or year of birth was not known; of another 11%, only birth month and not exact birthday was known, which also rendered them not useable for the analyses. This reduced the total sample to 29,695. About 88% of these were Muslims. Household interviews were conducted by teams of 12 to 14 interviewers with different specialisms, two of whom were health workers (typically nurses), trained by staff of the School of Public Health of the University of Gadjah Mada, Yogyakarta, one of Indonesia's most renowned universities. In many analyses, I will specifically make use of information collected by these health professionals.

I calculated whether a person was in utero during a Ramadan using the person's exact birthdate, the average length of human pregnancies (266 days as calculated from the day of conception), and the dates of each Ramadan in the years 1900-2000.[1] Figure 1 clarifies the procedure used. The reference group in all analyses consists of those who were certainly not in utero during Ramadan, i.e. those who were calculated to be conceived within a relatively narrow time window of about 59-60 days per Islamic year, starting right after a Ramadan and ending 266 days before the next fasting period. I drop from the data all those calculated to be conceived less than 21 days after the end of Ramadan. If their mothers' pregnancies lasted longer than average, their classification as not being exposed would be erroneous, which would create a relatively large amount of noise. Pregnancies lasting three weeks beyond term or more are rare (see e.g. Kieler et al., 1995), so 21 days is a safe margin. Actually, this bandwidth is longer than necessary for just this purpose: taking it this long also ensures that almost all children are dropped who were conceived in the festive days following Ramadan, who may differ from children conceived at other time points.

Note that preterm births can never lead to erroneously classifying someone as not exposed, but that it can lead to an erroneous classification as exposed. This happens if Ramadan ended less than 266 days before birth, but before the date of conception. Dropping people from the data would not solve this misclassification problem, since some pregnancies are preterm by a great number of days. It would necessitate removing most of those calculated to be conceived during

[1]These, I retrieved from www.phys.uu.nl/~vgent/islam/ummalqura.htm and (before 14 March, 1937) www.al-islam.com/eng. Note that since the occurrence of Ramadan depends on moon sightings which may vary by geographical place, there may be deviations of one or two days in the start and end dates in some years for groups of people. This causes a small amount of noise in my measures.

Ramadan. This would complicate analyses where effects of exposure during different stages of pregnancy are compared. For these latter analyses, I divide those calculated to have experienced Ramadan in utero into five subgroups: those conceived during Ramadan, those born during Ramadan and those who experienced an entire Ramadan in utero and who are further subdivided into those for whom Ramadan started during the first, second, or third trimester of pregnancy. People born during Ramadan are excluded from the latter group. Depending on variations in the exact length of pregnancies, there is some noise in these measures due to misclassifications.[2]

My basic specification now becomes:

(1)

$$y_i = \alpha + \beta exposure_i + \gamma_1 age_i + \gamma_2 age_i^2 + \gamma_3 age_i^3 + \gamma_4 age_i^4 + \sum_{m=1}^{11} \lambda_m birthmonth_{mi} + \theta sex_i + \varepsilon_i$$

Standard errors are clustered by family, as there may be within-family correlation on the health variable, y. The age variables refer to the number of days after Jan. 1st, 1900 that a person was born. I choose to control for age in this flexible way instead of using year of birth-dummies, since some Gregorian years contain two Ramadans, which might lead to unwanted correlations. Note that all estimates are probably underestimates of the real effect. First, (except for children living at home with their parents) I only know a person's own religion and not the religion of his/her mother. Deviations may lead to misclassification and attenuation. Second, I calculate whether persons had been exposed using the average length of human pregnancy. Persons conceived shortly after Ramadan and born prematurely, may be wrongly classified as "exposed". Third, I do not know which mothers actually did observe Ramadan during pregnancy. My results should therefore be seen as intention to treat estimates. If choice of fasting is uncorrelated to expected offspring's health outcomes, the magnitude of all estimates would have to be multiplied by one over the share of fasting women in order to get to an average treatment effect (ATE). If especially those mothers chose not to fast for whom fasting would have had a relatively large impact, my estimates would even be a larger underestimation of the ATE. If mainly mothers for whom the effect would have been relatively small (e.g. healthier mothers) would have refrained from fasting, the correction factor would have to be smaller than one over the share of fasters. As fasting rates are likely to differ per trimester of pregnancy, the difference between my estimates and the ATE probably differs between the phases of pregnancy that I distinguish. Fourth, all estimates are conditional upon survival. If exposure leads to higher mortality rates, then attrition before the moment of measurement may bias my results towards zero. Fifth, those who do not know their exact date of birth, were excluded from all analyses. Their average health is worse than that of those who

[2] I classify people based on their date of birth. Each group therefore contains people who were born pre- or postterm. Exposure, as argued, may cause premature birth. This leads to misclassification in that I classify some people for whom Ramadan started in trimester 1, respectively 2, of pregnancy, as having been exposed in trimester 2, respectively 3; some people who were conceived during Ramadan, as having been exposed to a Ramadan that started in trimester 1; and some who were not exposed as having been conceived during Ramadan.

do know their birthdate. Perhaps prenatal exposure induces health effects that make people less likely to remember their date of birth. The resulting attrition of some of those affected most strongly, would bias my results towards zero.[3]

5 Results

5.1 General health measures

5.1.1 Effects on general health

The following analyses go into general health. After showing that Indonesian Muslims who were exposed to Ramadan in utero have a worse general health, I look at a few alternative explanations: common shocks in health that happened to be correlated to the occurrence of Ramadan and systematic differences between mothers whose children were vs. were not exposed that can be lead back to selective timing by certain parents of pregnancies to avoid Ramadan. I will show that the finding that fasting during pregnancy negatively affects offspring's general health, is a very robust one.

In IFLS 3, nurses took measurements of a diverse set of physical and health variables such as weight, height and other anthropometric measures, blood pressure, pulse, lung capacity and hemoglobin level. For respondents aged 15 years and older,[4] they also took measurements of physical condition by letting the person rise from a sitting to a standing position five times and timing them doing this. In taking all these measurements, the nurses gained good insight into the health of the respondents. Afterwards, they rated how the health of the person compared, in general, to the health status of other people of the same age and sex. A nine-point scale was used, in which 1 referred to much worse and 9 to much better, etcetera. Because of the experience of the health workers, the specific training they had received for IFLS and because of the insight they had gotten into the respondents health after taking a broad set of measurements, this variable is arguably the best, and most objective, indicator of respondents' general health available in IFLS.

Table 1 shows the results from OLS-regressions following equation (1), for the effects of having been in utero during Ramadan for Indonesian Muslims. The upper panel shows the overall effects, in which people who were in utero during Ramadan are compared with those who were not. The second panel compares those who experienced Ramadan during different phases of pregnancy, with those who were not exposed. For the entire sample of Muslims aged one

[3] On the other hand, the timing of birth relative to the first Ramadan after birth is different for the not exposed than for the exposed, which leads to slight differences between both groups next to those induced by prenatal exposure. If experiencing a Ramadan at different points in time as a baby has differential effects on later life outcomes (e.g. because parents have more time during Ramadan to care for their babies, and parental attention has differential effects at different ages), then this might somewhat limit my analyses.

[4] Babies under one year of age were removed, because, due to rapid changes and "jumps" in growth, size and development at this age, it is very difficult for health workers to give reliable comparisons with people of the same age and sex.

year and older , I find a highly significant negative effect of having been exposed during pregnancy of 6.1% of a standard deviation of the general health variable. I next split up the sample in those under the age of 45 and those 45 and older, following the idea from fetal programming that fetal adaptations to adverse conditions in utero that are beneficial in the short run, mainly lead to problems after the reproductive age (Godfrey & Barker, 2000).[5] I find that, although there is a significant effect for the young, the effect is much stronger for the older people, where the effect is as much as 18.5% of a standard deviation. Note that I cannot distinguish between the effects on my estimates of ageing and those of changes over time in the share of mothers who chose to fast, or of changes over time in health care provisions. The general trend in Indonesia, however, during the last century has been toward an increased observance of traditional Islamic rites (e.g. Saleh, 2001), so that there is no reason to assume that fasting among the pregnant has decreased to such a degree that it can explain the threefold difference in effect sizes between the young and the old. The lower panel shows that the signs are negative for each phase of pregnancy during which Ramadan may be experienced (note that these phases differ in length, so that the power to find significant effects varies accordingly between the phases). The largest effects are found when an entire Ramadan was experienced during pregnancy, especially when Ramadan fell about halfway the pregnancy.

To check whether the reported effects are not a result of common shocks to cohorts, correlated by coincidence to Ramadan, columns (6) to (8), report the same analysis for non-Muslims. Non-Muslims are not affected by Ramadan fasting itself, but otherwise, largely experience the same common shocks as Muslims. Exception are religion-specific health shocks correlated to the occurrence of Ramadan, induced by e.g. price changes for products consumed predominantly by Muslims, and behavioral changes other than fasting itself. Indirectly, non-Muslims may be affected by Ramadan somewhat through changes in daily life patterns occurring during Ramadan. Consumption patterns may be affected to some extent in that it is often considered impolite or rude to eat and drink when fasting Muslims are around and through changes in availability of food (more sweets). Increased food prices are partially offset by the receipt of a 13th month wage and for the poor, by the receipt of food during Ramadan. Also, around the end of Ramadan, there is an important national holiday in which people *en masse* visit family. If it is not fasting during pregnancy, but the general change in life pattern during Ramadan that causes the previously described effects, or if it is common, non religion-specific, shocks that are coincidentally correlated with Ramadan, I should also find effects of having been in utero during a Ramadan on non-Muslims.

All common shocks influence non-Muslims more if they are living in predominantly Muslim provinces than if they are living in a non-Muslim province. I

[5] The exact age at which reproductivity ends is hard to pinpoint and differs between persons. One candidate would be the age at which women enter menopause. I chose 45, since 99.8% (96.1%) of children in IFLS were born before the mother (father) had reached the age of 45, so that few people are reproductive beyond this age. Online appendix table 1 shows results using alternative break points.

therefore report estimates only for non-Muslims living in provinces where more than half of the population is Muslim. These non-Muslims are mainly Protestant or Roman Catholic (84.7%), Hindu (5.9%) and Buddhist (8.8%). On average, their general health is better than that of Muslims: 6.47 vs. 6.13 on the nine-point general health scale ($p < .001$). I find no effects for the non-Muslims.[6,7] Similar robustness checks, with similar results, relating to all subsequent analyses are reported in Online appendix table 2. General health effects related to Ramadan during pregnancy are hence not caused by common shocks experienced by the whole population, that happened to be correlated with the occurrence of the Ramadan fasting period.

5.1.2 Selective timing of pregnancies

If some parents, whose offspring would have had a better health anyway, deliberately plan their pregnancy so as to avoid Ramadan, my results may confound effects of Ramadan during pregnancy with self-selection of healthy people into the control group. The fact that sampling in IFLS takes place at the household-level, gives me two instruments to check whether self-selection may have driven the results. First, I compare parents whose child was exposed to Ramadan with those whose child was not. The second strategy comprises family fixed effects.

Note here that a few things speak against the occurrence of selective timing. First, it is quite difficult to plan a pregnancy in such a way that Ramadan is completely avoided: the time window to get pregnant is then small; only less than three months per year can someone "safely" get pregnant. Second, according to the obstetricians and midwifes I interviewed, selective timing is not an issue at all: they had never heard of anybody planning in such a way or even thinking about doing this. Especially those Muslims who interpret fasting during pregnancy to be obligatory, believe that fasting is generally beneficial and would not avoid pregnancy during Ramadan.[8] Nevertheless, because selective timing is a clear potential source of bias, it is important to investigate this issue further.

If some parents deliberately time pregnancies so as to avoid Ramadan, then, arguably, differences in characteristics should exist between parents whose preg-

[6]It would be tempting to attribute the difference in average general health between Muslims and non-Muslims to prenatal Ramadan exposure. Although, based on the evidence presented here, this certainly seems to play a role, the general health difference between both groups is larger than the reduced form effect of exposure I find here; other socio-cultural aspects may also be factors in this difference in general health.

[7]Analyses for non-Muslims living in non-Muslim provinces yield similar results. In IFLS, all provinces have a great majority of Muslims, except for the island of Bali, where 86% of the Hindus in the sample are concentrated and where only 14% of the population is Muslim, many of whom have migrated there at some point in their life.

[8]Occasionally, a couple tried to plan the pregnancy in such a way that the child was delivered *during* Ramadan, which is considered a positive occurrence. It is questionable whether this phenomenon leads to any noticeable effect on my estimates, because of the small time window and because even those few couples mainly wanted to get pregnant and hence also tried this around the time window. Moreover, in case this does lead to selectivity, this cannot explain why, in table 1, there are effects of exposure e.g. halfway during pregnancy.

nancy overlapped with Ramadan and those for whom this was not the case. Particularly, higher educated and more health concerned parents might be more likely to avoid Ramadan. If so, not-exposed children would probably have a better health, even in the absence of any effects of Ramadan, just because of their parents' better health and more health-favoring circumstances.

Table 2 shows the results of a comparison of families where the oldest home-living child between the ages of one and eighteen had versus had not been exposed.[9] Note that all variables, except for age at giving birth, refer to the *present* state of the parent[10], not to the state at the moment of giving birth: such data are unavailable. Some variables may have endogenously changed since then, if, for example, a pregnancy with complications affected the mother's health. On the other hand, if unhealthy and older mothers are more likely to miscarry as a result of fasting, then the remaining mothers whose child was exposed, will have a health that is a bit above average and be a bit younger. The measuring of certain variables years after childbirth, limits the value of the present analysis somewhat.

There are no differences between the two groups of families in general health, nor in several specific health measures, BMI, maternal education, paternal age at giving birth, income, expenditure and household assets, nor in the number of siblings the oldest child has. Mothers whose child had been exposed report being sick less often and fathers whose child had been exposed completed junior high school more often. These difference are hard to explain, as they indicate a better health and more favorable background. Mothers in the not exposed-group were perhaps somewhat older at the time of giving birth than the others. This marginally significant difference is possibly caused by the general pattern that miscarriages happen more often among older women, in combination with a higher incidence of miscarriages among women who are pregnant during Ramadan – see also paragraph 5.2 below.[11] It can be concluded that families where the child was exposed to Ramadan in utero and families where this was not the case, are quite similar in a number of relevant characteristics. Online appendix table 3 shows that this pattern holds for each of the phases of pregnancy during which people could have been exposed.

Table 3 shows the results of the family fixed effects regression on children's general health. This analysis compares children within families and is hence insensitive to any systematic differences between families in general health. So if

[9] I exclude very young children, since their mothers' health may still have been affected by recently having given birth. This may lead to spurious correlations between pregnancy during (the recent) Ramadan and mothers' health. I also exclude children above the age of eighteen, the age at which many children start leaving home. Home-leaving may be correlated with health, so that this sub-sample may over represent children who had been affected by exposure during pregnancy more strongly than average.

[10] To be exact: because IFLS collects data on the household and does not link parents to children, I do not work with mothers (fathers) and children, but with the female (male) partner of the household head, or female (male) household head, and the biological children of the household head. The difference between the two definitions will be small.

[11] Controlling for age of mother at the moment of giving birth, does not alter the pattern of differences between mothers of exposed vs. not exposed children shown in table 2.

only parents chose to fast whose children would have had a worse health anyway, I should find no effect. The first column of the table shows the OLS-results for the sub sample used in this analysis, which is Muslim children between the ages of one and eighteen, living with their biological parents. In the second column family fixed effects are added, and the third column adds birth order dummies, to control for potential correlations between birth order and exposure on the one hand and birth order and health on the other hand. The OLS-coefficient is comparable to that of the entire sample (see table 1), but not significant, probably due to a lack of power. In the fixed effects analysis, the coefficient is almost the same, and, combined with the increased precision, is now significant. This gives strong evidence that the general health effects do not arise because of systematic between-family differences. Moreover, controlling for birth order effects does not change the size or significance of the effect.

5.1.3 Subjective feelings of general health and sickness

Having shown that general health as measured by health professionals is negatively affected by exposure to the Ramadan fast in utero, I now examine whether this pattern fits with the subjective health experiences of Indonesians. Respondents were asked whether they had been sick in the last four weeks and whether their own health was better or worse than that of another person of the same age and sex. The first question was also asked in the second wave of IFLS. This makes it possible to increase the precision of the estimates for this variable by pooling the data from IFLS 3 and IFLS 2. To allow for maximum flexibility, in equation (1), I now interact each regressor and the constant with a dummy for the IFLS-wave.

The results shown in table 4 confirm the picture from the health workers' reports. People who had been exposed report sickness in the last four weeks more often – an effect of about one percentage point on an average rate of seven per cent. Especially older people judge their own health more negatively relative to comparable others. Larger effects among older people concur with fetal programming theories which say that health adjustments of the fetus to adverse conditions in utero are detrimental mainly in the long run. Online appendix table 3 shows results for the non-Muslims living in a predominantly Muslim province. No significant effects for them are found, nor is there a clear, but non-significant, pattern in the results.

5.2 Sex ratio

In utero effects of exposure to fasting may affect the survival of the fetus. This should especially affect male fetuses, who are more vulnerable to a shortage of nutrition (Godfrey & Barker, 2001). In the absence of data on miscarriages and perinatal death, an altered sex ratio in my sample is hence a sign that some fetuses indeed did not survive pregnancy as a result of Ramadan exposure. One side-consequence of such an effect would be that the previously described general health effects are underestimates of the total-population effect, as those for whom the general health effect was strongest did not survive till after birth.

Since I do not observe the sex ratio at birth, but only the sex ratio of people in a cross-section of all ages, an alternative explanation for any effects found is that attrition of males does not take place at the fetal stage, but later in life. I.e. that the health of males is affected more strongly, so that they die younger, which then causes the changes in the sex ratio. I can check this by looking at the effect on the sex ratio at different ages. If a general effect on the sex ratio is caused by differential mortality later in life, then the sex ratio effect should be larger among older people. Also, arguably, health effects would then be stronger for males. Columns 4 and 5 of table 1 showed that men may indeed experience stronger effects during their lifetime than women, but the coefficients lie within each others' conficence intervals. And in the analyses on subjective feelings of general health and sickness, and in the following section on specific diseases, I find no systematic larger health effects on males.

My results, presented in table 5, corroborate those of Almond & Mazumder (2009), who find altered sex ratios both among newly-borns and adults. After correction for time trends and month of birth dummies, among the exposed, the share of males is about 2.6% lower (uncorrected average for the exposed: 50.55% males; not-exposed: 52.92%). The alternative explanation seems unlikely, as the estimated effect among the young (under 45 years of age) is larger than the effect among the old. Among the old, the effect in most phases of pregnancy has even disappeared: perhaps the least healthy girls are born but are short-lived, while the least healthy boys are not born at all.[12]

A second alternative explanation lies in the Trivers-Willard (1973) hypothesis which states that when conditions are favorable, it is more advantageous for a mother to produce males. This suggests that sex ratio effects do not arise because of miscarriages and perinatal death, but because of a purposeful biological process of sex determination at conception. Since sex is determined at conception, unfavorable conditions during Ramadan would then lead to a lower share of males among those conceived during Ramadan, while no effect is expected among those exposed later in gestation. The same holds for the hypothesis that sex ratio effects may result from altered patterns of sexual intercourse during Ramadan: it has been suggested that a lower frequency of sexual intercourse increases the chances that the child will be female (e.g. James, 1971). Both alternative hypotheses can be rejected, since effects are found in all trimesters and are even strongest among people born during Ramadan.

5.3 Specific diseases

The preceding sections have shown that exposure to Ramadan in utero causes negative health effects and most probably even fetal attrition. I will now turn back to people who survived the fetal stage and focus on investigating specific

[12]Note that with the present data, I cannot distinguish between pre-birth death and mortality in the first few years of life, since if analyzing only the sub-sample of very young children, I may confound effects of exposure with seasonal effects.

aspects of their health that may be affected. Effects on certain serious symptoms, particularly coronary heart disease, type 2 diabetes, hypertension and symptoms related to kidney problems, are specifically predicted by medical theory and should mainly be found in people who are after their reproductive age. A few questions in IFLS asked specifically to people aged 50 and older, provide a good, although indirect, insight into the former two symptoms. Respondents indicated whether they sometimes felt chest pains on the left side or during exertions, which can be a sign of coronary heart problems; and whether cuts or wounds take a long time to heal. This can be a sign of type 2 diabetes. Note that 34% of the elderly respondents answered "yes" to at least one of the chest pain sub-questions. This seems to be quite much and an overestimate of real, severe problems. I again pool data from the last two waves of IFLS in order to increase the precision of the estimates. (Data not available for IFLS 1.)

I find that chest pain occurs more often among people who were exposed to Ramadan in utero (see table 6). The effect appears for people exposed in each phase of the pregnancy. People exposed to Ramadan in utero also more often report that wounds take a long time to heal. This effect may be larger for people exposed late in gestation or born during Ramadan. This concurs with Ravelli et al. (1998), who report that the largest effect of the Dutch famine on decreased glucose tolerance is on people exposed late in pregnancy. The effects on both symptoms are quite strong. They potentially indicate very serious health problems and occur about eight and four percentage points more often among the exposed, for symptoms that on average occur in 34 and ten per cent of the population, respectively. Similar effects are not found for non-Muslims, see Online appendix table 2: coefficients partially even point into the opposite direction.

Online appendix table 4 shows results for a number of relatively mild health problems: a cold (runny nose/dry cough), headache, skin infection, nausea / vomiting, eye infection, diarrhea and toothache. Effects on these are not specifically predicted by medical theory. Exposure to Ramadan in utero does not affect the chances of having suffered from one of these symptoms in the past four weeks. This has two implications: the absence of effects on these subjective reports means that the exposed do not have an increased general propensity to complain, meaning that the effects on the serious health problems discussed above are not an artifact of this. Second, the effects on general health that were described extensively earlier are not caused by these generally mild, non-severe health problems, nor did these general health problems cause the increased incidences of self-reported sickness presented before. Exposure rather leads to effects on some more serious health problems that are specifically predicted by medical theory.

IFLS-health workers measured participants' blood pressure and the hemoglobin level in their blood. Increased occurrence of hypertension is specifically predicted by fetal programming theory, especially among older people. It may be caused by damage to the kidneys. Anemia (a low hemoglobin blood level) has several potential causes. It can be caused by a lower intake of iron than what is lost, which most often occurs among women in the fertile ages (related to menstruation), and by diseases including cancer, rheumatoid arthritis and sickle cell disease. But, like hypertension, it may also be caused by kidney problems. Recall that fetal adaptations to maternal undernutrition may lead to reduced numbers of nephrons in the kidneys, which may cause problems after ageing has caused a further decrease in their numbers. As shown in table 6, older people who experienced Ramadan in mid gestation more often have anemia, while the overall effect for the older group, relating to all phases of pregnancy, is only marginally significant. This concurs with the finding of Painter et al. (2005), who find that people aged around 50 who were exposed to famine in utero, have a higher chance of developing certain kidney problems, but only if exposure took place during the critical period for kidney development, which is in mid gestation. I do not find evidence for effects on hypertension. I do, however, find an effect on pulse pressure (systolic minus diastolic pressure): this turns out to be higher among the exposed. This effect is only significant for the younger part of the population. This makes the effect on pulse pressure a bit hard to interpret: a high pulse pressure is predictive of coronary heart disease among older people, but not among younger people (Franklin et al., 2001).

6 Discussion

Observing the Ramadan fast Ramadan during pregnancy may cause considerable negative health effects on the offspring, irrespective of the stage of pregnancy in which Ramadan took place. Such effects are not limited to health outcomes around the moment of birth, that were shown in earlier research. Indeed, some effects get stronger, or only show up when the offspring gets older. Exposure to fasting before birth is associated with poorer general health and a higher incidence of sickness. It also increases a person's chances of developing symptoms that are indicatory for serious health problems such as coronary heart disease and type 2 diabetes and, among older people who had been exposed during certain stages of gestation, may lead to anemia. People who had been exposed on average have a higher pulse pressure. A lower percentage of males among those born during, and in the months after Ramadan, suggests a higher incidence of miscarriages and perinatal death. I find such effects for exposure during each phase of pregnancy. These results are robust to a number of alternative explanations. Although often considerable in size, the presented effects are probably usually underestimates of the true effect (ATE).

Perhaps the main practical question these results call up is whether such effects will show up irrespective of how the fasting process is managed. Most of the Indonesian doctors I interviewed, for example, believed that fasting is not a problem, as long as the pregnant woman follows up advice on food and fluid intake and ceases fasting in case of complications. Among these doctors, as well as in the medical field in general, however, there is very little consensus on nutritional advice for Ramadan fasting women and on which pregnancy complications will necessitate women to stop fasting. But even with a scientifically based consensus on the latter point, it seems doubtful whether advising women to stop fasting at the right moment will work sufficiently well in practice to manage the apparent great risks. A continuous monitoring of all fasting pregnant women seems necessary. And even for well-equipped hospitals, this would probably pose a challenge. In the case of a country like Indonesia, an added practical problem is that many clinics in poorer areas lack the means to perform all the tests that would be required. Concerning the nutritional intake, avoiding hypoglycemia and a calorie deficiency might arguably mitigate effects on the fetus. General nutritional recommendations for avoiding hypoglycemia include having a healthy and varied diet, not containing much sugar. Abandoning the traditional consumption of many sweet products at breaking the fast may be beneficial, as it leads to a quick release of glucose into the blood, the opposite of the slow and even release that helps prevent hypoglycemia. Another part of such guidelines, however, is to eat small amounts, regularly. This is not possible during fasting. And it is questionable whether a healthy and varied diet in evening and morning is sufficient to prevent hypoglycemia and ketonuria altogether during so many hours without food; especially for pregnant women, for whom these symptoms arise much faster than for others (Metzger et al., 1982). The second part of the diet, consuming a sufficient amount, in practice proves to be a great problem for many women (Arab, 2004).

All in all, careful management of fasting during pregnancy may reduce problems, but it is unlikely that it reduces them to negligible levels. Several medical researchers advised not to skip meals during pregnancy, especially not during daytime, see e.g. Azizi, (2002), Malhotra et al. (1989), Meis, Rose & Swain (1984), and Metzger et al. (1982). But Ramadan is a religious event and the choice of whether or not to fast is also motivated by religious beliefs. It is hence not up to the researcher to prescribe whether pregnant women should fast during Ramadan. For women who adhere to the interpretation that they are obliged by religion to observe the Ramadan fast during pregnancy, it is imperative that knowledge is assembled and a consensus is reached on the conditions under which a woman can keep on fasting. It should become clear which consumption patterns are desirable and which ones are not. Also, the women need to be monitored well on a number of variables on which physicians should get consensus. Beside development of maternal and fetal weight, this may include measures such as blood sugar levels, ketone levels, fetal heart rate, amniotic fluid, and others. Pregnant women who adhere to the interpretation that fasting is not obligatory in general, or not obligatory if there are risks to the health of themselves or the child, should carefully consider the pros and cons when deciding whether or not to fast during this month.

References

[1] Almond, D. & Mazumder, B. (2009), *Health Capital and the Prenatal Environment: The Effect of Maternal Fasting During Pregnancy.* NBER working papers, No. 14428, National Bureau of Economic Research.

[2] 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.

[3] Arab, M. & Nasrollahi, S. (2001), Interrelation of Ramadan Fasting and Birth Weight, *Medical Journal of Islamic Academy of Sciences, 14*(3), 91-95.

[4] Azizi, F. (2002), Research in Islamic Fasting and Health, *Annals of Saudi Medicine, 22*(3 -4), 186 – 191.

[5] Barker, D.J.P. (1997), Fetal nutrition and cardiovascular disease in later life. *British Medical Bulletin, 53*(1) 96-108.

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

[7] Brace, R. (1997), Physiology of Amniotic Fluid Volume Regulation, *Clinical Obstetrics and Gynecology, 40*(2), 280-289.

[8] Casey, B.M., McIntire, D.D., Bloom, S.L., Lucas, M.J., Santos, R., Twickler, D.M., Ramus, R.M. & Leveno, K.J. (2000), Pregnancy outcomes after antepartum diagnosis of oligohydramnios at or beyond 34 weeks' gestation, *American Journal of Obstetrics & Gynecology, 182*(4), 909-912.

[9] Franklin, S.S., Larson, M.G., Khan .S.A, Wong, N.D., Leip, E.P., Kannel, W.B. & Levy, D. (2001), Does the relation of blood pressure to coronary heart disease risk change with aging? The Framingham heart study. *Circulation, 103*, 1245–1249.

[10] Godfrey, K.M. & Barker, D.J.P. (2000), Fetal nutrition and adult disease. *The American Journal of Clinical Nutrition, 71*(suppl), 1344S–52S.

[11] Godfrey, K.M. & Barker, D.J.P. (2001), Fetal Programming and Adult Health, *Public Health Nutrition, 4*(2B), 611-624.

[12] Harding, J.E. (2001), The nutritional basis of the fetal origins of adult disease, *International Journal of Epidemiology, 30*, 15-23.

[13] Heijmans, B.T., Tobi, E.W., Stein, A.D., Putter, H., Blauw, G.J., Susser, E.S., Slagboom, P.E. & Lumey, L.H. (2008), Persistent epigenetic differences associated with prenatal exposure to famine in humans, *Proceedings of the National Academy of Sciences, 105*(44), 17046-17049.

[14] Hermann, T.S., Siega-Riz, A.M., Hobel, C.J., Aurora, C. & Dunkel-Schetter, C. (2001), Prolonged periods without food intake during pregnancy increase risk for elevated maternal corticotropin-releasing hormone concentrations, *Am J Obstet Gynecol, 185*(2) 403-412.

[15] Hobel, C.J. & Culhane, J. (2003), Role of Psychosocial and Nutritional Stress on Poor Pregnancy Outcome, *The Journal of Nutrition, 133*, 1709S-1717S, Supplement: Nutrition as a Preventive Strategy against Adverse Pregnancy Outcomes.

[16] James, W.H. (1971), Cycle day of insemination, coital rate, and sex ratio. *The Lancet, 1*(7690), 112-114.

[17] Joosoph, J., Abu, J. & Yu S.L. (2004), A survey of fasting during pregnancy. *Singapore Med J, 45*(12), 583-586.

[18] Kieler, H., Axelsson, O., Nilsson, S. & Waldenström, U. (1995), The length of human pregnancy as calculated by ultrasonographic measurement of the fetal biparietal diameter. *Ultrasound in obstetrics & gynecology, 16*(5), 353-357.

[19] Leiper, J.B., Molla, A.M. & Molla, A.M. (2003), Effects on health of fluid restriction during fasting in Ramadan, *European Journal of Clinical Nutrition, 57*(Suppl 2), S30–S38.

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

[21] Meis, P.J., Rose, J.C. & Swain, M. (1984), Pregnancy Alters Diurnal Variation of Plasma Glucose Concentration, *Chronobiology International, I*(2), 145-149.

[22] Metcalfe, N.B. and Monaghan, P. (2001), Compensation for a bad start: grow now, pay later? *Trends. Ecol. Evol., 16*, 254–260.

[23] Metzger, B.E., Ravnikas, V., Vileisis, R.A. & Norbert, F. (1982), "Accelerated starvation" and the skipped breakfast in late normal pregnancy. *The Lancet, 1*(8272), 588-592.

[24] Mirghani, H.M., Weerasinghe, D.S.L., Ezimokhai, M. & Smith, J.R. (2003), The effect of maternal fasting on the fetal biophysical profile. International *Journal of Gynecology and Obstetrics, 81*, 17-21.

[25] Mirghani, H.M., Weerasinghe, S.D., Smith, J.R. and Ezimokhai, M. (2004), The effect of intermittent maternal fasting on human fetal breathing movements, *Journal of Obstetrics and Gynaecology, 24*(6),635-637.

[26] Mirghani, H.M., Weerasinghe, S.D., Al-Awar, S., Abdulla, L. & Ezimokhai, M. (2005), The Effect of Intermittent Maternal Fasting on Computerized Fetal Heart Tracing, *Journal of Perinatology, 25*, 90–92.

[27] Painter, R.C., Roseboom, T.J., Van Montfrans, G.A., Bossuyt, P.M.M., Krediet, R.T., Osmond, C., Barker, D.J.P. & Bleker, O.P. (2005), Microalbuminuria in Adults after Prenatal Exposure to the Dutch Famine, *J Am Soc Nephrol, 16*, 189-194.

[28] Prentice A.M., Prentice A., Lamb W.H., Lunn P.G. & Austin S. (1983), Metabolic consequences of fasting during Ramadan in pregnant and lactating women. *Hum. Nutr. Clin. Nutr., 37C*, 283–294.

[29] Rabinerson, D., Dicker, D., Kaplan, B., Ben-Rafael, Z. & Dekel, A. (2000). Hyperemesis gravidarum during Ramadan, *Journal of psychosomatic obstetrics and gynaecology, 21*(4), 189-191.

[30] Ravelli, A.C.J., Van der Meulen, J.H.P., Michels, R.P.J., Osmond, C., Barker, D.J.P., Hales, C.N. & Bleker, O.P. (1998), Glucose tolerance in adults after prenatal exposure to famine, *The Lancet, 351*, 173–77.

[31] Rich-Edwards, J. W. , Stampfer, M. J. , Manson, J. E., Rosner, B. , Hankinson, S. E., Colditz, G. A., Willett, W. C. & Hennekens, C. H. (1997), Birth weight and risk of cardiovascular disease in a cohort of women followed up since 1976, *BMJ, 315*, 396-400.

[32] Robinson, T. & Raisler, J. (2005), "Each one is a doctor for herself": Ramadan fasting among pregnant Muslim women in the United States, *Ethnicity & Disease, 15*(1 Suppl 1), S1-99-103.

[33] Roseboom, T.J., Van der Meulen, J.H.P., Osmond, C., Barker, D.J.P., Ravelli, A.C.J., Schroeder-Tanka, J.M., Van Montfrans, G.A., Michels, R.P.J. & Bleker, O.P. (2000), Coronary heart disease after prenatal exposure to the Dutch famine, 1944–45, *Heart, 84*, 595–598.

[34] Saleh, F. (2001), *Modern trends in Islamic theological discourse in 20th century Indonesia: a critical study*, Leiden, The Netherlands: Brill.

[35] Schaefer, U.M., Songster, G., Xiang, A., Berkowitz, K., Buchanan, T.A., & Kjos, S.L. (1997), Congenital malformations in offspring of women with hyperglycemia first detected during pregnancy. *Am J Obstet Gynecol, 177*,1165-1171.

[36] Seckl, J.R. & Holmes, M.C. (2007), Mechanisms of Disease: glucocorticoids, their placental metabolism and fetal 'programming' of adult pathophysiology, *Nat Clin Pract Endocrinol Metab, 3*, 479–488.

[37] Strauss, J., Beegle, K., Sikoki, B., Dwiyanto, A., Herawati, Y. & Witoelar, F. (2004), *The Third Wave of the Indonesia Family Life Survey (IFLS3): Overview and Field Report.* Working paper, WR-144/1-NIA/NICHD, RAND.

[38] Trivers, R.L. & Willard, D.E. (1973), Natural Selection of Parental Ability to Vary the Sex Ratio of Offspring, *Science, 179*(4068), 90 – 92.

Table 1: Effects of having been in utero during Ramadan on general health as compared to other people of the same age and sex

	Muslims					Non-Muslims		
	All	Young (<45)	Old (≥45)	Female	Male	All	Young (<45)	Old (≥45)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Exposed	-0.061**	-0.048*	-0.186**	-0.051	-0.068*	0.012	-0.007	0.083
	(0.021)	(0.022)	(0.065)	(0.030)	(0.028)	(0.065)	(0.072)	(0.168)
Born during Ramadan	-0.034	-0.028	-0.097	-0.048	-0.016	0.040	0.004	0.132
	(0.030)	(0.032)	(0.087)	(0.042)	(0.042)	(0.093)	(0.104)	(0.199)
Ram. started in tr. 3	-0.064*	-0.050	-0.191*	-0.069	-0.061	-0.051	-0.105	0.165
	(0.025)	(0.027)	(0.077)	(0.037)	(0.035)	(0.083)	(0.090)	(0.216)
Ram. started in tr. 2	-0.079***	-0.063*	-0.255***	-0.052	-0.104**	0.028	0.022	0.054
	(0.024)	(0.025)	(0.074)	(0.034)	(0.032)	(0.072)	(0.079)	(0.189)
Ram. started in tr. 1	-0.057*	-0.047	-0.159*	-0.051	-0.057	0.022	0.010	0.093
	(0.023)	(0.025)	(0.073)	(0.034)	(0.031)	(0.074)	(0.082)	(0.196)
Conceived during Ramadan	-0.041	-0.023	-0.211*	-0.017	-0.063	0.029	0.045	-0.066
	(0.029)	(0.031)	(0.088)	(0.043)	(0.040)	(0.093)	(0.103)	(0.239)
N	22567	20023	2544	11224	11343	2065	1685	380
Mean	6.13	6.15	5.96	6.04	6.21	6.47	6.50	6.35
(SD)	(1.01)	(1.00)	(1.01)	(1.00)	(1.00)	(0.96)	(0.96)	(0.97)

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table shows coefficients and (standard errors) (clustered by family) from regressions that control for age, age^2, age^3, age^4, month-of-birth and sex. Sample: Indonesian Muslims (column (1) to (5)) and non-Muslims living in predominantly Muslim provinces (column (6) to (8)), age 1 year and older. Upper and lower panel show results from separate regressions. People's general health as rated by professional health workers on a 9-point scale, is compared between those who had not been in utero during a Ramadan and those who had been.

Table 2: Comparison of Muslims whose oldest home-living child between the ages of 1 and 18, was vs. was not exposed to Ramadan during pregnancy

	Child exposed			Child *not* exposed			p (difference)
	Mean	SD	N	Mean	SD	N	
Education (junior high school), mother	0.46	0.50	2486	0.44	0.50	307	0.482
General health, mother	6.09	0.97	2412	6.09	0.94	289	0.991
Mother sick in last 4 weeks	0.06	0.24	2420	0.10	0.29	293	0.042*
High blood pressure, mother	0.21	0.40	2407	0.17	0.38	289	0.181
Anemia, mother	0.35	0.48	2213	0.37	0.48	275	0.392
Age mother at giving birth	24.5	5.41	2491	25.1	5.76	307	0.064
Body Mass Index (BMI) mother	23.3	4.03	2406	23.6	3.96	288	0.208
Mother was not exposed to Ramadan in utero herself	0.90	0.30	2491	0.90	0.30	307	0.973
Mother's own health compared to others w. same age & sex	2.16	0.48	2420	2.20	0.48	293	0.239
Lives in urban area	0.56	0.50	2491	0.54	0.50	307	0.478
Education (junior high school), father	0.55	0.50	2436	0.50	0.50	321	0.048*
General health, father	6.34	0.99	2248	6.32	0.96	302	0.814
Father sick in last 4 weeks	0.05	0.22	2298	0.07	0.26	308	0.121
High blood pressure, father	0.25	0.43	2250	0.29	0.46	302	0.151
Anemia, father	0.26	0.44	2227	0.24	0.43	301	0.520
Age father at giving birth	29.42	6.79	2443	29.70	6.79	324	0.491
BMI, father	21.95	4.30	2238	22.05	3.11	301	0.683
Father was not exposed to Ramadan in utero himself	0.89	0.31	2443	0.89	0.31	324	0.998
Father's own health compared to others w. same age & sex	2.25	0.53	2297	2.22	0.52	309	0.247
Number of siblings	0.82	0.96	2491	0.82	1.01	307	0.986
Log food & drinks expenditure for own families' consumption	11.56	0.64	2479	11.60	0.75	304	0.301
Log yearly wage	15.07	1.06	2165	14.99	1.06	293	0.213
Log total value of household assets	16.37	1.67	2255	16.44	1.69	299	0.460

* = difference significant at $p<0.05$, ** = $p<0.01$, *** = $p<0.001$

Table 3: Family fixed effects regressions on children's general health

	OLS	Fam. fixed effects	Fam. fixed effects with birth order dummies[1]
	(1)	(2)	(3)
Exposed	-0.065	-0.066*	-0.065*
	(0.039)	(0.033)	(0.033)
Born during Ramadan	-0.024	-0.071	-0.070
	(0.054)	(0.046)	(0.046)
Ram. started in tr. 3	-0.048	-0.041	-0.040
	(0.047)	(0.038)	(0.038)
Ram. started in tr. 2	-0.110*	-0.088*	-0.088*
	(0.047)	(0.039)	(0.039)
Ram. started in tr. 1	-0.067	-0.073	-0.072
	(0.046)	(0.038)	(0.038)
Conceived during Ramadan	-0.093	-0.078	-0.078
	(0.056)	(0.047)	(0.047)
N	7661	7661	7661

* p<0.05, ** p<0.01, *** p<0.001

Table shows coefficients and (standard errors) (clustered by family) from regressions that control for age, age^2, age^3, age^4, month-of-birth and sex. Upper and lower panel show results from separate regressions. Sample: children between the ages of 1 and 18, living with their biological parents. The middle and right column include fixed effects for 4302 families.

[1]Dummies divide into 1st-born, 2nd, 3rd and 4th and up, among the children in the age group.

Table 4: Subjective estimates of own health

	All Muslims		Muslims < 45 years		Muslims ≥45 years	
	Sick[1]	Comp. health[2]	Sick[1]	Comp. health[2]	Sick[1]	Comp. health[2]
	(1)	(2)	(3)	(4)	(5)	(6)
Exposed	0.012**	0.002	0.010*	0.019	0.026*	-0.083*
	(0.005)	(0.012)	(0.005)	(0.013)	(0.011)	(0.040)
Born during Ramadan	0.015*	0.012	0.011	0.036	0.036*	-0.102
	(0.007)	(0.018)	(0.008)	(0.019)	(0.017)	(0.053)
Ram. started in tr. 3	0.011*	-0.004	0.009	0.003	0.033*	-0.041
	(0.006)	(0.015)	(0.006)	(0.016)	(0.014)	(0.047)
Ram. started in tr. 2	0.012*	0.005	0.010	0.027	0.020	-0.112*
	(0.005)	(0.015)	(0.006)	(0.015)	(0.013)	(0.047)
Ram. started in tr. 1	0.013*	-0.001	0.013*	0.013	0.018	-0.081
	(0.005)	(0.014)	(0.006)	(0.015)	(0.013)	(0.045)
Conceived during Ramadan	0.009	0.011	0.004	0.027	0.033	-0.083
	(0.007)	(0.018)	(0.007)	(0.019)	(0.018)	(0.052)
N	25376	14928	20737	12390	4639	2538
Mean	0.07	2.19	0.07	2.17	0.07	2.30
(SD)	(0.25)	(0.50)	(0.25)	(0.48)	(0.26)	(0.60)

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table shows coefficients and (standard errors) from OLS-regressions that control for age, age^2, age^3, age^4, month-of-birth and sex. Upper and lower panels show results from separate regressions. Sample: Indonesian Muslims 15 years and older. Data for sick are pooled over IFLS-waves 2 and 3 and standard errors are clustered by person; for comphealth, data from IFLS 3 are used and standard errors are clustered by family. [1]Stayed in bed due to poor health at least one day in last four weeks; [2]Own health compared to that of another person of same age and sex; three-point scale (worse than / same as / better than others)

Table 5: Effects of exposure to Ramadan in utero on the sex ratio (proportion males)

	All Muslims (1)	$<$ 45 years (2)	$\geq$45 years (3)
Exposed	-0.026**	-0.027*	-0.008
	(0.010)	(0.011)	(0.031)
Born during Ramadan	-0.044**	-0.036*	-0.089*
	(0.014)	(0.015)	(0.042)
Ram. started in tr. 3	-0.021	-0.021	-0.016
	(0.012)	(0.013)	(0.037)
Ram. started in tr. 2	-0.022	-0.025*	0.017
	(0.011)	(0.012)	(0.036)
Ram. started in tr. 1	-0.026*	-0.029*	0.018
	(0.011)	(0.012)	(0.035)
Conceived during Ramadan	-0.031*	-0.032*	-0.014
	(0.014)	(0.015)	(0.043)
N	24690	21929	2761
Mean	0.508	0.501	0.561

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table shows coefficients and (standard errors) from OLS-regressions that control for age, age^2, age^3, age^4, and month-of-birth. Upper and lower panel show results from separate regressions. Sample: Indonesian Muslims 0 years and older.

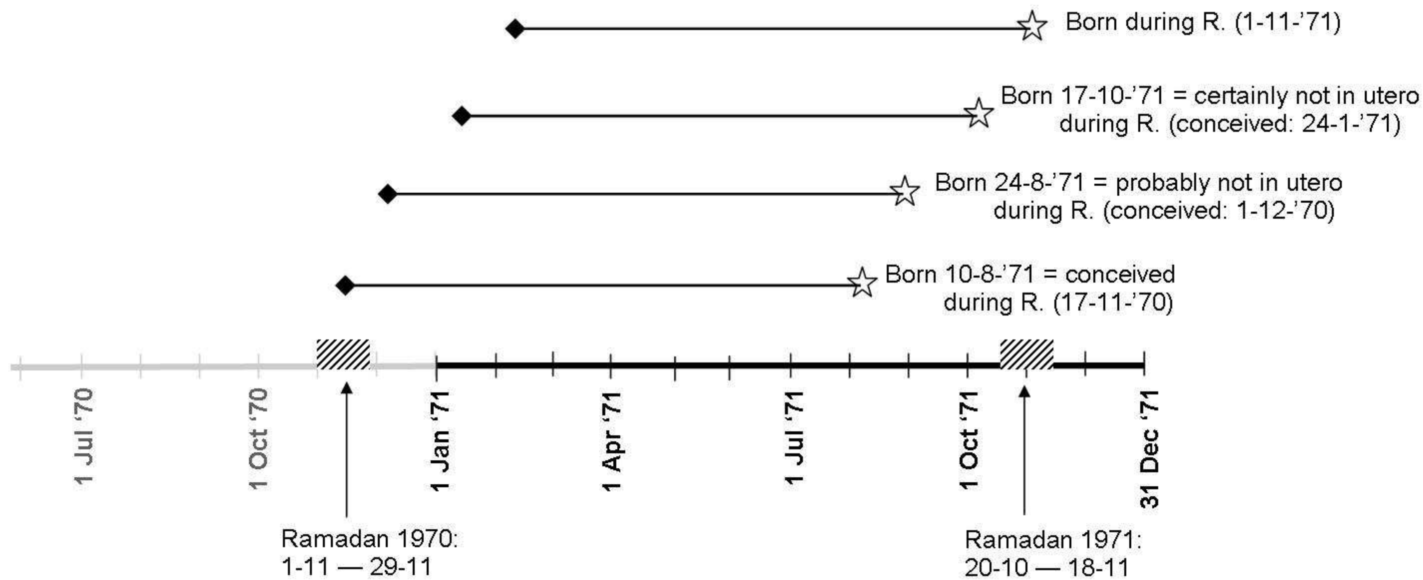
Table 6: Specific diseases: subjective indicators of coronary heart disease and diabetes type 2 and measurements on blood and blood pressure

	Subjective indicators		Clinical measures					
	Muslims $\geq$ 50 years		Muslims $<$ 45 years			Muslims $\geq$ 45 years		
	Chestpain[1]	Woundheal[2]	Anemia[3]	Hiblood[4]	Pulsepr[5]	Anemia[3]	Hiblood[4]	Pulsepr[5]
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Exposed	0.072*	0.042**	-0.010	0.012	0.944**	0.054	-0.032	0.753
	(0.029)	(0.016)	(0.014)	(0.011)	(0.330)	(0.032)	(0.033)	(1.087)
Born during Ramadan	0.071	0.059*	-0.013	0.014	0.422	0.005	-0.043	0.374
	(0.040)	(0.024)	(0.021)	(0.016)	(0.476)	(0.042)	(0.043)	(1.447)
Ram. started in tr. 3	0.078*	0.055*	0.013	0.001	0.764	0.059	-0.041	-0.853
	(0.036)	(0.022)	(0.017)	(0.014)	(0.406)	(0.038)	(0.039)	(1.301)
Ram. started in tr. 2	0.066	0.038*	-0.004	0.005	1.185**	0.082*	-0.033	0.309
	(0.034)	(0.019)	(0.016)	(0.013)	(0.393)	(0.037)	(0.038)	(1.311)
Ram. started in tr. 1	0.062	0.034	-0.020	0.018	1.075**	0.059	-0.031	1.921
	(0.034)	(0.019)	(0.016)	(0.013)	(0.378)	(0.036)	(0.037)	(1.266)
Conceived during Ramadan	0.093*	0.030	-0.031	0.028	0.874	0.040	-0.002	2.004
	(0.040)	(0.023)	(0.019)	(0.016)	(0.495)	(0.044)	(0.046)	(1.564)
N	2952	2952	9932	10390	10372	2526	2543	2493
Mean	0.34	0.10	0.29	0.17	39.8	0.39	0.47	53.5
(SD)	(0.47)	(0.31)	(0.46)	(0.37)	(11.6)	(0.49)	(0.50)	(18.6)

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table shows coefficients and (standard errors) from OLS-regressions that control for age, age^2, age^3, age^4, month-of-birth and sex. Upper and lower panels show results from separate regressions. Columns (1) and (2): sample is Indonesian Muslims 50 years and older; data are pooled over IFLS-waves 2 and 3 and standard errors are clustered by person. Columns (3) to (8): sample is Indonesian Muslims 18 years and older and standard errors are clustered by family. [1]Sometimes feels chest pains on left side or in stairs/up-hill, or when active/walking fast [2]If you have a cut or wound, does it take a long time to heal? [3]Anemia: hemoglobin level $<$ 13.5 g/dl for men, $<$ 12 g/dl for non-pregnant women, or taking medicine for anemia; [4]high blood pressure: systolic $\geq$ 140 mmHg and/or diastolic $\geq$ 90 mmH, or taking medicine for hypertension; [5]pulse pressure: systolic minus diastolic pressure, excludes those taking medicine for hypertension

Figure 1: Calculating whether a person was in utero during a Ramadan – an example using people born in 1971.



The figure shows as an example people born in 1971. Stars indicate the day of birth. E.g. someone born on Nov. 1^{st}, 1971, is born during the Ramadan of that year (shaded area on the axis). Lines represent the average length of a human pregnancy, which is 266 days. Diamonds indicate the estimated day of conception. E.g. someone born on Aug. 10^{th}, 1971, is estimated to be conceived 266 days earlier, which is on Nov. 17^{th}, 1970. This day fell during the previous year's Ramadan (lower line). Someone who is estimated to be conceived on Dec. 1^{st} 1970, has probably not been in utero during a Ramadan (second line from below). However, if this particular pregnancy was a few days longer than average, this would have been a misclassification, since conception *did* take place during Ramadan. For someone estimated to be conceived on Jan. 24^{th} 1971, a misclassification is extremely unlikely. The latter person is therefore placed in the reference group, while the former person is removed from the data. Note that Ramadan lasted 29 days in 1970 and 30 days in 1971 and that it started 12 days earlier in 1971, due to the Islamic year being a bit shorter than the Gregorian year.

Online Appendix to "Long-term health effects on the next generation of Ramadan fasting during pregnancy"

Table A1: Effects of having been in utero during Ramadan on general health as compared to other people of the same age and sex, using different young-old age cut-offs.

	Younger Muslims						
	< 30	< 35	< 40	< 45	< 50	< 55	< 60
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Exposed	-0.048	-0.048*	-0.047*	-0.048*	-0.051*	-0.049*	-0.055**
	(0.025)	(0.023)	(0.023)	(0.022)	(0.022)	(0.021)	(0.021)
Born during Ramadan	-0.033	-0.038	-0.034	-0.028	-0.032	-0.031	-0.029
	(0.035)	(0.033)	(0.033)	(0.032)	(0.031)	(0.031)	(0.030)
Ram. started in tr. 3	-0.040	-0.047	-0.044	-0.050	-0.052*	-0.052*	-0.060*
	(0.030)	(0.028)	(0.027)	(0.027)	(0.026)	(0.026)	(0.026)
Ram. started in tr. 2	-0.061*	-0.060*	-0.060*	-0.063*	-0.067**	-0.064**	-0.070**
	(0.028)	(0.027)	(0.026)	(0.025)	(0.025)	(0.024)	(0.024)
Ram. started in tr. 1	-0.051	-0.046	-0.048	-0.047	-0.048*	-0.046	-0.052*
	(0.028)	(0.026)	(0.025)	(0.025)	(0.024)	(0.024)	(0.024)
Conceived during Ramadan	-0.031	-0.030	-0.025	-0.023	-0.026	-0.030	-0.036
	(0.035)	(0.033)	(0.032)	(0.031)	(0.031)	(0.030)	(0.030)
N	15542	17437	18880	20023	20868	21428	21873

	Older Muslims						
	$\geq$ 30	$\geq$ 35	$\geq$ 40	$\geq$ 45	$\geq$ 50	$\geq$ 55	$\geq$ 60
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Exposed	-0.094*	-0.100*	-0.132*	-0.186**	-0.188*	-0.238*	-0.284*
	(0.041)	(0.048)	(0.056)	(0.065)	(0.077)	(0.101)	(0.131)
Born during Ramadan	-0.038	-0.017	-0.031	-0.097	-0.100	-0.101	-0.150
	(0.057)	(0.066)	(0.075)	(0.087)	(0.107)	(0.136)	(0.189)
Ram. started in tr. 3	-0.117*	-0.111*	-0.139*	-0.191*	-0.216*	-0.213	-0.228
	(0.049)	(0.056)	(0.066)	(0.077)	(0.095)	(0.126)	(0.160)
Ram. started in tr. 2	-0.128**	-0.135*	-0.195**	-0.255***	-0.237**	-0.344**	-0.430**
	(0.045)	(0.053)	(0.062)	(0.074)	(0.090)	(0.116)	(0.155)
Ram. started in tr. 1	-0.075	-0.101	-0.114	-0.159*	-0.165	-0.253*	-0.281
	(0.045)	(0.054)	(0.063)	(0.073)	(0.091)	(0.119)	(0.160)
Conceived during Ramadan	-0.076	-0.074	-0.132	-0.211*	-0.198	-0.243	-0.322*
	(0.055)	(0.066)	(0.076)	(0.088)	(0.103)	(0.128)	(0.152)
N	7025	5130	3687	2544	1699	1139	694

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table shows coefficients and (standard errors) (clustered by family) from regressions that control for age, age^2, age^3, age^4, month-of-birth and sex. Sample: Indonesian Muslims, age 1 year and older. Each panel shows results from separate regressions. Top half of table shows results for young Muslims, using different age cut-offs; bottom half shows corresponding results for older Muslims, using the same age cut-offs. People's general health as rated by professional health workers on a 9-point scale, is compared between those who had not been in utero during a Ramadan and those who had been.

Table A2: Effects on non-Muslims living in predominantly Muslim-provinces

	Estimates of own health		Sex ratio	Subjective indicators		Clinical measures		
	Sick[1]	Comp. health[2]	Male	Chestpain[1]	Woundheal[2]	Anemia[3]	Hiblood[4]	Pulsepr[5]
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Exposed	-0.006	-0.011	-0.019	-0.043	0.028	-0.027	0.064	0.393
	(0.016)	(0.040)	(0.032)	(0.074)	(0.044)	(0.039)	(0.034)	(1.101)
Born during Ramadan	-0.033	0.048	0.015	-0.201*	-0.026	-0.011	0.058	0.051
	(0.020)	(0.060)	(0.046)	(0.100)	(0.053)	(0.059)	(0.051)	(1.742)
Ram. started in tr. 3	-0.015	-0.041	-0.018	-0.062	0.008	0.013	0.058	0.363
	(0.018)	(0.050)	(0.040)	(0.087)	(0.051)	(0.047)	(0.043)	(1.346)
Ram. started in tr. 2	-0.013	0.023	-0.047	0.033	0.063	-0.056	0.078*	0.110
	(0.017)	(0.044)	(0.037)	(0.082)	(0.054)	(0.045)	(0.039)	(1.318)
Ram. started in tr. 1	0.011	-0.041	0.006	-0.042	0.029	-0.049	0.074	0.617
	(0.019)	(0.046)	(0.037)	(0.089)	(0.052)	(0.044)	(0.040)	(1.268)
Conceived during Ramadan	0.008	-0.038	-0.040	0.005	0.042	0.013	0.017	1.050
	(0.022)	(0.061)	(0.046)	(0.102)	(0.062)	(0.054)	(0.045)	(1.474)
N	2473	1426	2322	482	482	1172	1223	1214
Mean	0.06	2.17	0.502	0.32	0.11	0.27	0.26	43.4
(SD)	(0.24)	(0.51)	(0.500)	(0.47)	(0.31)	(0.44)	(0.44)	(15.6)

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table shows coefficients and (standard errors) from OLS-regressions that control for age, age^2, age^3, age^4, month-of-birth and (except for column (3)) sex. Upper and lower panels show results from separate regressions. Columns (1) and (2): Sample is Indonesian non-Muslims living in provinces where more than half of the population is Muslim. Columns (1) and (2) 15 years and older; column (3): 0 years and older; columns (4) and (5); 50 years and older; columns (6) to (8): 18 years and older. Columns (1), (2), and (6) to (8): standard errors are clustered by family; columns (4) and (5): data are pooled over IFLS-waves 2 and 3 and standard errors are clustered by person.[1]Sometimes feels chest pains on left side or in stairs/up-hill, or when active/walking fast [2]If you have a cut or wound, does it take a long time to heal? [3]Anemia: hemoglobin level < 13.5 g/dl for men, < 12 g/dl for non-pregnant women, or taking medicine for anemia; [4]high blood pressure: systolic ≥ 140 mmHg and/or diastolic ≥ 90 mmH, or taking medicine for hypertension; [5]pulse pressure: systolic minus diastolic pressure, excludes those taking medicine for hypertension

Table A3: Comparison of Muslims whose oldest home-living child between the ages of 1 and 18, was vs. was not exposed to Ramadan during pregnancy

	Child born during Ramadan (N = 228-261)		Child exposed during trimester 3 (N = 406-465)		Child exposed during trimester 2 (N = 702-796)		Child exposed during trimester 1 (N = 625-766)		Child conceived during Ramadan (N = 177-216)	
	Mean	p	Mean	p	Mean	p	Mean	p	Mean	p
Education (junior high school), mother	0.46	0.624	0.44	0.995	0.46	0.710	0.48	0.244	0.48	0.445
General health, mother	6.19	0.255	6.06	0.604	6.07	0.700	6.09	0.970	6.17	0.392
Mother sick in last 4 weeks	0.06	0.111	0.05	0.029*	0.08	0.283	0.06	0.020*	0.08	0.595
High blood pressure, mother	0.27	0.008**	0.20	0.385	0.20	0.355	0.19	0.451	0.22	0.150
Anemia, mother	0.32	0.191	0.37	0.997	0.35	0.405	0.34	0.316	0.37	0.850
Age mother at giving birth	24.0	0.022*	24.4	0.115	24.7	0.294	24.3	0.044*	24.8	0.541
Body Mass Index (BMI) mother	23.4	0.520	23.0	0.039*	23.4	0.387	23.3	0.241	23.6	0.902
Mother was not exposed to Ramadan in utero herself	0.92	0.399	0.89	0.790	0.90	0.890	0.90	0.916	0.91	0.619
Mother's own health compared to others w. same age & sex	2.14	0.139	2.18	0.548	2.15	0.104	2.18	0.624	2.16	0.424
Lives in urban area	0.57	0.481	0.56	0.559	0.54	0.958	0.57	0.306	0.57	0.408
Education (junior high school), father	0.53	0.441	0.52	0.488	0.56	0.055	0.57	0.021*	0.58	0.065
General health, father	6.38	0.480	6.34	0.837	6.30	0.727	6.35	0.643	6.36	0.650
Father sick in last 4 weeks	0.06	0.435	0.06	0.323	0.05	0.211	0.05	0.089	0.05	0.323
High blood pressure, father	0.27	0.525	0.27	0.610	0.22	0.018*	0.25	0.226	0.30	0.810
Anemia, father	0.21	0.423	0.27	0.341	0.27	0.307	0.25	0.628	0.24	0.997
Age father at giving birth	29.0	0.215	29.5	0.741	29.6	0.822	29.3	0.365	29.5	0.735
BMI, father	21.9	0.700	22.3	0.549	21.9	0.450	21.9	0.542	21.5	0.045*
Father was not exposed to Ramadan in utero himself	0.88	0.691	0.89	0.794	0.89	0.855	0.91	0.357	0.87	0.422
Father's own health compared to others w. same age & sex	2.24	0.681	2.24	0.460	2.28	0.070	2.24	0.477	2.23	0.804
Number of siblings	0.82	0.985	0.77	0.520	0.86	0.482	0.80	0.731	0.81	0.933
Log food & drinks expenditure for own families' consumption	11.54	0.288	11.53	0.168	11.56	0.453	11.58	0.696	11.53	0.335
Log yearly wage	15.04	0.616	15.12	0.114	15.04	0.505	15.13	0.053	14.92	0.504
Log household assets	16.31	0.355	16.39	0.654	16.30	0.207	16.45	0.937	16.38	0.686

* = difference significant at $p<0.05$, ** = $p<0.01$, *** = $p<0.001$

All comparisons are with Muslims whose child had not been exposed to Ramadan in utero, see columns (4) to (6) of table 2.

Table A4: Generally non-severe health problems, all Muslims

	cold[1]	headache	skin infection	nausea / vomiting	eye infection	diarrhea	toothache
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Exposed	0.007	0.007	-0.003	-0.000	-0.004	-0.009	0.001
	(0.010)	(0.010)	(0.006)	(0.006)	(0.004)	(0.005)	(0.006)
Born during Ramadan	-0.007	0.001	-0.018*	0.000	-0.007	-0.008	-0.001
	(0.015)	(0.015)	(0.008)	(0.009)	(0.006)	(0.007)	(0.009)
Ram. started in tr. 3	0.009	0.007	-0.002	0.004	-0.006	-0.008	0.000
	(0.013)	(0.013)	(0.007)	(0.008)	(0.005)	(0.006)	(0.008)
Ram. started in tr. 2	0.012	0.006	0.006	0.001	-0.004	-0.008	0.005
	(0.012)	(0.012)	(0.007)	(0.007)	(0.005)	(0.005)	(0.007)
Ram. started in tr. 1	0.010	0.003	-0.001	-0.002	-0.002	-0.011*	0.000
	(0.012)	(0.012)	(0.007)	(0.007)	(0.005)	(0.005)	(0.007)
Conceived during Ramadan	-0.000	0.025	-0.012	-0.007	-0.003	-0.005	-0.006
	(0.014)	(0.014)	(0.008)	(0.009)	(0.006)	(0.006)	(0.009)
N	25347	25395	25394	25388	32041	32023	32037
Mean	0.53	0.56	0.09	0.11	0.05	0.07	0.12
(SD)	(0.50)	(0.50)	(0.29)	(0.31)	(0.22)	(0.25)	(0.33)

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table shows coefficients and (standard errors) from OLS-regressions that control for age, age^2, age^3, age^4, month-of-birth and sex. Sample: Indonesian Muslims 15 years and older. All variables are self-reports on whether the symptom occurred in the last four weeks. Data for eye infection, diarrhea and toothache are pooled over IFLS-waves 1, 2 and 3; for the other variables, pooling is over the data from IFLS-waves 2 and 3. Standard errors are clustered by person. [1]Runny nose / dry cough