Early Life Public Health Intervention and Adolescent Cognition: Evidence from the Safe Motherhood Program in Indonesia

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Abstract

Between 1990 and 1996, over 54,000 midwives were introduced in most of Indonesia's nonmetropolitan villages as part of its safe motherhood strategy. I combine the variation in the availability and timing of the program arrival with the biology of cognition and the panel dimension of Indonesia Family Life Survey to carefully examine the long run impact of the program on cognition. In addition, I also examine program impacts on measures of schooling. The paper empirically tests and corroborates the findings in the biological literature that the fetal period and the first two years of life are critical periods in brain development during which environmental influences could have persistent effects on cognitive development. In addition, the results also support recent biological findings that show the importance of maternal health and nutritional status prior to conception for child's long term development.

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1 Introduction

The past decades have seen a growing interest in public health investments in children at early stages of development. This is primarily due to the growing knowledge and awareness of the importance of environmental influences during the earliest childhood years on human capital achievement and success later in life. Striking evidence from a number of disciplines including behavioral development, neurobiology, medical epidemiology, population and economics converge on the key finding that environmental influences early in life have important implications for subsequent development. Despite this, few papers establish a direct link between early life public health interventions in developing countries and long run human capital outcomes (Cutler et. al., 2010; Joshi and Schultz, 2007; Field et. al., 2009; Maluccio, 2009; Ozier, 2011; Politt et. al., 1993). Likewise, important policy questions such as *when* and *until when* to intervene remain unresolved. Most studies show the importance of either the fetal period in isolation (Barker, 1994; Berhman and Rosenzweig, 2004; Almond, 2006; Almond et. al., 2009) or the early childhood years (Alderman, 2006; Maccini and Yang, 2009) and thus little is still known about the relative importance of each period of development.

This paper exploits the ambitious safe motherhood intervention implemented in Indonesia during the early 1990s to evaluate the effects of a public health intervention on later human capital. Between 1990 and 1996, over 54,000 nursing school graduates with one year of midwifery training were introduced in most of Indonesia's nonmetropolitan villages. Beyond providing skilled and safe delivery services to mothers, the village midwives implemented safe motherhood protocols that include providing prenatal, obstetric, postnatal and general primary health care to mothers and their children, as well as educating families on proper nutrition and other health promoting behaviors. Earlier studies find evidence of the impact of the program on health outcomes in the short run: improved antenatal care and postnatal care (including longer exclusive breastfeeding); higher birth weight; better height-for-age of young children (aged 1 to 4) as well as improved body mass index of the reproductive age women in the communities (Frankenberg and Thomas, 2001; Frankenberg et. al., 2005, 2009).

The paper adds to the earlier studies on expanding access to midwives by examining the impact of the program expansion on cognitive outcomes measured during adolescence. I focus on cognition because there is a strong biological basis for the linkage between health and environment during early life and later cognitive ability. Influential researchers in the field of developmental psychobiology hypothesized that the nature of early experiences leads to 'permanent changes in neural cells in the cerebrum cortex' (Hunt, 1961; Politt et. al., 1993). Studies conducted in both animals and humans show that poor nutrition, micronutrient deficiencies, environmental toxins and poor stimulation particularly during the fetal period and the first two years of life result in later cognitive deficit (Politt et. al., 1993; Grantham-McGregor and Ani, 1999; Liu et. al., 2000; Meaney, 2001). More recently, a growing avenue of research based primarily in animal studies postulates that maternal health and nutrition status (diet, vitamin intake and glucose levels) prior to ovulation and conception, can have long term effects on fetal health as well as adolescent and adult outcomes (Aagaard-Tillery et. al., 2008; Kanakkaparambil, 2009; Wang et. al., 2009; Watkins and Fleming, 2009).

Since cognitive ability is likely to influence schooling outcomes, I also examine various measures of education including years of education completed. Attained education is a widely recognized measure of human capital and countless studies have examined the linkage between years of education and other outcomes including income, productivity and bargaining power (see Strauss and Thomas (1995) for survey of literature).

Beyond safe motherhood, my findings contribute to the small but growing literature that examines the long run impact of early life health interventions on later human capital. For instance, studies show that the maternal-and-child health and family planning program in Bangladesh had long run effects on test scores, health and schooling of children (Barham, 2010; Chauduri, 2005; Joshi and Schultz, 2007). Field, Robles and Torero (2009) show that Tanzanian children who benefited from iodine supplementation while in utero attained more schooling 10 to 14 years later than their counterparts who did not benefit from the supplementation. Cutler et. al. (2010) illustrate that exposure to malaria eradication program early in life led to modest increase in household per capita consumption of prime aged men. A recent paper by Ozier (2011) finds large cognitive effects for children who were less than one year old when their community received mass deworming intervention in Kenya. The well-known INCAP experimental study in Guatemala shows the importance of nutritional intervention in the earliest childhood years (age 0 to 3) for later cognition, schooling and income (i.e., Hoddinott, 2008; Maluccio et. al., 2009; Politt et. al., 1993). The INCAP has been an influential treatment-control study linking child health to cognitive development. Despite this, the experimental study has some weaknesses which include large attrition and a small sample size with only four villages and no pure control group (see Strauss and Thomas (2008) for more detailed discussion).

In this study I use the Indonesian Family Life Survey (IFLS) which is a high quality, long-running longitudinal socio-economic survey of individuals, households and communities. I combine the panel dimension of IFLS with the variation in the availability and timing of the arrival of village midwives as well as the biology of cognition in order to carefully examine the impact of the program on outcomes of children over the longer run, at ages 11 to 17, when human capital outcomes are still in formation. Results show that exposure to program midwives had sizable and significant impacts on later measures of human capital. In particular, I find that children who were born during the rapid program expansion increased their test scores on average by 5.12% to 5.49%. This is equivalent to about 0.23 to 0.25 standard deviations increase if cognitive test scores are standardized, which is comparable to the effect size of receiving nutritional intervention from birth to age 3 (as that found in the INCAP experimental study in Guatemala). As a complementary analysis, I exploit the variation in the year of the arrival of the program midwives with respect to the timing of the child's birth to examine the effect of the program for each exposure period. Using this more flexible specification, the resulting estimates reveal patterns of dose response. That is, the impact of the program is larger for those who are exposed at earlier stages of development. In particular, I find relatively large effects on cognition and schooling of children who were born in communities that received a midwife prior to their conception, while they were in utero and during their first two years of life (ranging from 0.13 to 0.33 standard deviations increase in standardized cognitive test scores and 0.23 to 0.52 more years of schooling). For children whose exposure began at age three or later, estimates become really small and non-significant. These results are consistent with the findings in the biological literature that the fetal period and the first two years of life are critical periods in brain development during which environmental influences could have persistent effects on one's cognitive processes. The results also support more recent biological findings that suggest the importance of maternal health and nutritional status prior to conception in predicting later measures of human capital.

The rest of the paper is organized as follows. Section 2 provides the background on the Safe Motherhood Program. Section 3 discusses the data and outcomes. Section 4 provides some background on the biology of cognition. Section 5 presents the econometric strategy. Section 6 discusses the results. Section 7 concludes.

2 Indonesia's Safe Motherhood Program

In this section I briefly review the history and the features of the first comprehensive Safe Motherhood Intervention in Indonesia drawing broadly from Frankenberg et. al. (2005), Frankenberg and Thomas (2001), Sweet et. al. (1995) and World Bank (1991). In 1987, the global Safe Motherhood Initiative was launched by the United Nations in cooperation with international maternal and child health organizations. The initiative issued a call to action for national governments, funding agencies, and non-governmental organizations (NGOs) to make maternal health an urgent health priority. Thus in 1989, sparked by this global event, the Indonesia Ministry of Health (MOH) launched its first comprehensive safe motherhood intervention that aimed to train and deploy a large number of community midwives locally known as bidan desa throughout the nonmetropolitan villages in Indonesia. Between 1990 and 1996, over 54,000 nursing school graduates with one year of midwifery training were gradually deployed in most of Indonesia's nonmetropolitan villages with the objective of exponentially increasing women's access to health care and safe delivery services.

This safe motherhood strategy is based on the principle that the village midwife will act as a 'linchpin' of safe motherhood activities at the community level. Beyond providing access to safe and medically oriented delivery services, the village midwife serves as a health resource person in the community providing antenatal, postnatal and general health care, working with traditional birth attendants and referring complicated obstetric cases to health centers and hospitals. Her duties include promoting community participation in health as well as educating families on family planning, on proper nutrition and other health-promoting behaviors. The village midwife particularly offers a number of services that could affect children's health. This includes provision of curative care and medicines such as antibiotics and cough syrup as well as children's immunizations and vitamins and mineral supplements.

Once assigned to a community, the village midwife is given a salary by the Government of Indonesia for three to six years in the expectation that this will lead to a permanent private practice in the community. She maintains a public practice during normal working hours and is allowed to practice privately after that.

Safe Motherhood studies in Indonesia

Since the safe motherhood program is primarily motivated by the long standing problem with maternal mortality in Indonesia, many studies examine the effect of the above intervention on maternal health. For instance, studies find that women in communities that received village midwives by the time of their conception were more likely to receive antenatal care, take iron tablets during their pregnancy and obtain medically oriented delivery (Frankenberg et. al., 2009; Hatt et. al, 2007). In general, the availability of village midwives in the communities also improved the nutritional status (body mass index) of women of reproductive age (Frankenberg and Thomas, 2001; Setyowati, 2003). Other studies examine the effects of the program on the outcomes of the children in their early life. For example, Shresthra (2010) finds that the introduction of the program led to lower infant mortality while Frankenberg, Suriastini and Thomas (2005) show that program improved the nutritional status of children aged 1 to 4 (as measured by height-for-age). A recent study by Giles and Satriawan (2011) show that the effect of nutritional status on school enrollment of children aged 7-9 is higher if the child had access to the midwife during early childhood.[1]

These earlier studies suggest that the Safe Motherhood program had an immediate impact on the health of reproductive age women as well as children in the recipient communities. My study will examine whether these short term benefits actually persist and translate in better cognition and schooling outcomes of children later in adolescence.

3 The Indonesia Family Life Survey (IFLS)

The data come from the four waves of the Indonesia Family Life Survey (IFLS) conducted in 1993, 1997, 2000 and 2007 (known as IFLS1, IFLS2, IFLS3 and IFLS4, respectively). The IFLS is a large-scale ongoing longitudinal survey that collects information at the individual, household and community level. The IFLS began in 1993 with a sample of 7,224 households and 22,000 individuals in 13 provinces, representing 83% of the Indonesian population. One of the exceptional features of the data set is the high re-contact rate, including among those who relocate. The re-contact rates were high, with 94.4% of IFLS1 households re-contacted in IFLS2, and 95.3% of the original IFLS1 households re-contacted in IFLS3. In IFLS4 (nearly 15 years since IFLS1), 90.6% of the IFLS1, IFLS2 and IFLS3 households were re-contacted. These rates are high compared to other long-running longitudinal surveys in developing countries.[2]

In the analysis I focus on children born between 1983 and 1996 in the original IFLS communities. In addition, I also examine the cohorts born between 1976 and 1982 as part of a falsification exercise. I match these children to their community of birth based on their mothers' location at the time of their birth.[3] I supplement that information

[1]Studies conducted by Frankenberg and colleagues take into account of the non-random placement of the program. Satriawan and Giles (2011) also try to address the endogeneity of the program using community fixed effects.

[2]See Frankenberg and Karoly (1995), Frankenberg and Thomas (2000), Strauss et. al. (2004) and Strauss et. al. (2009) for a full description of IFLS1, IFLS2 and IFLS3 and IFLS4, respectively.

[3]About 51% of the mothers in the sample have been living in the same village since age 12 or have never stayed outside the village for more than six months. For the rest of the mothers, I use mainly the

with the individual responses of children who are aged 15 and above by 1997, 2000 or 2007 regarding their place of birth. Out of 10,245 children born between 1983 and 1996 and living in baseline IFLS communities in IFLS1 and IFLS2, 8762 were re-surveyed as young adults (age 11 to 17) in IFLS3 or IFLS4. Of the re-surveyed children, 8295 can be matched to their community of birth while 467 cannot be matched either because these children were born outside the original 321 IFLS enumeration areas or they have missing information on their place of birth.[4] The analysis for this paper will focus on children who were born in one of the original 321 IFLS enumeration areas (matched children). However as part of the robustness checks later, I add the unmatched children back to the sample to check whether estimates are sensitive to their inclusion.[5]

Identifying Presence of Village Midwife

In each IFLS wave, the village head and the head of the PKK (Village Women's Group) were asked about the presence of village midwife in each community.[6] In IFLS2, IFLS3 and IFLS4, more detailed information were asked including the timing of the first village midwife's arrival in the community, number of village midwives in the community, the length of their stay and year when they left. The information in these modules is cross-checked against information from the volunteers at the village health post about where women obtain prenatal care and delivery assistance in order to evaluate the consistency of reporting on the village midwife's presence in the community. An index of the presence of midwives in the community and when they arrived is then constructed by combining

location information based on their last move or the date of migration from the community where they were previously living to the IFLS baseline community. Thus the reporting bias on migration history could be less of an issue here given that individuals may be most accurate about their recent moves. As mentioned above, this information is also cross-checked with the individual responses of children interviewed in 1997, 2000 and 2007 as young adults.

[4]For the cohorts used in falsification analysis, of the 11,510 children born in1976 to 1989, about 7751were re-surveyed at ages 18 to 24. Of the re-surveyed children, 7068 can be matched to their community of birth while 683 cannot be matched either because they were born outside the IFLS original communities or they have missing information on place of birth. As expected, the individuals who were no longer interviewed are different from the ones interviewed in 2000/2007. This is particularly true for the falsification cohorts (see Appendix Table).

[5]The unmatched children are likely to be born to mothers who are more mobile. As expected, they are quite different from the matched children (see columns 1-3 of Appendix Table).

[6]In general the village leaders in Indonesia are known to be knowledgeable of the activities and programs, particularly government-sponsored ones, in their communities.

information from these multiple sources. The Indonesian Family Life Survey (IFLS) data reflects the remarkable expansion of this program. As Figure 1 shows, while only about 5 percent of the IFLS communities had received program midwives in 1992, this fraction had risen to about 47 percent by 1996 indicating the rapid expansion of the program between 1993 and 1996. On average there are about 1.25 village midwives in the communities that received the program by 1997. Earlier studies (Frankenberg and Thomas, 2001; Frankenberg et. al., 2005) also show that the communities that received a village midwife were more likely to have poorer infrastructure and poorer economic and health status. This non-random placement of the program therefore makes the evaluation less straightforward.

Outcomes

I examine cognition and also measures of education (completed years of education, age of entry in school, and school enrolment) when children are aged 11 to 17. The IFLS3 and IFLS4 survey waves administered the same cognitive test to individuals aged 7-24. The purpose of the cognitive test is to assess general cognitive level using Raven's Colored Progressive Matrices (CPM) test questions as well as a set of mathematics test questions. There are two levels of tests, one for those aged 7 to 14 and another for those aged 15 to 24. The Raven's CPM assessment is commonly used as a measure of general intelligence, and is considered as the single best measure of Spearman's general "intelligence factor" g (Kaplan and Saccuzzo, 1997). This test consists of pattern-matching exercises wherein the respondent is asked to identify the 'missing piece' that best matches the shown patterns (see an example in Figure 2). I considered standardizing the cognitive test scores within the sample but instead chose to use raw scores (percent correct) as dependent variable. The results are not sensitive to using standardized tests scores.

4 The Biology of Cognition

David Barker and his colleagues coined the term "fetal origins" hypothesis which proposes that alterations in nutrition and endocrine status in utero (and in very early childhood) result in developmental adaptations that permanently change structure, physiology and metabolism, thereby "programming" individuals to diseases and poor outcomes in adult life (Barker, 1994; Godfrey and Barker, 2000). Likewise, influential researchers in the field of developmental psychobiology hypothesized that the nature of early experiences leads to 'permanent changes in neural cells in the cerebrum cortex' which could influence subsequent development (Hunt, 1961; Politt et. al., 1993). Negative effects of environment on the development of cerebral cortex have been documented extensively in both animal and human studies. Experimental studies in animals show that early under-nutrition, micro-nutrient deficiencies, environmental toxins and poor stimulation can lead to permanent changes in brain structure and function and thus have long-lasting cognitive and behavioral effects (see for instance Liu et. al., 2000; Meaney, 2001; Rodier, 2004; Webb et. al., 2001). These animal studies were supported by large number of observational studies and a few randomized experiments conducted in humans providing evidence that poor nutrition and micronutrient deficiencies particularly during the fetal period and first two years of life results in later cognitive deficit (see a review of studies in Grantham-Mc-Gregor and Ani, 1999; Politt et. al., 1993). In economics, economists have investigated a wide range of environmental shocks during the fetal period and find impacts on a variety of later life outcomes along with health such as test scores, schooling and labor market outcomes (see Almond and Currie (2011) for a review of this rapidly growing literature). Other studies examine the effects of postnatal exposure to environmental shocks (particularly during the first 2 or 3 years of life) for later schooling and health outcomes (Alderman et. al., 2006; Maccini and Yang, 2009). The well-known INCAP experimental study in Guatemala finds that child exposure to nutritional supplementation from birth up to age 3 has long run positive effects on cognition and schooling (Maluccio, 2009).

More recently, a growing avenue of research (although still based primarily from animal studies) postulates that maternal health and nutrition status (diet, vitamin intake and glucose levels) prior to ovulation and conception, can have long term effects on adult outcomes (Aagaard-Tillery et. al., 2008; Kanakkaparambil, 2009; Wang et. al., 2009; Winder et. al., 2011). Studies suggest that the intrinsic developmental program during the pre-implantation period (or the period between fertilization of the egg and the implantation of the embryo in the uterus) appears to be responsive to external signals from the maternal environment to fine tune the course of development (Eckert and Fleming, 2008; Watkins and Fleming, 2009). In other words, during the first few days or weeks of pregnancy, the embryo undergoes rapid and significant developmental changes that depend largely on the prior health and nutritional status of the mother. From a range of animal studies and from different laboratories, it has been demonstrated that changes in the environment prior to the implantation of embryo either through nutrition or in vitro culture treatments can affect adult cardiovascular and metabolic health (Sinclair et. al., 2007; Thompson et. al., 2007, Watkins et. al., 2008). [7]Thus these studies suggest the important role played by pre-conception health and nutritional status of mothers in determining the development of embryo and subsequent outcomes later in life. In humans, research shows that folic acid supplementation, started prior to conception, has markedly decreased the incidence of severe developmental defects (Czeizel and Dudas, 1992; Berry et. al., 1999) although its long run effects on child development is not yet well understood.

Critical or Sensitive Periods

The environmental effect on the developing brain depends on a large extent on the timing of the exposure to the stimulus or insult. The time periods during which developmental processes are sensitive to perturbation by environmental influences are also known

[7]For instance, Watkins and Fleming (2009) investigates the effects of low protein diet prior to conception in a mouse model. Although the treatment mice were fed with normal diet subsequently after conception, their offsprings experienced higher probability of hypertension, arterial disease and evenmetabolic disorders later in life. In this paper, I expand on the hypothesis of biological studies to examine the importance of preconception health for later economic outcomes.

among scientists as "critical periods" and usually such periods are during periods of rapid growth or development. Brain development studies suggest that the critical or sensitive periods in the development of human cerebral cortex include the time window ranging from the fetal period (as early as 7 days since the estimated last ovulation) until about the first or second postnatal year (Chugani, 1998; Utsonomiya et. al., 1999; Huttenlocher, 2002; Knickmeyer et. al., 2008). During these periods, the brain develops rapidly through a series of ontogenetic events such that any disruption in these developmental processes as a consequence of environmental insults can have long-lasting or permanent effects on brain structure and function. Since these genetically determined processes build on each other, the earlier the timing of insult in this critical window, possibly the more detrimental the effect is. This may also be due to the decreasing plasticity of brain with age or time. Although rarely are studies able to show the differential impact of nutrition and environmental insults for each period of development, as shown earlier, empirical findings from both the biological and social sciences support the notion that the fetal period and the first two years of life are particularly vulnerable periods. These periods of developmental vulnerability are also deemed to be the "windows of opportunity" in which beneficial interventions would have the greatest positive effects (Knickmeyer et. al., 2008). Scientists hypothesize that intervention during these early windows may be most effective in facilitating subsequent development (Bertenthal and Campos, 1987; Chugani, 1998; Nelson, 2000; Ruben, 1997). More recently, however, scientists including Barker and colleagues (see Eriksson et. al., 2011) are beginning to conjecture that the developmental processes start even before the fetal period. There is now a growing notion that the health of the mother prior to and at the time of conception also plays an important role in determining long run outcomes of the child.

5 Econometric Strategy

The summary statistics in Table 1 illustrate the non-random placement of the program. In general, children in communities that received a midwife tend to have lower socioeconomic status and poorer health endowment (as indicated by mother's height). On average, they also tend to have lower test scores and poorer schooling outcomes.

Thus the paper's identification strategy combines the variation in the availability and timing of the arrival of the program across communities with the biology of cognition to empirically examine the causal impact of the program. In particular, I draw from the biology of cognition and the results of the earlier studies that environmental factors which influence maternal health prior to conception and during the fetal period as well as the first two to three years of life mark the critical or sensitive periods during which environmental influences could have lasting impact on cognition and other measures of human capital. This thus suggests that children who are exposed to the program at age 4 and beyond are less likely to benefit from the program. I estimate two basic specifications of two-way fixed effect models: first using a crude measure of being exposed to the program, focusing on the major expansion that occurred between 1990 and 1996, and another using a finer exposure measure that allows for empirically examining the critical periods for cognitive development. Given the biological linkage between environmental influences in early life and later cognition, I particularly focus my analysis on cognition, but also examine the measures of schooling later on.

I begin with the simple difference-in-difference framework wherein I ask whether children born during the rapid program expansion (1993 to 1996) have better outcomes compared to their counterparts who were born prior to the start of the program (1986 to 1989) in the communities that received the program, and relative to those born in the same year in other communities that did not receive the program.[8] Note that the pre-program cohorts (born 1986 to 1989) were already at least age 4 in 1993 when the rapid program expansion began. Thus the program is unlikely to have long run benefits

[8]I can also just compare cohorts who were born during the program expansion (1990-1996) with the same span of cohorts born prior to program expansion (1983-1989). But for this specification I restrict the analysis to those born during the rapid program (1993-1996) to ensure that the treatment cohorts are exposed only within the first three years of life depending on when the village midwife arrived between 1993 and 1996. Children who were born in 1990 would be exposed at age 3 if the program arrived in 1993 but would already be age 4 and above if the program arrived in 1994 to 1996. To avoid this inefficiency, I will just exclude them for this specification but include them back to the sample when I estimate the effect of the program for each birth year cohort and also in the second specification where I use a finer measure of exposure to the program.

on these children.[9] This suggests estimating the following reduced-form equation:

$$Y_{ijt} = c_1 + \beta(VM_{ij} * EXP1_{it}) + \theta X_{ijt} + \mu Z_{jt} + \delta_t + \gamma_j + \epsilon_{ijt} \quad (1)$$

where Y_{ijt} is the outcome of interest of individual i born in community j in year t, VM_{ij} is a dummy indicating whether the individual's community of birth received a program midwife between 1990 and 1996, $EXP1_{it}$ denotes whether the individual was born during the rapid program expansion period 1993-1996, δ_t is the cohort of birth fixed effect while γ_j is the community of birth fixed effect. X_{ijt} is a vector of individual and parental characteristics including gender, age at the time of measurement, mother's and father's education and mother's height. Z_{jt} is a vector of time-varying community characteristics that includes an indicator of changes in local amenities (such as new schools, new health facilities, or new road constructed) and the availability of child development services over time across communities. I also include the number of schools (junior and senior level) in the community at the time of measurement.[10]

As a second empirical strategy I take advantage of the phased-in deployment of the safe motherhood program in the communities and combine it with the timing of birth of the child to come up with relatively finer exposure measures. In this specification, I now examine cohorts born 1983 to 1996, thus including cohorts 1990 to 1992 who are likely to be exposed to the program in the post-birth period. In particular I ask whether children who were born in the communities that received a village midwife and exposed to the village midwife before birth or during the first 2 to 3 years of life, have better

[9] Although they are aged 1 to 3 in 1990 to 1992, only about 3.6 percent of the children in the sample received the program between 1990 and 1992, thus, on average, the effect of the program should be close to zero for these children.

[10] A section in the community surveys of IFLS1 and IFLS2 ask the village heads to indicate the important events that occurred in the communities in the last 5 years (for IFLS2, IFLS3 and IFLS4) and since 1980 for IFLS1, including information of when the event occurred and how it impacted the welfare of the local population. The questionnaire provides a list of commonly occurring positive events (such as construction of new school, new health facility or new roads, etc.) in the communities. Any other event that is not mentioned is provided by the village head. Also the questionnaire administered to posyandu (community health center) asks question on the availability and timing of provision of child development services in the community. For the availability of schools at the time of measurement (using IFLS3 and IFLS4), I exclude primary level schools since the large scale primary school construction program launched in Indonesia in 1970s and enrollment in primary level has been very high since then (see Duflo (2001) for the impact of this program).

outcomes than their counterparts who already passed those critical years, and relative to those born in other communities in the same year. Instead of creating a simple indicator of whether an individual belongs to such treatment status, I create dummies for each particular period of child's development. This suggests running the following regression:

$$Y_{ijt} = c_1 + \sum_l \beta_l EXP2_{ijtl} + \theta X_{ijt} + \mu Z_{jt} + \delta_t + \gamma_j + \epsilon_{ijt} \quad (2)$$

where $EXP2_{ijtl}$ is a set of indicator variables that reflect the timing of the timing of the arrival of the midwife relative to child's birthdate. The indicator is set to zero if the community did not receive a village midwife. Exposure to village midwife ranges from 6 years prior to birth until 13 years after birth in the sample.[11] Given the pattern of arrival of the program in these communities, there are fewer cases where individuals are exposed 4 to 6 years prior to birth and so I lump them together under 3 to 6 years prior to birth. Each β_l can be interpreted as the effect of the program on a given exposure period.

The biology of cognition and the results of earlier studies suggest that children exposed at age 4 and above are unlikely to benefit from the program. Thus, β_l should be 0 for $l >= 4$. On the other hand, children born in communities that received a midwife 2 or more years prior to their birth are fully exposed to the prenatal care, postnatal care and general health care services provided by the midwife. They may also have the additional benefit of having mothers whose preconception health and nutritional status were positively affected by the presence of midwife.[12] Meanwhile, children who were exposed to the midwife while in utero may only be partially exposed to the prenatal care services but fully exposed to the postnatal and general health care services provided by the midwife.[13] Likewise, those who were exposed to the village midwife during their

[11]Given the period of program expansion occurred in 1990 to 1996 and the birth year cohorts spans 1983 to 1996, the timing of midwife's arrival with respect to child's birth can be determined by the following difference: year of village midwife's arrival in community - birth year, where -6 is the difference between the earliest year the program arrived (1990) and the youngest birth cohort (1996) while 13 is the difference between the latest year the program arrived (1996) and the oldest birth cohort.

[12]Frankenberg et. al. (2001) carefully showed earlier that the presence of midwife in the communities led to better nutritional status of women of reproductive age.

[13]A limitation of this study is that only information on the year of the arrival of village midwife is available. Thus receiving a midwife while in utero or "1 year before birth" means that the midwife arrived anytime in the previous year before the child's year of birth. Thus these children may only be partially exposed to prenatal services of the midwife.

first year or second year of life may only be partially exposed to the postnatal services provided by the midwife. In general, effects should be increasing with earlier exposure for $l < 4$.

Since I am examining the outcomes of individuals during the period (age 11 to 17) when they are still developing at the cognitive and behavioral level as well as still attending school, it is crucial to compare treatment and control cohorts whose outcomes were measured at the same age. Thus I exploit the panel dimension of IFLS and in particular the seven years gap between IFLS3 (2000) and IFLS4 (2007) to take into account age-dependent variation in cognition.[14] To examine the effect of the program, I compare the outcomes of the treatment cohorts born in 1990 to 1996 and measured in 2007 at age 11 to 17 with the outcomes of control cohorts born in the prior years 1983 to 1989 and measured in 2000 when they are of same age. This can be further illustrated using a lexis diagram in Figure 3. Time in years is represented in x-axis. The vertical lines in 2000 and 2007 correspond to the years IFLS measures the outcomes of interest and the diagonal lines identify different cohorts: the red diagonal line refers to the cohorts born during the program expansion (1990-1996), the blue diagonal line refers to cohorts born prior to program expansion (1983-1989) and the green line refers to the cohorts born in 1976-1982. In the main experiment of interest, I compare the red diagonal (treatment) cohorts with blue diagonal (control) cohorts. To ensure that I am comparing children of same age (taking into account of age effects), I measure the outcomes of red diagonal cohorts in 2007 at age 11 to 17 while I measure the outcomes of blue diagonal cohorts in 2000 when they are of similar age. In the falsification experiment, I compare the outcomes of blue diagonal (pseudo-treatment) cohorts with the outcomes of green diagonal cohorts (pseudo-control) cohorts. This time I measure the blue diagonal cohorts in 2007 at age 18 to 24 while I measure the outcomes of the green diagonal cohorts in 2000 when they are of similar age.

[14]Frankenberg et. al. (2005) also exploited the panel dimension of IFLS1 and IFLS2 such that they compare the height-for-age of children aged 1-4 in 1997 with the height-for-age of children aged 1-4 in 1993.

6 Results

Table 2 reports the results of estimating the impact of the program on cognition based on the diff-in-diff specification (specification 1). In Panel A, I compare the outcomes of cohorts born during the rapid program expansion (1993 to 1996) with the outcomes of cohorts born at least four to seven years ago (1986 to 1989).[15] In column 1, the specification controls only for birth year and community of birth fixed effects while in column 2 individual and parental controls are added. Controlling for parental characteristics is particularly important as this helps to address the issue that there could be positive selection into fertility during the program expansion period and that could be driving the improved outcomes of children. The estimates are statistically significant at 1% level and suggest that exposure to safe motherhood program increases test scores by 5.12% for the whole sample (column 2, row A) and 5.49% for the sample restricted to those who did not move out of the village before age 5 (column 2, row B).[16] If test scores are standardized within the sample, these estimates are equivalent to about 0.23 to 0.25 standard deviations increase. Interestingly, these standardized estimates are about the same as the Raven's test z-score estimate based on the well-known INCAP experimental study that examined the impact of child's exposure to nutritional supplementation during the first three years of life (see details of study in Maluccio et. al., 2009).

The above estimates could be interpreted as a causal impact of the program based on the assumption that the allocation of the program expansion is uncorrelated with the other contemporaneous events in the communities. Although there is no known program that is correlated with the allocation of the safe motherhood program, in column 3 I also control for any other time-varying changes in local amenities as well as the availability of

[15] I examine these children when they are aged 11 to 14. Following the lexis diagram, the cohorts born 1993 to 1996 are measured in 2007 at ages 11 to 14 while cohorts born 1986 to 1989 are measured in 2000 when they are of same age.

[16] The movement of children before age 5 is tied to the migration of mothers. IFLS has a very intensive tracking system that allows for tracking of the movement of households from their original location in 1993 to their new locations in 1997, 2000 and 2007. In general, based on IFLS data, mobility of mothers tends to be limited when their children are still young (before teenage years). For instance, of the cohorts belonging to experiment of interest, 94% of the children have not moved out of the village before their age 5.

child development services over time across communities. Column 4 adds the availability of the schools (at the junior and senior level) at the time of measurement. This helps to address the concern that the program may have been targeted to those villages that are likely to develop faster or are likely to be targeted by future programs that improve cognition and schooling. Estimates in columns 3 and 4 are significant at 1% level and suggest that the program increased the test scores by 5.21% to 5.54% (column 4, row A and row B).

To ensure that the resulting estimates are not driven by time effect, panel B of Table 2 presents the results of the falsification experiment that compares the test scores of older cohorts (those born in 1986 to 1989 vis--vis those born in 1979 to 1982) who also took the cognitive tests in 2000 and 2007. The pseudo-treatment cohorts or children born in 1986 to 1989 are measured in 2007 (at age 18 to 24) while the pseudo-control cohorts or children born in 1979 to 1982 are measured in 2000 at the same age. As shown in row A of panel B, estimates are very small and not significant.[17] Thus estimates are not likely to be explained by time effects. Further, this exercise also shows that estimates are not likely to be an artifact of mean reversion. There is a concern that individuals in the communities that received the program may have poor cognition or poor human capital when measured in 2000 due to temporary shock and as conditions just get better in these communities in the following period (2007), the individuals also improve their cognition or human capital. However, if that is really what is driving the results in panel A, then we should also see systematic improvement in cognitive test scores among cohorts born 1986 to 1989 who are measured in 2007 relative to cohorts born 1979 to 1982 who are measured in 2000. However the results in Panel B of table 2 suggest that is not the case here.

In Figure 4A, I present estimates of the effect of the safe motherhood program for each of the birth year cohorts born 1983 to 1996. The 1983 birth cohort forms the control group and is omitted from the regression. Each dot in the solid line represents the coefficient of the interaction of the dummy of being a given birth year cohort and the

[17]Note that I do not present falsification estimates for the sample restricted to non-movers before age 5 since in the sample these children are likely to have been living in the same communities since birth.

indicator of the availability of village midwife in the community by 1997 while the dashed lines represent the 95% confidence interval. The coefficients tend to fluctuate around zero until 1990 and then become larger after that. Except for 1993, all coefficients starting 1991 are statistically different from zero at conventional levels. In Figure 4B, I repeat the same analysis for each of the falsification cohorts born 1979 to 1983. The 1976 birth cohort now forms the control group and is omitted from the regression. As expected, since these cohorts were born prior to the program expansion and were at least age 4 and above when the safe motherhood program arrived in these communities, the effect of the program is close to zero for them. All coefficients are not statistically different from zero.

Although the previous exercise is reassuring that the identification strategy is reasonable and that the safe motherhood program had an impact on cognition, it may not necessarily provide a clear picture of the impact of the program. In general, the program may have had differential impact depending on the timing of the arrival of the village midwife with respect to the child's stage in development.

Using the same sample used in Figures 4A and 4B, I use the information on the year (timing) of the arrival of village midwives in these communities with respect to child's year of birth to create an individual level measure of exposure to the program. To be as flexible as possible, I relax the earlier hypothesis that the program must have had an impact only on children who are less than age 4 when the village midwife arrived. I estimate the coefficients of the intensity of exposure for each of the exposure period ranging from 3 to 6 years prior to birth up to age 11 and omit exposures at ages 12 to 13 to serve as part of the reference group. Figure 5 plots the coefficients for each of these exposure measures while the dash. As shown in the graph, coefficients are close to zero and about same level until age 3 and then increases markedly after that, for children two and younger, or not yet conceived, when the midwife arrived. In fact coefficients for children 2 and younger when the midwife arrived are statistically different from zero. This picture provides evidence that the program had an impact, consistent with the findings in the biological literature that suggest the importance of maternal health prior to conception, the prenatal period and the first two years of life in shaping outcomes later in life.

Instead of testing whether β_l is equal to 0 for $l >= 4$, I now impose that restriction. In Table 3, I examine the impact of the program for each particular exposure period before age 4. The omitted group is now comprised of individuals with exposures of age 4 and above. As shown in the first four columns of Table 3, results change little even if I enter the control variables separately. In general, the estimates tend to show patterns of dose response (except for ages 1 and 2 which tend to switch in magnitude) which may reflect the decreasing plasticity of brain. Also, although cohorts born in 1990 to 1996 have varying exposures ranging from 3 to 6 years prior to birth to about 6 years after birth depending on the timing of the arrival of the village midwife, estimates are only relatively large and significant for those children exposed 3 to 6 years prior to birth until age 2; beyond that estimates become really small and non-significant (by age 3). Once again, this pattern coincides with the findings in biology and is similar to the results based on a more flexible specification plotted in Figure 5. As shown in column 4 of Table 3, exposure to the benefits of safe motherhood program prior to conception, while in utero and during the first two years of life increase test scores by about 2.88% to 7.27% (equivalent to 0.13 to 0.33 standard deviations increase if test scores are standardized).

Since this specification relies on the timing of the arrival of village midwives, a major concern is that the timing of the arrival of village midwives might be correlated with the time-varying development in these communities. Thus in column 5 I add province-specific trends (province x birth year fixed effects) to account for differential evolution of provinces. This particularly addresses the worry that communities in certain provinces that received midwives earlier may have evolved differently or grew faster than communities in other provinces that received midwives later or have not received midwives.[18] As shown in column 5 although standard errors slightly increase as a result of imposing this additional restriction, results remain robust which suggest that this is not likely to be an important issue.

[18] In other words, this helps identify the causal impact of the program so long as the unobserved factors determining that a village midwife is allocated to community i versus community j in the same province are uncorrelated with the relative economic development in these communities over time.

On top of this restrictive specification, in columns 6 and 7 I examine whether results might be driven by selective migration. This is done by restricting the sample to those children who did not move out of their village before age 5 (column 6) and to those children whose mothers have been living in the same community even three years prior to birth (column 7).[19] Estimates only become bigger when I correct for the issue of selective migration, suggesting that estimates are not likely to be upward biased by possible differential migration of high ability mothers into the communities that received midwives.

Another concern is that estimates might be only driven by time effect. To address this concern, I ran the same specification using the cohorts born prior to the program as a falsification exercise. Although there could be several ways of doing this, I implement the simplest one which is to assume that the program expansion occurred exactly 7 years earlier and then replicate the analysis for cohorts born 1976 to 1989.[20] As shown in column 8, estimates do not yield the same pattern observed above and are not significant.

In column 9, I restrict the sample to communities that ever received a midwife as of 2007.[21] By restricting the sample to all communities that received the program at some point, I remove the communities that never received a midwife as of 2007 which may be very different. In general, results are invariant to this sample restriction although the coefficient for exposure period *1 year after birth* is less precisely estimated.

Additional Robustness Checks

As a robustness check, I include back in the sample children who were not matched to their IFLS community of birth because they were identified as either not born in one of the 321 original IFLS communities or have missing information on the place where they were born. I use the community where these children are found in the 1993 baseline

[19]In very small number of cases wherein information on community of birth is determined solely based on own response of the individual as young adult (15 and above) due to lack of information on mother's location at the time of birth, I do not have information on mother's community 3 years prior to birth. In this case I just use the community of birth.

[20]This means that if the program midwife arrived in 1990, it would be coded as arrived in1983 or if the program midwife arrived in 1995, it would be coded as arrived in 1988.

[21]Between 1997 and 2007 (after the rapid program expansion) the fraction of communities that received midwives rose from 47% to 57%.

survey as proxy for their community of birth. As shown in column 10 of Table 3 (and in rows (C) in panels A and B of Table 2), the estimates are just slightly smaller but remain highly statistically significant.

Also, to ensure that estimates in Table 3 were not influenced by the inclusion of birth cohorts 1990 to 1992 in the sample, I ran the intensity of exposure specification using the sample used in Table 2.[22] As shown in column 11, even if I restrict the analysis to cohorts born 1993 to 1996 vis--vis cohorts born 1986 to 1989, I still get the same pattern of estimates observed in general in Table 3. Thus the results cannot be attributed to the inclusion of these cohorts in the sample.

Subcomponents of Cognitive Test and Measures of Schooling Outcomes

In Table 4, I examine the subcomponents of cognitive test and measures of schooling. All specifications include all control variables and the three columns under each variable presents the results for full sample, sample restricted to non-movers before age 5 and finally, sample that includes the children who were not matched to IFLS communities.[23] In columns 1 to 6, I examine the impact of the program separately for the subcomponents of cognitive test: Raven's CPM test (which comprise 80% of the test questions) and Mathematics questions. In general results remain robust regardless of change in sample specification. The patterns of estimates under the Raven's CPM test questions score are similar to the results shown in Tables 2 and 3 for pooled cognitive test score although the coefficients under 1 year after birth are not significant. Interestingly, for the Mathematics test questions score, estimates are relatively large and statistically significant only until about age 1.

For the remaining columns of Table 4, I examine the impact of the program on measures of schooling. Studies conducted in developed and developing countries show that early cognitive and socio-emotional development is strongly associated with school progress (Currie and Thomas, 1999; Feinstein, 2003; Gorman and Politt, 1996; Maluccio,

[22]Note the sample used in Table 2 comprise of cohorts born during the rapid program expansion, 1993 to 1996.

[23]Note that results are in general robust to other sample specifications used in Table 3 although not shown here

2009; Daniels and Adair, 2004). In columns 7 to 9, I first investigate whether the program had an impact on early school entry of the child. I find that the program had no impact on whether or not the child enters elementary school by age 6.[24] Looking at other measures of schooling in columns 10 to 15, I find that the children exposed to the program are more likely to still be attending school at the time of measurement and they also tend to complete more years of education. Estimates suggest that the program led to an increase of about 0.23 to 0.52 years of education (column 13) depending on the exposure of the child to the program. These effects are in general robust to restricting the sample to non-movers (column 14) and the inclusion of unmatched children in the sample (column 15) although in the former, the coefficient for exposure at year of birth is not statistically significant. Interestingly, the patterns observed for measures of schooling are similar to the pattern observed in Mathematics test scores. That is, coefficients are relatively large and significant until the first year of life, but beyond that estimates become really small and not statistically significant. One possible explanation for this is that mathematics ability could be influencing the child's progress in schooling. However, the question of why the pattern of relatively large and significant coefficients for Mathematics test scores ceases by age 2 needs further research.

7 Conclusion

Although many papers have documented the importance of early life health for later human capital outcomes, few papers have attempted to rigorously evaluate the long run impacts of early life public health interventions. In addition, the question of "when is it most effective to intervene?" tend to come up frequently in policy discussions and yet it is rarely even tackled in the literature. This paper aims to address these unresolved issues using an identification strategy that combines the variation in the availability and timing of the arrival of a public health intervention with the biology of cognition.

The first comprehensive Safe Motherhood intervention in Indonesia that allocated over 54,000 midwives in most of nonmetropolitan villages in Indonesia led to an increase

[24] In Indonesia, children typically enter elementary school by age 6 or 7.

in both cognition and education of individuals at age 11 to 17. On average, estimates indicate that the program led to an increase of about 5.12% to 5.49% in cognitive test scores (equivalent to 0.23 to 0.25 standardized deviations increase in standardized test scores). These findings are robust to using alternative specification based on intensity of exposures which indicate that the program led to an increase of about 2.88% to 7.27% in cognitive test scores (about 0.13 to 0.33 standard deviations increase in standardized test scores). The program also led to an increase of 0.23 to 0.52 years of education depending on the timing of child's exposure to the program. A number of specification checks as well as robustness checks support the causal interpretation of these estimates.

The results are consistent with the conjecture based on findings in biology that the fetal period and the first two years of life mark the "windows of opportunity" during which positive influences may be most beneficial in the developmental processes of the child. In addition, the results also support recent biological findings (although still based mainly in animal models) which suggest that the mother's health even prior to conception is important for the long term development of the child.

One challenge in this study is the difficulty in disentangling the effects of the intervention itself from factors such as lag in the acceptance of midwife in the community or improvement in the relationship of the midwife with members of the community over time. Nevertheless, given that the pattern of results coincide well with the findings in biology and earlier studies in the literature, this issue is unlikely to overturn the general conclusion established above regarding the importance of maternal health prior to conception, the prenatal period and the first two years of life in influencing outcomes later in life.

This study is one of the very few studies that examine the long run impact of early life public health intervention on later human capital (during adolescence). Examining whether these benefits actually persist into adulthood and translate into higher productivity will be the subject of future work.

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Table 1. Summary Statistics By Presence of Village Midwife

Variables	Panel A. Experiment of Interest Cohorts Born 1983 - 1996		Panel B. Falsification Experiment Cohorts Born 1976 - 1989	
	Has Village Midwife by 1997	No Village Midwife by 1997	Has Village Midwife by 1997	No Village Midwife by 1997
Panel A. Control Variables				
Mother's education	5.01	6.49	4.09	5.63
	(4.02)	(4.30)	(3.68)	(4.12)
Father's education	5.94	7.52	5.37	7.09
	(4.13)	(4.39)	(3.93)	(4.24)
Mother's height	150.08	150.68	149.49	150.07
	(5.24)	(5.56)	(5.26)	(5.35)
Male	0.51	0.52	0.50	0.49
	(0.50)	(0.50)	(0.50)	(0.50)
Panel B. Outcomes				
Cognitive Test Score (% correct)	65.68	70.34	58.21	63.85
	(22.44)	(21.34)	(23.79)	(23.17)
Math Questions Score (% correct)	53.63	59.11	39.79	46.38
	(29.46)	(29.33)	(31.16)	(32.17)
Raven's CPM Questions Score (% correct)	72.13	76.40	69.72	74.76
	(24.67)	(22.92)	(26.81)	(24.89)
Entered school by age 6 (%)	50.82	60.96	42.82	50.64
	(50.00)	(48.79)	(49.49)	(50.00)
Still attending school (%)	76.68	85.53	15.15	23.48
	(42.29)	(35.19)	(35.86)	(42.40)
Completed education level (in years)	6.89	7.36	9.17	10.64
	(2.24)	(2.21)	(3.30)	(3.20)
Observations	8295		6991	

Note: For all variables (except gender), the difference between children in communities that received midwives and did not receive midwives are statistically significant at 1%. In Panel A, outcomes for cohorts born 1983-1989 are measured in 2000 (when they are aged 11 to 17) while outcomes for cohorts born 1990-1996 are measured in 2007 (when they are aged 11 to 17) and these data are pooled together. In Panel B, outcomes for cohorts born 1976-1982 are measured in 2000 (when they are aged 18 to 24) while outcomes for cohorts born 1983-1989 are measured in 2007 (when they are aged 18 to 24) and these data are pooled together. Variable means displayed to the right of variable names. Standard deviations displayed below the mean in parentheses.

Table 2.Impact of Safe Motherhood Program on Long-run Cognition: Coefficients based on the Interaction between Cohort Dummies and the Availability of Village Midwife by 1997 (Diff-in-diff Specification)

		Cognitive Test Score (% Correct)			
	Obs	(1)	(2)	(3)	(4)
Panel A. Experiment of Interest: For cohorts born 1993 to 1996 or cohorts born 1986 to 1989					
(Treatment Cohorts: Born during rapid program expansion: 1993 to 1996)					
(A) Full Sample	4575	5.37***	5.12***	5.12***	5.21***
		[1.19]	[1.17]	[1.17]	[1.17]
(B) Sample of non-movers (before age 5)	4281	5.76***	5.49***	5.48***	5.54***
		[1.25]	[1.22]	[1.22]	[1.23]
(C) Full sample plus those either not born in the same	4847	4.22***	4.14***	4.17***	4.20***
community or have missing information on community of birth		[1.16]	[1.14]	[1.14]	[1.15]
Panel B. Falsification Experiment: For cohorts born 1986 to 1989 or cohorts born 1979 to 1982					
(Pseudo-treatment cohorts: Born prior to program expansion: 1986 to 1989)					
(A) Full Sample	4221	0.70	0.63	0.64	0.65
		[1.40]	[1.39]	[1.39]	[1.39]
(C) Full sample plus those either not born in the same	4520	0.78	0.96	0.95	0.95
community or have missing information on community of birth		[1.36]	[1.34]	[1.34]	[1.34]
Controls:					
Birth year and community of birth fixed effects		Yes	Yes	Yes	Yes
Individual and parental characteristics		No	Yes	Yes	Yes
Time-varying changes in local amenities and availability of child devt services		No	No	Yes	Yes
Availability of schools at the time of measurement		No	No	No	Yes

Note: In the experiment of interest, children born 1993 to 1996 are measured in 2007 (when they are aged 11 to 14) while children born in 1986 to 1989 are measured in 2000 (when they are aged 11 to 14) and these data are pooled together. In the falsification experiment, children born in 1986 to 1989 are measured in 2007 (when they are aged 18 to 21) while children born 1979 to 1982 are measured in 2000 (when they are aged 18 to 21) and these data are pooled together. Individual and parental characteristics include mother's and father's education, mother's height, birth order, age at the time of measurement and sex. Time-varying community characteristics include an indicator of changes in local amenities (i.e., a new health facility, a new road, etc.) and the timing of the availability of child development services in the communities over the period covered. Availability of schools are measured in 2000 for cohorts born 1986 to 1989 (1976 to 1982) and in 2007 for cohorts born 1993 to 1996 (1986 to 1989). In column 3 for panel B, I only include the availability of child development services in the communities over time since I do not have complete information for history of community events between 1979 to 1982. Standard errors adjusted for clustering at the community level in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 3.Impact of Safe Motherhood Program on Long-run Cognition: Coefficients based on Intensity of Exposure to the Program

Timing of Midwife's Arrival	Cognitive Test Score (% correct)										
	Main Results				*Robustness Checks*						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Experiment of Interest: For Cohorts born 1983 to 1996											
3 or more years before birth [-3 to -6]	7.59***	7.21***	7.22***	7.27***	7.11***	7.25***	7.72***	-0.67	7.87***	6.78***	7.69***
	[2.03]	[2.00]	[2.00]	[2.00]	[2.08]	[2.20]	[2.09]	[2.41]	[2.39]	[2.06]	[2.12]
2 years before birth [-2]	6.50***	6.50***	6.49***	6.56***	5.89***	6.91***	6.20***	2.16	6.37***	5.56***	6.99***
	[1.72]	[1.69]	[1.69]	[1.69]	[1.78]	[1.90]	[1.80]	[2.18]	[2.03]	[1.76]	[1.81]
1 year before birth [-1]	4.39***	4.44***	4.44***	4.54***	3.88**	4.65***	4.45***	2.35	3.74**	3.23**	4.78***
	[1.56]	[1.53]	[1.53]	[1.53]	[1.61]	[1.71]	[1.62]	[1.88]	[1.83]	[1.59]	[1.66]
At year of birth [0]	4.57***	4.44***	4.34***	4.39***	4.06***	4.51***	4.27***	-0.15	4.28***	3.51**	5.29***
	[1.42]	[1.40]	[1.40]	[1.40]	[1.46]	[1.55]	[1.48]	[1.77]	[1.66]	[1.44]	[1.53]
1 year after birth [1]	3.32**	2.81**	2.83**	2.88**	2.33*	2.76*	2.58*	1.02	2.5	2.26*	3.11*
	[1.34]	[1.32]	[1.32]	[1.32]	[1.39]	[1.43]	[1.40]	[1.68]	[1.54]	[1.37]	[1.78]
2 years after birth [2]	2.84**	2.95**	2.97**	3.06**	2.54*	2.47*	2.89**	-1.55	2.81*	2.45*	5.78***
	[1.34]	[1.32]	[1.32]	[1.32]	[1.38]	[1.42]	[1.41]	[1.55]	[1.51]	[1.37]	[2.24]
3 years after birth [3]	0.65	0.59	0.66	0.67	0.76	0.71	1.06	2.17	0.94	0.52	2.57
	[1.32]	[1.30]	[1.30]	[1.30]	[1.36]	[1.38]	[1.38]	[1.58]	[1.45]	[1.34]	[2.55]
Controls:											
Birth year and community of birth fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual and parental characteristics	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time-varying changes in local amenities and availability of child development services	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Availability of schools at the time of measurement	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province in 1993 x birth year fixed effects	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	No
Sample Compositions (columns):											
(A) Full Sample (cols 1-5)	Yes	Yes	Yes	Yes	Yes						
(B) Sample of non-movers before age 5 (col 6)	No	No	No	No	No	Yes					
(C) Full Sample using community of mother 3 years before child's birth (col 7)	No	No	No	No	No	No	Yes				
(D) Falsification (full) sample: cohorts born 1976 to 1989 (col 8)	No	No	No	No	No	No	No	Yes			
(E) Restricted to communities that ever received midwives as of 2007 (col 9)	No	No	No	No	No	No	No	No	Yes		
(F) Full sample plus those either not born in the same community or have missing information on community of birth (col 10)	No	No	No	No	No	No	No	No	No	Yes	
(G) Sample in Table 2: cohorts born 1993 to 1996 vs born 1986 to 1989 (col 11)	No	No	No	No	No	No	No	No	No	No	Yes
Observations	8295	8295	8295	8295	8295	8073	7981	6146	6991	8729	4575

Note: The sample includes cohorts born 1983 to 1996 for the experiment of interest (columns 1 to 11, except column 8). Cohorts born 1990 to 1996 are measured in 2007 (when they are aged 11 to 17) while children born in 1983 to 1989 are measured in 2000 (when they are aged 11 to 17) and these data are pooled together. Individual and parental characteristics include mother's and father's education, mother's height, birth order, age at the time of measurement and sex. Time-varying community characteristics include an indicator of changes in local amenities (i.e., a new health facility, a new road, etc.) and the timing of the availability of child development services in the communities over the period 1983 to 1996. Availability of schools are measured in 2000 and 2007. Standard errors adjusted for clustering at the community level in brackets. In column 8, cohorts born 1983 to 1989 are measured in 2007 (when they are aged 18 to 24) while children born in 1976 to 1982 are measured in 2000 (when they are aged 18 to 24). * significant at 10%; ** significant at 5%; *** significant at 1%

Table 4.Impact of Safe Motherhood Program on Measures of Cognition and Schooling: Coefficients based on Intensity of Exposure Estimation

	Sub-components of Cognitive Test						Measures of Schooling								
Timing of Midwife's Arrival	Raven's CPM Test Questions' Score (% correct)			Mathematics Test Questions' Score (% correct)			Whether entered school by Age 6 (%)			Whether Still Attending School (%)			Education Completed (years)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Experiment of Interest: For Cohorts born 1983 to 1996															
3 or more years before birth [-3 to -6]	7.26***	7.34***	6.77***	6.67**	7.14**	5.95**	-1.72	-3.46	2.23	14.13***	13.86***	13.61***	0.52***	0.47***	0.52***
	[2.26]	[2.40]	[2.24]	[2.68]	[2.82]	[2.66]	[4.72]	[4.99]	[3.95]	[3.49]	[3.71]	[3.45]	[0.16]	[0.17]	[0.15]
2 years before birth [-2]	6.07***	6.73***	5.64***	7.43***	8.36***	7.00***	3.33	2.74	0.75	10.76***	11.64***	10.68***	0.48***	0.46***	0.48***
	[1.91]	[2.04]	[1.90]	[2.27]	[2.41]	[2.25]	[3.99]	[4.26]	[3.58]	[2.95]	[3.17]	[2.92]	[0.13]	[0.14]	[0.13]
1 year before birth [-1]	3.58**	3.99**	2.99*	6.40***	7.82***	5.72***	1.54	0.07	2.78	8.09***	9.27***	7.50***	0.48***	0.49***	0.47***
	[1.73]	[1.84]	[1.71]	[2.05]	[2.17]	[2.03]	[3.64]	[3.87]	[3.24]	[2.67]	[2.86]	[2.63]	[0.12]	[0.13]	[0.12]
At year of birth [0]	3.97**	4.69***	3.32**	5.13***	4.95**	4.40**	2.79	2.26	2.18	4.04*	3.86	3.74	0.23**	0.19	0.23**
	[1.59]	[1.68]	[1.56]	[1.88]	[1.98]	[1.84]	[3.31]	[3.51]	[3.06]	[2.44]	[2.60]	[2.39]	[0.11]	[0.12]	[0.11]
1 year after birth [1]	2.36	2.47	2.05	4.01**	4.57**	3.92**	3.09	2.6	-1.96	4.47*	4.62*	4.38*	0.29***	0.31***	0.29***
	[1.49]	[1.54]	[1.47]	[1.76]	[1.82]	[1.74]	[3.12]	[3.21]	[3.05]	[2.30]	[2.39]	[2.26]	[0.10]	[0.11]	[0.10]
2 years after birth [2]	3.78**	3.65**	3.39**	1.88	1.99	1.98	-1.64	-1.77	0.98	0.61	0.7	0.53	0.11	0.08	0.12
	[1.49]	[1.53]	[1.47]	[1.76]	[1.80]	[1.74]	[3.10]	[3.18]	[3.00]	[2.29]	[2.37]	[2.26]	[0.10]	[0.11]	[0.10]
3 years after birth [3]	0.56	0.41	0.25	0.8	0.94	0.7	0.58	0.07	-2.45	0.59	0.63	0.4	-0.04	-0.04	-0.03
	[1.47]	[1.48]	[1.44]	[1.74]	[1.75]	[1.70]	[3.07]	[3.10]	[4.66]	[2.26]	[2.30]	[2.21]	[0.10]	[0.10]	[0.10]
Observations	8295	7981	8729	8295	7981	8729	8145	7834	8570	8295	7981	8729	8295	7981	8729
Sample Compositions:															
(A) Full Sample	Yes	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes	No	No
(B) Sample of non-movers (before age 5)	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes	No
(C) Full sample plus those either not born in the same community or have missing information on community of birth	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes

Note: Cohorts born 1990 to 1996 are measured in 2007 (when they are aged 11 to 17) while children born in 1983 to 1989 are measured in 2000 (when they are aged 11 to 17) and these data are pooled together. All specifications control for individual and parental characteristics which include mother's and father's education, mother's height, birth order, age at the time of measurement and sex; time-varying community characteristics include an indicator of changes in local amenities (i.e., a new health facility, a new road, etc.) and the timing of the availability of child development services in the communities over the period 1983 to 1996 and availability of schools measured in 2000 and 2007.The outcomes Whether entered school by age 6 and Whether still attending school are estimated using Linear Probability Model. Standard errors adjusted for clustering at the community level in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%

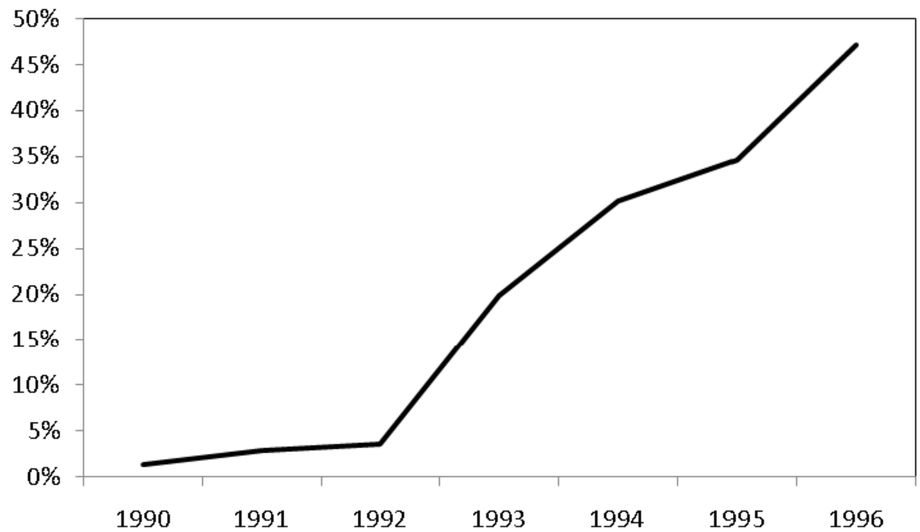
Appendix Table. Comparison of Matched/Unmatched Individuals to Community of Birth and Attrition Analysis

Baseline Individual Characteristics	Not Matched to IFLS Community of Birth	Matched to IFLS community of Birth	Difference (Matched - Not Matched)	Matched to IFLS Community of Birth: Not Interviewed in 2000/2007	Matched to IFLS Community of Birth: Interviewed in 2000/2007	Matched to IFLS Community of Birth: Difference (Not Interviewed - Interviewed)	Not Matched to IFLS Community of Birth: Not Interviewed in 2000/2007	Not Matched to IFLS Community of Birth: Interviewed in 2000/2007	Not Matched to IFLS Community of Birth: Difference (Interviewed - Not Interviewed)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Cohorts born 1983 to 1996 (measured at age 11 to 17)									
Mother's education	7.11	5.68	1.44	5.87	5.60	0.27	7.11	7.12	-0.01
			(0.14)***			(0.15)*			(0.24)
Father's education	7.73	6.63	1.11	6.66	6.59	0.07	7.79	7.66	0.14
			(0.14)***			(0.15)			(0.23)
Mother's height	150.6	150.3	0.28	150.33	150.32	0.01	150.63	150.60	0.04
			(0.20)			(0.20)			(0.30)
Male	0.49	0.51	-0.02	0.50	0.51	-0.01	0.47	0.51	-0.03
			(0.02)			(0.02)			(0.03)
Observations	1043	9202		907	8295		591	467	
Panel B: Cohorts born 1976 to 1989 (measured at age 18 to 24)									
Mother's education	6.56	4.75	1.81	4.69	4.78	-.09	6.47	6.74	-0.26
	(0.07)	(0.04)	(0.09)***	(0.08)	(0.05)	(0.09)	(0.08)	(0.15)	(0.16)*
Father's education	7.44	6.10	1.34	5.97	6.15	-.18	7.26	7.79	-.54
	(0.07)	(0.04)	(0.10)***	(0.08)	(0.05)	(0.10)*	(0.08)	(0.14)	(0.15)***
Mother's height	150.52	149.68	0.85	149.50	149.74	-0.24	150.63	150.31	0.32
	(0.08)	(0.06)	(0.13)***	(0.12)	(0.06)	(0.13)*	(0.09)	(0.17)	(0.18)*
Male	0.45	0.51	-0.05	0.54	0.49	0.04	0.45	0.46	-.01
	(0.01)	(0.01)	(0.01)***	(0.01)	(0.01)	(0.01)***	(0.01)	(0.02)	(0.02)
Observations	2061	9449		2381	7068		1378	683	

In Panel A, background characteristics for cohorts born 1983-1989 are measured in 2000 when they are aged 11 to 17 and outcomes for cohorts born 1990-1996 are measured in 2007 when they are aged 11 to 17. In Panel B, background characteristics for cohorts born 1976-1982 are measured in 2000 when they are aged 18 to 24 and outcomes for cohorts born 1983-1989 are measured in 2007 when they are aged 18 to 24. Standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

FIGURES

Figure 1 . Expansion of the Safe Motherhood Program over the period 1990 to 1996



Source: Indonesian Family Life Survey.

Note: The x-axis shows the years of program expansion while the y-axis shows the fraction of all IFLS communities that received the program.

Figure 2. Raven's CPM Sample Exercise

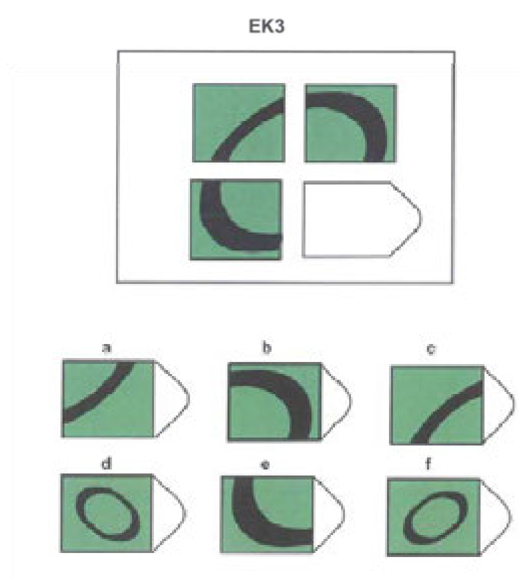
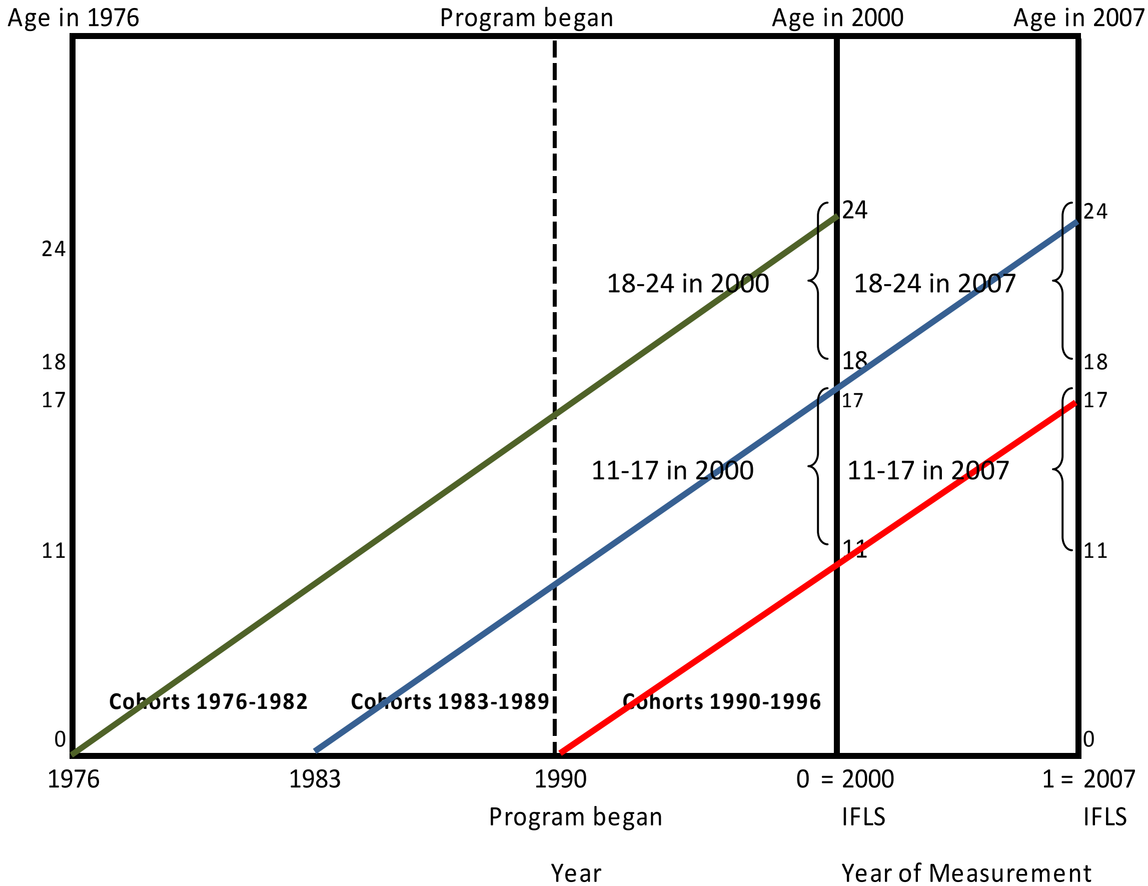
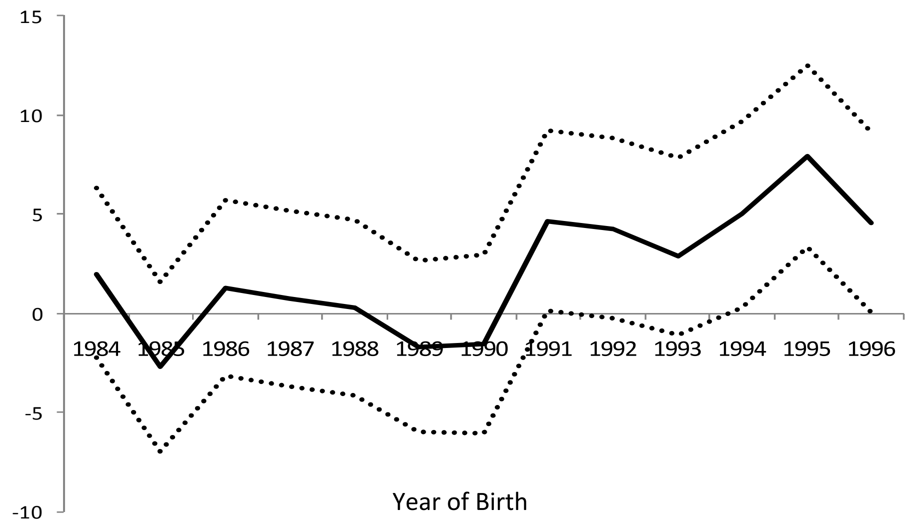


Figure 3. Lexis Diagram: Comparing Cohorts of Same Age



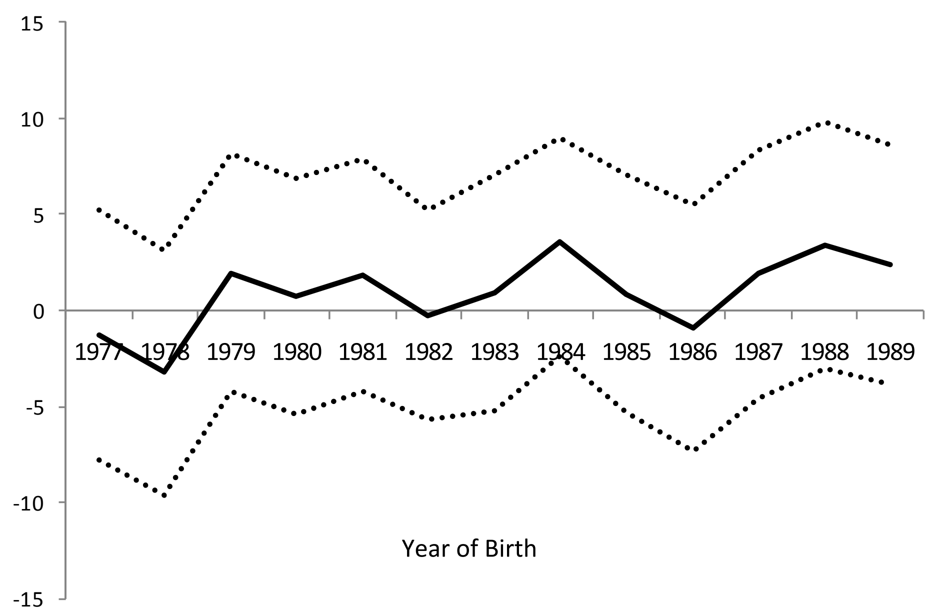
Note: The x-axis shows the time in years. The vertical lines in 2000 and 2007 correspond the years IFLS measures the outcome of interest (i.e., cognition) and the diagonal lines identify different cohorts. The red diagonal line refers to the cohorts born during the program expansion (1990-1996). The blue diagonal line refers to cohorts born prior to program expansion (1983-1989). The green line refers to the cohorts born in 1976-1982.

Figure 4A. Coefficients of the Interactions Program Availability in the Community by 1997*Birth Year (Cohorts born 1983 to 1996) in Cognition Equation



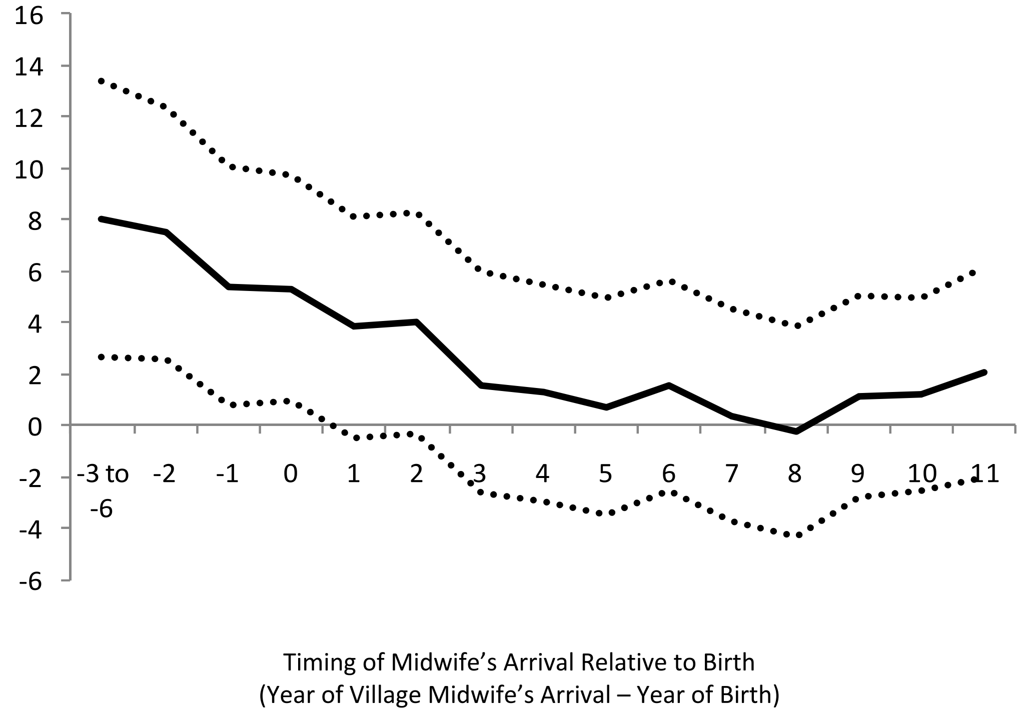
Note: The *y* axis plots the birth year-specific coefficients (in solid line) based on the interactions of program availability in the community with birth year dummies (1984 to 1996), plus the 95% confidence intervals (dashed lines). The *x*-axis refers to the birth year. The sample consists of cohorts born 1983 to 1996 measured at age 11 to 17.

Figure 4B. Coefficients of the Interactions Program Availability in the Community by 1997*Birth Year (Cohorts born 1976 to 1989) in Cognition Equation



Note: The *y* axis plots the birth year-specific coefficients (in solid line) based on the interactions of program availability in the community with birth year dummies (1977 to 1989), plus the 95% confidence intervals (dashed lines). The *x*-axis refers to the birth year. The sample consists of cohorts born 1976 to 1989 measured at age 18 to 24.

Figure 5. Coefficients of the Intensity of Exposure to Safe Motherhood Program in the Cognitive Test Score Equation (Cohorts born 1983 to 1996)



Note: The y-axis plots the coefficients for the intensity of exposure to the program, plus the 95% confidence intervals (dashed lines). The x-axis corresponds to age of the child when the village midwife arrived to the program. Negative numbers refer to the years when the village midwife arrived prior to child’s birth (for instance, -3 to -6 means the village midwife arrived 3 to 6 years prior to child’s birth). The sample consists of cohorts born 1983 to 1996 measured at age 11 to 17.