Fertility Responses to Prevention of Mother-to-Child Transmission of HIV *

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Abstract

Prevention of mother-to-child transmission (PMTCT) interventions reduce the cumulative probability of transmission from a HIV positive woman to her child by as much as 40 percentage points. This paper is the first economic analysis of the behavioral effects of PMTCT. I examine fertility responses to the scale-up of PMTCT in Zambia, a country where approximately 15 percent of adults age 15-49 are HIV positive. My results suggest that the local introduction of PMTCT reduced pregnancy rates by up to 20 percent, that the fertility response was greater among women who were more likely to be HIV positive, and that PMTCT substantially increased breastfeeding rates.

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1 Introduction

Prevention of mother-to-child transmission (PMTCT) interventions are a highly effective method of preventing new HIV infections. Approximately 10 percent of new HIV infections occur through mother-to-child transmission (De Cock et al 2000). A HIV positive woman may transmit the disease in utero, during childbirth, or to a child while breastfeeding. PMTCT reduces the cumulative probability of transmission from as much as 45 percent in the absence of PMTCT to as little as 3 percent (Dabis and Ekpini 2002, Canning 2006).

In the past decade, Zambia has dramatically expanded access to subsidized PMTCT at antenatal clinics.[1] The number of hospitals and clinics offering PMTCT has risen from fewer than 6 sites in 2000 to nearly 600 sites (or roughly 40 percent of health sites) by the end of 2007. Although the medical effects of PMTCT in this setting are well-documented (e.g., Stringer et al 2003, Stringer et al 2005), there is little research on the behavioral effects of this expansion.

This paper examines fertility responses to PMTCT scale-up in Zambia. In a country where more than 15 percent of adults age 15-49 are HIV positive, the availability of PMTCT changes the incentives women and couples face in their fertility decisions. However, the theoretical prediction about the sign of the effect of PMTCT on fertility is unclear. PMTCT may increase fertility because decreasing the probability that a child is born HIV positive means that the child will require fewer health inputs while alive and is likely to be more productive. Conversely, PMTCT may decrease fertility because it increases the expected return to household investment in children's human capital, which in turn likely causes households to substitute child quality for quantity. Aside from the effects on the shadow prices of child quantity and child quality, PMTCT may decrease fertility by reducing the need for replacement and precautionary fertility.

In addition to the sign of the theoretical prediction being ambiguous, there is little reliable empirical evidence on this question. There are several economic analyses of the effects of the spread of HIV/AIDS on fertility, human capital investment, and economic growth (e.g., Young 2005, Young 2007, Ahuja et al 2008, Fink and Linnemayr 2009, Fortson 2009, Juhn et al 2009, Fortson 2010, Kalemli-Ozcan and Turan 2010, Kalemli-Ozcan 2010), but it is far from obvious that PMTCT should simply reverse many of these effects. One major difference between the rise of HIV/AIDS and the introduction of PMTCT is that the HIV/AIDS pandemic affects child and adult mortality (and life expectancy), whereas PMTCT only directly affects child mortality.[2]

[1] The Zambian experience roughly parallels estimates of the broader scale-up in the developing world. For example, in 2005, just 15 percent of HIV positive pregnant women received PMTCT, whereas 45 percent received PMTCT in 2008, and 53 percent received PMTCT in 2010 (WHO 2010a).

[2] PMTCT may indirectly affect adult mortality. In a high maternal mortality environment, changes in pregnancy rates induced by PMTCT availability should affect adult female mortality. Similarly, in a high HIV prevalence environment, changes in pregnancy-seeking behavior (i.e., unprotected sex) induced by PMTCT availability should affect adult mortality.

The rapid expansion of PMTCT in Zambia provides quasi-experimental evidence on the effect of PMTCT on fertility. I augment the Japanese International Cooperation Agency 2006 Health Facilities Census, which includes the GPS coordinates of each health facility in Zambia, with newly assembled data on the month and year each facility began offering PMTCT. Data on reproductive behavior and fertility outcomes come from repeated nationally representative cross-sectional household surveys conducted before, during, and after the scale-up, where each survey year includes respondents from multiple interview months. Combined with detailed geographic information on the location of survey households, I use these data to measure how reproductive behavior changes when PMTCT is introduced at a local health clinic. Multiple rounds of survey data before the introduction of PMTCT, as well as multiple rounds after the introduction PMTCT, mean that I am able to identify the effect of PMTCT on fertility while controlling for unobserved time-invariant characteristics of locations receiving PMTCT and differential trends between PMTCT and non-PMTCT locations.

I find evidence that the local introduction of PMTCT reduced pregnancy rates. Although the estimated average effect is not robust to the full set of controls, my point estimates suggest that local PMTCT availability reduced pregnancy rates by roughly 3 percentage points, or 10 percent relative to the mean pregnancy rate. An analysis of the the heterogenous effects of PMTCT availability indicates that the fertility reduction was concentrated among women who were more likely to be HIV positive, among women in their main childbearing years, and among women who had completed secondary school. I also find that local PMTCT availability increased breastfeeding rates, an important input into child quality, by roughly 15 percentage points.[3] An event study analysis suggests the absence of a pre-local introduction "effect" and that the medium term response to local PMTCT introduction was larger than the short term response.

In further support of a causal interpretation of these results, I find that the local introduction of PMTCT substantially increased awareness of PMTCT and reduced under-1 child mortality by approximately 4 percentage points. Similarly, my child mortality estimates are not far from a back-of-the-envelope calculation of pediatric HIV/AIDS mortality. According to the 2007 DHS, HIV prevalence among pregnant women is approximately 14 percent. In the absence of PMTCT, a mother-to-child transmission (MTCT) probability of between 25-50 percent implies that approximately 3.5-7 percent of children are born HIV+. Estimates indicate that between 25 and 50 percent of HIV positive infants in this setting die by age one (Spira et al 1999, Taha et al 1999, Dabis et al 2001, Brahmbhatt et al 2001).

[3]This is consistent with the predictions of a quantity-quality model, in which a decrease in child quantity should be associated with an increase in child quality. However, there exist at least two alternative interpretations. First, the increase in breastfeeding could be a response to the decreased risk of infecting one's child through breastfeeding. Second, widespread use of lactational amenorrhea as a contraceptive method in the developing world means that breastfeeding may simply be the mechanism by which women are decreasing pregnancy rates.

To the best of my knowledge, this paper is the first economic analysis of the behavioral response to PMTCT, arguably the single most effective prevention intervention in existence.[4] However, this paper contributes to the literature on fertility responses to changes in child mortality risk (e.g., Ben-Porath 1976, Wolpin 1984, Sah 1991, Soares 2005, Hossain et al 2007, Angeles 2010, Lucas 2010). Similarly, the current analysis contributes to a broader economic literature on the behavioral responses to changes in reproductive technology (e.g., Donohue and Levitt 2001, Pop-Eleches 2006, Portner 2010, Valente 2011).

The paper is organized as follows. Section 2 describes the transmission of HIV from mother-to-child in Zambia, the medical effects of PMTCT, and the expansion of PMTCT in Zambia. Section 3 provides a conceptual framework for thinking about the behavioral response to PMTCT scale-up. Section 4 describes the household survey and health facilities census data. Section 5 explains the empirical strategy I use to identify the fertility response to PMTCT scale-up. Section 6 presents the results. Section 7 concludes.

2 Prevention of mother-to-child transmission

2.1 MTCT and PMTCT clinical facts

Mother-to-child transmission (MTCT) of HIV is one of the primary sources of new HIV infections. Approximately 10 percent of new HIV infections are due to MTCT (De Cock et al 2000). During the first decade of the twenty-first century, there were roughly 400,000 to 500,000 new perinatal and infant HIV infections each year (UNAIDS 2010). The vast majority of mother-to-child transmission is in Sub-Saharan Africa. More than 90 percent of pediatric HIV infections and 94 percent of pediatric AIDS deaths occur in this region (Foster and Williamson 2000).

Among pregnant women who are HIV positive, the likelihood of transmission of HIV in the absence of PMTCT is quite high. There are three ways in which a HIV positive woman may transmit the virus to her child: in utero, during childbirth, and through breastfeeding. The cumulative probability of transmission in the absence of PMTCT is between 25 and 45 percent (Dabis and Ekpini 2002).

Children who acquire HIV from their mother are very likely to die before reaching age five.[5]

[4] Theoretically, abstaining from sexual activity may be as or more effective. However, aside from small population sub-groups, individuals appear to be highly unlikely to abstain from sexual activity for the entire course of their lives.

[5] Mother-to-child transmission of HIV is not the only way in which having a HIV positive mother increases the probability of child death. Maternal mortality due to HIV/AIDS further reduces the resources available to poor households in poor countries. Consistent with this burden, in a longitudinal study in Rakai, Uganda, Brahmbhatt et al (2003) find under-2 child mortality rates of 166 per 1000 for HIV negative children of HIV positive mothers, compared to 128 per 1000 for HIV negative children of HIV negative mothers. However, mother-to-child transmission appears to be the largest effect, with a under-2 child mortality rate of 547 per 1000 for HIV positive children of HIV positive mothers.

Between 25 and 50 percent of HIV positive infants die by age 1. Similarly, between 35 and 60 percent of HIV positive infants die by age 2 (Spira et al 1999, Taha et al 1999, Dabis et al 2001, Brahmbhatt et al 2001).[6]

Prevention of mother-to-child transmission (PTMCT) interventions consist of giving women and infants antiretrovirals (ARVs) similar to those provided to HIV positive adults. World Health Organization (WHO) guidelines recommend azidothymidine (AZT) as part of a multiple-drug combination therapy (including nevirapine (NVP)) for mothers and infants (WHO 2006). Meta-analyses indicate that PMTCT reduces the cumulative probability of transmission from as much as 45 percent in the absence of PMTCT to as little as 3 percent (Dabis and Ekpini 2002, Canning 2006).

Implementation in Zambia appears to differ somewhat, most likely because of resource constraints.[7] Stringer et al (2003) and Stringer et al (2005) report that standard practice in the capital district, Lusaka, is to provide a dose of NVP to pregnant woman at time of diagnosis of being HIV positive, another dose with instruction to take at onset of labor, and a third dose (i.e., NVP syrup) to the infant prior to release from a health facility or to be administered by the mother at home if the birth is not at a health facility. This approach is roughly similar to that in much of the of the developing world: among HIV positive pregnant women receiving PMTCT in low- and middle-income countries in 2007, 49 percent received "single-dose" NVP (WHO 2010a).[8]

2.2 PMTCT scale-up

As part of The United States President's Emergency Plan for AIDS Relief (PEPFAR) and in conjunction with the Global Fund to Fight AIDS, Tuberculosis, and Malaria and other partners, access to PMTCT expanded across much of Sub-Saharan Africa during the past decade. For example, 15 percent of HIV positive pregnant women in Sub-Saharan received PMTCT in 2005, whereas 45 percent received PMTCT in 2008, and 54 percent received PMTCT in 2010 (WHO 2010a).

Zambia, a PEPAR focus country, has been a major participant in this expansion. As shown in Figure 1, between the start of 2000 and the end of 2007, the number of health facilities in Zambia offering PMTCT increased from fewer than 6 to nearly 600.[9] Not only was this a large increase in absolute terms, but the facilities coverage rate increased substantially as well. At the end of this

[6] Even in the absence of acquiring HIV/AIDS, child mortality in Zambia is high. Overall, the neonatal mortality rate in Zambia is 36 per 1,000 live births, the under-1 infant mortality rate is 92 per 1,000 live births, and the under-5 child mortality rate is 148 per 1,000 live births. HIV/AIDS accounts for 12% of under-5 mortality in Zambia (WHO 2010b).

[7] Consistent with this explanation, Skordis and Nattrass (2002) show that single-dose nevirapine for mother and child is more cost-effective than using a longer regimen of zidovudine (i.e., AZT).

[8] "Single-dose" means a single drug, instead of a combination therapy (i.e., "ARV cocktail"). The three-stage NVP treatment in Zambia is "single-dose".

[9] The data used to create Figures 1 and 2 are discussed in more detail in Section 4.

period, approximately 40 percent of health facilities in Zambia offered PMTCT.

PMTCT expansion was not distributed evenly across Zambia. Figure 2 shows the expansion of PMTCT in Zambia by year of introduction, as well as the district-level population density and the main transportation routes. The initial round of PMTCT expansion was concentrated in the three largest urban areas in Zambia (Lusaka, Kitwe, and Ndola), as well as in urban and peri-urban areas in Southern Province. Subsequent rounds of expansion continued in these areas, in other urban areas, and in rural areas along the main road network.

The vast majority of pregnant women in Zambia visit an antenatal clinic at least once during their pregnancy, helping ensure that the scale-up of access to PMTCT translated into use of PMTCT.[10] Among the respondents in the nationally representative survey data used in the current analysis, more than 93 percent of women who report being pregnant at any point during the twelve months prior to the survey date reported at least one visit to an antenatal clinic during that pregnancy. Perhaps surprisingly, this probability is remarkably flat across the survey rounds, varying no more than two percentage points between any two years among the four survey rounds (i.e., 2001, 2003, 2005, and 2007). Similarly, the likelihood of visiting an antenatal clinic at least once during pregnancy is greater than 90 percent in urban areas and greater than 90 percent in rural areas. As of 2007, the modal visit to an antenatal clinic occurred during the fourth to fifth month of pregnancy (Central Statistical Office et al 2009).

Although most pregnant women visit an antenatal clinic, there are two additional possible constraints to ensuring effective PMTCT coverage. First, most births occur at home and not in a health facility. For example, in the 2007 Demographic Health Survey (DHS), 52 percent of births during the five years proceeding the survey date occurred in the home (Central Statistical Office et al 2009). However, nevirapine (NVP) is provided to pregnant women upon diagnosis to be taken at home at the onset of labor and during the first few weeks of breastfeeding (Stringer et al 2003, Stringer et al 2005). Thus, home births do not appear to be a major constraint unless adherence is low among pregnant women conditional on receiving the NVP to be taken at home.

Second, evidence from Goldstein et al (2010) on the effect of health worker absence on HIV/AIDS-related antenatal care in a clinic in Kenya suggests that health worker absence may be an important constraint in Zambia. Although there do not appear to be data on health worker absence in Zambia antenatal clinics, there is nationally representative information on HIV testing during antenatal clinic visits. Among female respondents in the 2003 Zambia Sexual Behavior Survey (ZSBS) re-

[10] PEPFAR (http://www.pepfar.gov/countries/zambia/index.htm) reports that 66,400 HIV-positive pregnant women received PMTCT through PEPFAR funding during 2010. With a population of approximately 12 million individuals, half of whom are between the ages of 15 and 49, and a further subset of 50 percent are women, there are roughly 3 million women of childbearing age. With a pregnancy rate of approximately 0.31 and HIV prevalence of 14 percent among pregnant women, this indicates an individual-level PMTCT coverage rate through PEPFAR of approximately 5 percent. The existence of non-PEPFAR funded PMTCT programs means that the total individual-level PMTCT coverage rate is above 5 percent.

porting an antenatal clinic visit during a pregnancy in the twelve months proceeding the survey date, 15 percent report being offered a HIV test during the visit and 45 percent of these report accepting the HIV test. By the 2005 ZSBS, these figures had increased to 27 percent and 60 percent, respectively. In the 2007 Demographic Health Survey (DHS), 64 percent of women received a HIV test during an antenatal clinic.

The rapid increase in the proportion of women receiving a HIV test at an antenatal clinic visit, combined with the relatively high acceptance rate, indicates that the physical expansion of PMTCT generated a large increase in effective coverage of HIV positive pregnant women and at-risk infants. UNICEF (2010) reports that 20 percent of HIV positive pregnant women in Zambia received PMTCT in 2004 and 8 percent of infants born to HIV positive women received PMTCT at birth. By 2007, these proportions had increased to 52 percent and 23 percent, respectively. An individual coverage rate that is higher than the facilities coverage rate is consistent with the higher population densities in the locations that were more likely to receive PMTCT (i.e., urban areas).

During this period, Zambia also dramatically expanded access to antiretroviral therapy (ART) for adults and to voluntary counseling and testing (VCT).[11] Table 1 shows the hierarchy of HIV/AIDS service expansion. Relative costs appear to be a major determinant of the hierarchy of expansion. VCT expansion slightly outpaced PMTCT expansion and ART expansion expansion lagged well behind PMTCT. For example, by the end of 2007, approximately 47 percent, 42 percent, and 21 percent of health facilities offered VCT, PMTCT, and ART, respectively. Among the 582 PMTCT sites open by the end of 2007, more than 49 percent offered ART and nearly 95 percent offered VCT.

3 Conceptual framework

3.1 Mechanisms

Prevention of mother-to-child transmission (PMTCT) interventions reduce the likelihood of a HIV positive woman transmitting HIV in utero, during childbirth, or to her child through breastfeeding. PMTCT reduces the cumulative probability from between 25-45 percent in the absence of PMTCT to as little as 3 percent (Dabis and Ekpini 2002, Canning 2006). Between 25 and 50 percent of HIV positive children die by age 1 and between 35 to 60 percent of HIV positive children die by age 2 (Spira et al 1999, Taha et al 1999, Dabis et al 2001, Brahmbhatt et al 2001). Thus, PMTCT should increase life expectancy at birth for children born to HIV positive mothers, conditional on fertility seeking behavior and child human capital investment behavior remaining unchanged.

[11] Although access to the three main HIV/AIDS services increased rapidly during this period, access to and/or the quality of non-HIV/AIDS related care may have decreased. Case and Paxson (2011) show that the rise of the HIV/AIDS pandemic led to a decline in the quality of general health care in Sub-Saharan Africa.

A simple quantity-quality model of fertility and household investment in children's human capital (Becker and Lewis 1976) generates an ambiguous prediction about the net effect of PMTCT on fertility. The decrease in child mortality caused by PMTCT reduces the cost of child quantity. That is, PMTCT reduces the number of births the household requires to achieve a given number of surviving children. Thus, PMTCT reduces the price of child quantity, leading to an increase in fertility.

Conversely, PMTCT means that infants are more likely to live on to older ages. This increases the expected return to household investments in child quality, or in other words, reduces the price of child quality. This should lead to an increase in the quality of children and, under the quantity-quality tradeoff in this model, reduce the quantity of children, leading to a decrease in fertility.

Not only does PMTCT change the shadow prices of child quantity and child quality, but PMTCT also reduces the need for replacement fertility. Because PMTCT reduces child mortality, PMTCT will reduce fertility because the household will need to "replace" fewer births (i.e., births that result in child death).[12] Thus, even holding the shadow prices of child quantity and child quality constant, we would still expect PMTCT to affect fertility.

In addition to reducing the likelihood of mother-to-child transmission, receiving PMTCT may provide information to pregnant women about their HIV status. To receive PMTCT, a pregnant woman must test HIV positive. After receiving the result of this test, she may revise her belief about her HIV status. Although evidence on the behavioral response to learning one's HIV status is mixed, the change in her beliefs may change her subsequent reproductive decisions.

3.2 Timing

To understand the timing of the fertility response to the local introduction of PMTCT, consider the following timeline. Let t denote the month at which a woman is surveyed about her pregnancy status during the twelve months leading up to the interview date, inclusive. For women who report being pregnant at some point between t and $t-11$, the likely range of possible conception dates is $t-1$ to $t-20$. Assuming individuals are perfectly informed about local PMTCT availability on the date that it is introduced, the local introduction of PTMCT by period $t-2$ or before may affect

[12] Doepke (2005) examines "replacement fertility" (i.e., a mechanism where households increase fertility ex post in response to child mortality when birth choice is sequential) and "hoarding" (or precautionary fertility) (i.e., a mechanism where households increase fertility ex ante in response to expected child mortality). Doepke (2005) demonstrates that because households may accidentally have "too many" children if realized child mortality is low, replacement fertility dominates precautionary fertility as a fertility strategy in the face of child mortality. In contrast, Ben-Porath (1976) notes that hoarding (or precautionary fertility) may be important if there exists substantial risk of child mortality after a woman's childbearing years are over (e.g., if children are likely to die as adults). Because HIV positive infants die with high probability within two years, whereas mortality rates among adults who acquire HIV do not begin to rise until 8-10 years after the infection date, the main risk of child mortality appears to be during the woman's childbearing years.

fertility behavior as measured at period t.

If conceptions are evenly distributed across months, then the representative pregnancy measured during the interval t to $t-11$ would have begun in approximately period $t-10$. That is, the representative pregnancy would have been conceived midway through the possible conception interval, $t-1$ to $t-20$. Assuming individuals are not changing their fertility behavior in anticipation of the local introduction of PMTCT, this suggests that we are unlikely to see an effect of local PMTCT availability on pregnancy rates that are measured during the interval t to $t-11$ until PMTCT has been locally available for approximately 11 months.

The lag between local PMTCT introduction and the fertility response may be even greater than this. PMTCT may affect fertility not just through decreased risk of death of future births, but also through decreased mortality among recent births. Under this latter mechanism, a decrease in pregnancy, either through lactational amenorrhea due to breastfeeding a child who is still alive or through a decrease in replacement fertility, would take longer to appear.

4 Data

4.1 Individual-level data

Data on fertility come from the 2001 and 2007 Zambia Demographic Health Surveys (DHS) and the 2003 and 2005 Zambia Sexual Behavior Surveys (ZSBS). These are repeated cross-sectional nationally representative household surveys. Administrative records on the primary sampling units in these surveys allows me to calculate the approximate latitude and longitude of each survey household.[13] This process yields 7,683 adult females (i.e., ages 15-49) in the 2001 DHS, 2,296 adult females in the 2003 ZSBS, 2,072 adult females in the 2005 ZBS, and 7,146 adult females in the 2007 DHS.[14]

[13]The nature of the spatial information in these surveys likely introduces bias toward zero in the estimates of the fertility response to local PMTCT availability. For the ZSBS and the 2001 DHS, I use information on the respondent's Standard Enumeration Area (SEA) of residence to define the precise location of the respondent as the centroid of this SEA. These administrative units were designed to capture approximately 1,000 individuals, so although they tend to be quite small in urban areas they may be relatively large in rural areas. The 2007 DHS contains slightly different spatial information. Instead of revealing the respondent's SEA of residence, the 2007 DHS provides GPS data points that are intentionally measured with error for each respondent to address privacy concerns associated with the HIV testing module in this DHS. In the Zambia 2007 DHS, these data points were generated by adding a random vector with length drawn from a uniform distribution on 0 to 10 kilometers to the latitude and longitude of the centroid of the SEA of residence.

[14]The digitized census map provided by the Zambia Central Statistical Office, which I use to identify the location of the primary sampling units for the respondents in the 2001-2005 survey rounds, is missing approximately seven percent of the Statistical Enumeration Areas (SEAs) in Zambia. Thus, I am unable to identify the precise location of approximately seven percent of the 2001-2005 survey respondents and exclude these respondents from the empirical analysis.

The main fertility measure I use in this analysis is an indicator variable for whether the female respondent reported being pregnant in the twelve months leading up to the survey date. I also use three measures of child mortality: neonatal (i.e., one month or younger) mortality, under-1 (i.e., 12 months or younger) mortality, and under-2 (i.e., 24 months or younger) mortality. Mortality data come from the birth history module in the DHS and provide retrospective data on child mortality. To augment the fertility and mortality outcomes, I examine knowledge about the existence of PMTCT and I examine breastfeeding behavior among women with children age 24 months or younger.

Table 2 reports the age profiles among the DHS and ZSBS respondents for several of the key variables in this analysis. Several important facts emerge from this analysis. First, the main childbearing ages in Zambia are ages 20-29 and, to a slightly lesser extent, ages 30-39. Second, as in most high HIV prevalence countries, the HIV prevalence-age profile takes an inverted U-shape and peaks among ages 30-39. Third, under-1 mortality, knowledge about mother-to-child transmission (MTCT), and knowledge about PMTCT remain relatively flat across age groups, although the youngest women are somewhat less informed than women at older ages.

Table 2 also illustrates how these key variables vary by the education level of the respondents. More educated women have fewer children and their children are less likely to die by age 1, despite the fact that more educated women are more likely to be HIV positive. Perhaps not surprisingly, more educated women are more likely to know about mother-to-child transmission and (MTCT) and about PMTCT. They are also less likely to breastfeed their children, possibly because they are more aware of the increased risk HIV transmission. However, more educated women may also have a higher time cost of breastfeeding and have better access to nutritional inputs for their children outside of breastfeeding.

In Table 3, I provide mean characteristics of respondents residing in locations that ever received PMTCT and in locations that never received PMTCT. Partly because of the non-random placement of PMTCT sites, respondents in locations receiving PMTCT appear to be more educated, less likely to be married, and more likely to be HIV positive. They also have lower levels of fertility and greater knowledge about PMTCT.

4.2 Health facilities data

I collected retrospective data on the month and year each health facility began offering each of the three main HIV/AIDS services: PMTCT, antiretroviral therapy (ART), and voluntary counseling and testing (VCT). The 2006 Japanese International Cooperation Agency (JICA) Health Facility Census (HFC) surveyed each health clinic and hospital in Zambia and recorded the exact latitude and longitude of each health site. To augment these data, I arranged for each clinic to be re-surveyed to provide information on the month and year (if any) it began offering each of the three

main HIV/AIDS services. This process effectively began in June of 2008 so this retrospective panel provides comprehensive information on the expansion of HIV/AIDS services in Zambia through the middle of 2008.[15]

5 Empirical strategy

The main empirical strategy in this paper is to measure the change in fertility associated with the local introduction of PMTCT while controlling for a host of time and geographic fixed effects and linear trends. To implement this strategy, I use the detailed spatial information in the JICA 2006 HFC and the household survey data to calculate the distance from each survey respondent to each health facility and measure fertility among respondents who reside near health facilities currently offering PMTCT. Because I have information on fertility in locations receiving PMTCT before they received PMTCT, I am able to control for unobservable characteristics (both time-invariant and time-varying) affecting fertility that are associated with the placement of PMTCT sites. PMTCT was not introduced everywhere simultaneously, so instead of including a "post" indicator as in a standard difference-in-differences specification I include year fixed effects interacted with month fixed effects. This controls for unobserved time-specific shocks to fertility. I also include district fixed effects to control for additional time-invariant spatial heterogeneity.[16]

Thus, the primary regression equation is:

$$fertility_{ijt} = \alpha_1 PMTCT_{ij(t-11)} + \alpha_2 PMTCTever_{ij} + X_{ijt}^{'}\Gamma + \eta_j + \delta_t + \epsilon_{ijt} \quad (1)$$

where $fertility_{ijt}$ denotes the reproductive behavior of female respondent i residing in district j in month t (e.g., January 2007), $PMTCT_{ij(t-11)}$ is an indicator variable equal to one if a health clinic offering PMTCT at least 11 months prior to the survey date is located near respondent i, $PMTCTever_{ij}$ is an indicator variable equal to one if a health clinic located near respondent i ever offered PMTCT even if it was subsequent to the interview date for respondent i, X_{ijt} is a vector of individual-level demographic controls, η_j are district fixed effects, and δ_t are month times year fixed effects. As in a standard difference-in-differences empirical strategy, I interpret α_1 as the causal effect of local PMTCT availability on fertility.[17]

[15] Service interruptions (e.g., because of ARV shortages or health worker absence) mean that PMTCT may not have been continuously available at all of these clinics from the local introduction date onward. However, this should only work against the regression analysis yielding any estimate effect of local PMTCT availability on pregnancy rates. The fact that I find a large and statistically significant effect suggests that the behavioral response to any service interruptions was not large enough to outweigh the effect of the documented service availability.

[16] This is a concern because I don't observe fertility before and after local PMTCT introduction in every location where I have household survey respondents. There are 72 districts in Zambia and the major urban areas are often their own district.

[17] In a difference-in-differences interpretation of this regression specification, $PMTCTijt$ is "treatment" interacted

There remain at least two major threats to identifying the causal effect of local PMTCT availability on fertility. First, PMTCT may have been introduced in locations that were following a different time trend than those locations that did not receive PMTCT.[18] To address this concern, in the majority of specifications I include district-specific linear time trends and a linear time trend for locations ever receiving PMTCT. Second, the expansion of ART and VCT may have been correlated with the expansion of PMTCT. Thus, in the majority of specifications I use information from the augmented-HFC to control for proximity to ART and VCT.[19]

I measure fertility using an indicator variable equal to one if the respondent reported being pregnant at some point during the twelve months prior to the survey month, inclusive. The representative location with PMTCT in Zambia received it around 2005. Birth spacing in Zambia is roughly 3 to 4 years. Thus, the representative woman exposed to PMTCT in Zambia only faced one (or fewer) likely births after the local introduction of PMTCT. Because very few women were at risk of having more than one birth during this period, I focus on pregnancy rates as my primary measure of fertility behavior.

The baseline specification defines a respondent as being near a health clinic if the respondent lives within 10 kilometers of the nearest health clinic. In an analysis of the correlates of maternal health care usage in Kalabo District in Zambia, Stekelenburg et al (2004) find that usage rates decline substantially for women residing more than a two-hour walk (i.e., roughly 10 kilometers) from a maternal health care site. Similarly, female respondents in the 2007 DHS indicate that distance is one of the primary barriers to seeking health care (Central Statistical Office et al 2009).

6 Results

6.1 Effect of local PMTCT on fertility

The regression results suggest that the local introduction of PMTCT reduced pregnancy rates. Estimates of the effect of local PMTCT availability on pregnancy rates appear in Table 4. All specifications include district fixed effects and month times year fixed effects. In addition, all specifications include an indicator variable equal to one if a clinic within 10 kilometers of the respondent ever offered PMTCT. Standard errors are clustered by Standard Enumeration Area (SEA).

Column (1) presents the results from the baseline specification. The point estimate indicates

with "post", $PMTCTever_{ij}$ is the "treatment" indicator variable, and the month fixed effects interacted with the year fixed effects correspond to the standard "post" variable.

[18] The rural-urban difference in fertility trends during the period spanned by the household survey data support this hypothesis. Between 2001 and 2007, rural fertility increased from 6.9 births per woman to 7.5 births per woman, whereas urban fertility remained constant at 4.3 births per woman (Central Statistical Office et al 2009).

[19] In the specifications in which I control for ART and VCT availability, I include the ART (and VCT) analogues of $PMTCT_{ijt}$ and $PMTCTever_{ij}$.

that local PMTCT availability (i.e., at a clinic located within 10 kilometers of the respondent) reduced the likelihood that the respondent was pregnant by 4.6 percentage points. This effect is fairly large not only in absolute terms, but also in relative terms and is statistically significant at the 1 percent level. Compared to the mean pregnant rate of 0.31 in the entire sample, a 4.6 percentage point reduction corresponds to approximately a 15 percent reduction in pregnancy rates.[20]

In Column (2), I include district-specific linear time trends and a linear time trend for locations ever receiving PMTCT. This should address concerns that PMTCT locations and non-PMTCT locations may have been on different time trends prior to the local introduction of PMTCT. Although including these controls attenuates the coefficient estimate somewhat, it remains relatively large and statistically significant at the 5 percent level.

The coefficient estimate presented in Column (3) comes from a regression where I control for the availability of the two other main HIV/AIDS (i.e., voluntary counseling and testing (VCT) and antiretroviral therapy for adults (ART)). To do so, for each service I include an indicator variable equal to one if a clinic within 10 kilometers ever offered that service and an indicator variable equal to one if a clinic within 10 kilometers of the respondent offered that service at least eleven months prior to the respondent's interview date. The point estimate in Column (3) is somewhat smaller than that in the baseline specification and is statistically significant at the 10 percent level.

Finally, Column (4) reports the results from a regression that simultaneously includes the linear trends and the controls for the availability of the other main HIV/AIDS services. Using the full set of controls yields a point estimate that is roughly three-quarters the magnitude of the baseline estimate and is no longer statistically significant at conventional levels. In the regressions that follow, I include both sets of controls (i.e., the linear trend controls and the indicator variables for ART (and for VCT) ever available within 10 kilometers and for ART (and for VCT) available at least eleven months prior to the respondent's interview date).

6.2 Effect dynamics

The longitudinal dimension of these data enables several additional analyses that support a causal interpretation of the baseline results. Figure 3 provides an event study analysis of the effect of local PMTCT availability on pregnancy behavior. This figure plots the estimates of β_k from the following regression equation:

[20] An alternative explanation for the effect of local PMTCT availability on pregnancy is that PMTCT may be bundled with additional emphasis on family planning services. However, empirical evidence does not support this hypothesis. The 2001 and 2007 DHS ask respondents whether a health worker discussed family planning with the respondent during a visit during the twelve months leading up to the survey date. Using the same specification as in Column (1) of Table 4, regression results indicate that local PMTCT availability does not increase the likelihood a health worker discussed family planning with the respondent. In fact, the coefficient on local PMTCT availability is negative (i.e., -0.022), although statistically insignificant (i.e., p-value is 0.355). The lack of an effect of local PMTCT availability on family planning discussions is robust to including additional controls as in Column (4) of Table 4.

$$fertility_{ijt} = \sum_{k=-72}^{84} \beta_k 1(\tau_{ijt} = k) + \alpha PMTCTever_{ij} + X_{ijt}^{'}\Gamma + \eta_j + \delta_t$$
$$+t\mu_j + tPMTCTever_{ij} + S_{ijt}^{'}\Pi + \epsilon_{ijt} \quad (2)$$

where τ_{ijt} denotes the twelve (or eleven) month event window and is defined such that $\tau = 0$ for respondents surveyed 0 to 10 months after the local introduction of PMTCT, $\tau = 1$ for respondents surveyed 11 to 23 months after the local introduction of PMTCT, $\tau = 2$ for respondents surveyed 24 to 35 months after the local introduction of PMTCT, and so forth. For $\tau < 0$, respondents were surveyed prior to the local introduction of PMTCT. $t\mu_j$ and $tPMTCTever_{ij}$ are the district-specific trends and the linear trend for locations ever receiving PMTCT, respectively. $S_{ijt}^{'}$ is a vector of controls for the two other main HIV/AIDS services. Aside from the event study parameters, this specification is identical to the specification with the full set of controls in Table 4 (i.e., Column (4)).

The coefficient estimates plotted in Figure 3 are consistent with a causal interpretation of the baseline results.[21] There is no evidence of a pre-local introduction trend in fertility in locations ultimately receiving PMTCT. Furthermore, there is evidence of a clear downward trend in the point estimates that begins with the local introduction of PMTCT.

Table 5 continues this dynamic analysis by expanding the specification with the full set of controls in Table 4 (i.e., Column (4)) to allow the effect of local PMTCT availability to vary by the length of time it has been available. In particular, I allow for an additional effect of PMTCT on fertility in locations in which PMTCT has been available for at least thirty-six months. The coefficient estimates suggest that although fertility may respond in the short term, it is only after PMTCT has been available for at least thirty-six months that respondents demonstrate a statistically significant reduction in the likelihood of pregnancy. Moreover, the point estimates suggest that the medium term response is approximately twice as large as the short term response.

This finding is consistent with a reduction in replacement fertility, a mechanism that would generate a lagged response. However, the lagged response is also consistent with another channel by which PMTCT may affect fertility: lactational amenorrhea due to breastfeeding a child who is still alive. More generally, if social learning about PMTCT availability is important, then we might expect a larger response in the medium term than in the short term.

[21] This specification includes respondents in locations that never received PMTCT. A Wald test fails to reject the equality of the event study coefficients across this sample specification and a restricted sample specification which includes only those respondents in locations that received PMTCT by the end of the augmented HFC.

6.3 Heterogeneity by HIV prevalence

Presumably, women who are more likely to be HIV positive should demonstrate a greater fertility response to the local availability of PMTCT. Because the 2007 DHS is the only survey round that includes information on HIV status that is linked to information on fertility decisions, I cannot examine how the response varies by the respondents' actual HIV status. However, I can examine how it varies by HIV prevalence across demographic group as defined by the interaction of gender, five-year age group, and province of residence.[22]

Table 6 presents the results of a regression that allows the fertility response to vary by HIV prevalence among the respondent's demographic group. In particular, I examine whether women in demographic groups with HIV prevalence above the median level responded more strongly to the local availability of PMTCT. The results presented in Table 6 indicate that women who were more likely to be HIV positive reduced their fertility more in response to PMTCT availability. Respondents in demographic groups with HIV prevalence above the median level reduced their likelihood of being pregnant by 4.4 percentage points, an effect that is significant at the 10 percent level. In contrast, women in demographic groups with HIV prevalence below the median level did not demonstrate a statistically significant change in their pregnancy rate.

6.4 Heterogeneity by age

There are several reasons to think that women of different ages may have responded differently to the introduction of PMTCT. As shown in Table 2, fertility behavior varies substantially across age groups. Older women may be close to having completed their childbearing and hence may be unlikely to change their fertility behavior in response to the introduction of PMTCT. Similarly, older women may be less informed about recent developments in reproductive technology. Conversely, younger women are less likely to have ever had a child, less likely to have had a child die, and hence less likely to be at risk of engaging in replacement fertility.

To examine this question, I allow the effect of local PMTCT to vary by the age of the respondent. Table 7 presents the results from this regression. The omitted age category is age 15-19. The coefficient estimates suggest that the reduction in pregnancy rates was concentrated among women in their main childbearing years. Specifically, local PMTCT availability reduced pregnancy rates among women age 20-29 by approximately 4 percentage points (significant at the 5 percent level) and did not significantly reduce pregnancy rates among women in other age groups.

[22]There is substantial variation in HIV prevalence across age groups and provinces. For example, as shown in Table 2, HIV prevalence is approximately four times as high among women age 30-34 and 35-39 than among women age 15-19. Similarly, HIV prevalence in Lusaka Province is nearly three times as high as in Northern Province. In addition, aggregate HIV prevalence in Zambia has been relatively flat during the period 2001-07 (Central Statistical Office et al 2009).

Although this evidence may confound age and cohort effects, it appears that the local availability of PMTCT did not reduce fertility behavior by the same amount across the life cycle. Instead, it appears that the response was larger in the main childbearing years. One explanation for this finding is that these are the women who were most likely to have recently avoided transmission from mother-to-child because of the availability of PMTCT and hence had a lower need for replacement fertility. Another explanation is that these are the women who are most likely to have knowledge of PMTCT (see Table 2). However, women in the main childbearing years may have greater knowledge of PMTCT because they are more likely to be pregnant and hence may be more likely to have been exposed to PMTCT during an antenatal visit.

6.5 Heterogeneity by education

Table 8 explores whether the response to local PMTCT availability varied by education level. To do so, I interact the measure of PMTCT availability with indicator variables for completed primary schooling and for completed secondary schooling. The results indicate that women who have completed secondary school responded much more than did women with lower levels of schooling. The point estimates indicate that local PMTCT availability had no effect on pregnancy rates among women with less than secondary school completion. In contrast, local PMTCT availability reduced pregnancy rates among women who have completed secondary school by 5.2 percentage points, an effect that is statistically significant at the 10 percent level.

There are several possible explanations for the larger fertility response among more-educated women. First, more educated women may be more informed about or have better access to local PMTCT. The effect of local PMTCT availability on knowledge of PMTCT presented in the next sub-section is consistent with this interpretation. Second, more educated women may have better access to effective contraception. Among women with primary school completion or less, fewer than 38 percent report current contraceptive use (Central Statistical Office et al 2009). In contrast, more than 49 percent of women with secondary school completion report current contraceptive use and more than 57 percent of women with more than secondary school completion report current contraceptive use.

A third possible reason is that observed fertility among less educated women may be at a technological constraint, possibly because their optimal number of births is at or above a technological constraint rather than because of some unmet desire for contraception.[23] The rise of HIV/AIDS may not have affected their fertility (Fortson 2009) and the reduction in child mortality due to PMTCT may not either. Although it is difficult to determine whether less educated women in this setting truly are at a technological fertility constraint, fertility rates in this group are quite high on average. Among women without primary school completion in Zambia, the total fertility rate

[23]The biological maximum for fertility is one factor possibly determining a technological fertility constraint.

(TFR) is 8.2 (Central Statistical Office et al 2009).[24]

6.6 Effect of local PMTCT on knowledge of PMTCT

In addition to increasing access to PMTCT, local PMTCT availability may affect fertility behavior because it increases knowledge about PMTCT. The current analysis does not attempt to disaggregate the total effect of PMTCT on fertility decisions into these two effects (i.e., a price effect and a health information effect). Nonetheless, examining the effect of local PMTCT availability on knowledge about PMTCT provides complementary evidence on the main results presented thus far.

The first two columns of Table 9 investigate whether local PMTCT availability increased awareness of PMTCT and whether the awareness effect varied by the education level of the respondent. As shown in Table 2, more than 90 percent of female respondents know of mother-to-child transmission (MTCT). However, fewer than half of female respondents know of PMTCT.[25]

Local PMTCT availability appears to affect knowledge about PMTCT. The estimated effect presented in Column (1) of Table 9 indicates that local PMTCT availability increased the likelihood that a woman knows that it is possible to prevent mother-to-child transmission by 4.8 percentage points, an effect that is statistically significant at the 1 percent level. Column (2) allows the effect to vary by education level of the respondent. The results presented in Column (2) indicate that there was not a statistically significant effect for women who had less than secondary school completion and that there was a 10.2 percentage point increase among women who had completed secondary school (significant at the 1 percent level).

6.7 Effect of local PMTCT on breastfeeding

Avoiding breastfeeding reduces the probability of mother-to-child transmission (MTCT) by roughly 15-20 percentage points (Newell et al 2004). However, breastfeeding is an important nutritional input for infants, particularly in resource-constrained settings. Thus, current World Health Organization (WHO) guidelines recommend breastfeeding for women who have unknown HIV status and even for women who are known to be HIV positive (WHO 2009).

The next two columns in Table 9 explore the effect of local PMTCT availability on breastfeeding and whether the breastfeeding effect varied by the education level of the respondent. These regres-

[24]Bongaarts (1978) provides estimates of several measures of the biological fertility constraint. A TFR of 8.2 is within the range of estimates of the biological constraint after taking into account lactational infecundity (i.e., the "total natural marital fertility rate"). For high fertility countries (i.e., countries with a high rate of lactational infecundity due to repeated and lengthy breastfeeding spells), these estimates range from 7.0 and 11.0. The pure biological maximum (i.e., the "total fecundity rate") is between 13.0 and 17.5.

[25]The 2001 DHS does not ask respondents about knowledge of PMTCT, presumably because it was not yet readily available in Zambia. Because only 3 percent of respondents in 2003 reported knowledge of PMTCT, I treat knowledge of PMTCT in 2001 as zero.

sions use the child age 0-24 months as the unit of observation instead of the mother and restrict the sample of children to those born January 1999 or later.[26] The coefficient estimate in Column (3) indicates that local PMTCT availability increased the probability of breastfeeding for a child age 24 months or younger by approximately 17 percentage points, an effect that is significant at the 1 percent level.[27] The positive effect of local PMTCT availability on the likelihood of breastfeeding is consistent with the prophylactic effect of PMTCT dominating the information effect of PMTCT. That is, although local PMTCT availability may increase a pregnant woman's awareness of being HIV positive, receiving PMTCT reduces the risk of transmission associated with breastfeeding. As presented in Column (4), allowing the effect of PMTCT on breastfeeding to vary by the education level of the mother does not suggest that the effect was greater among more educated women.

6.8 Effect of local PMTCT on child mortality

The dramatic increase in PMTCT availability suggests we should observe a concurrent reduction in child mortality. Table 10 examines the effect of local PMTCT availability on neonatal mortality, under-1 child mortality, and under-2 child mortality. As with the breastfeeding regressions, these regressions use the child as the unit of observation instead of the mother and restrict the sample of children to those born January 1999 or later. The dependent variable in Columns (1), (2), and (3) is an indicator equal to one if the child died by 1 month of age, by 12 months of age, and by 24 months of age, respectively.

Throughout, the point estimates indicate that the local availability of PMTCT is associated with lower child mortality rates. For neonatal mortality and under-one year mortality, the local introduction of PMTCT reduces child mortality rates by between roughly 3 and 4 percentage points, effects that are statistically significant at the 1 percent level. Compared to the overall probabilities of 0.041 and 0.089 of child death by one month and age 1, respectively, the point estimates correspond to 68 and 45 percent reductions in child mortality rates. The local introduction of PMTCT is not associated with a statistically significant reduction in under-2 child mortality rates. However, the rapid onset of AIDS-related morbidity for infants born HIV positive means that HIV/AIDS-related mortality likely constitutes a smaller fraction of under-2 child death causes of death than at younger ages. In any case, the coefficient estimate is negative and not dramatically

[26]The median breastfeeding duration in Zambia is approximately 20 months (Central Statistical Office et al 2009).

[27]In an analysis of the effect of health worker absence at a single antenatal clinic in Western Kenya on health outcomes, Goldstein et al (2010) find that the presence of a PMTCT nurse when a pregnant woman visits an antenatal clinic is associated with no change in the probability of receiving PMTCT or in the probability of breastfeeding. However, among the subset of pregnant women who believe they are HIV positive the presence of a PMTCT nurse increases the probability they receive PMTCT by 7.4 percentage points and decreases the probability they breastfeed by 9 percentage points. The seemingly divergent effects documented in Goldstein et al (2010) and in the current analysis suggest that there is heterogeneity across locations in the advice and care that antenatal clinics provide clients.

different in magnitude from those in Columns (1) and (2), consistent with a large reduction in child mortality caused by the local introduction of PMTCT.

7 Conclusion

This paper examines fertility responses to a dramatic change in the availability of a critical reproductive technology, prevention of mother-to-child transmission of HIV (PMTCT), in one of the highest HIV prevalence and highest fertility countries in the world. I use three main sets of nationally representative data to estimate the causal effects of this country-wide expansion. First, data on reproductive behavior and child mortality before and after the local introduction of PMTCT come from four rounds of repeated cross-sectional nationally representative surveys. Second, the JICA 2006 Health Facilities Census provides the exact GPS coordinates of each hospital and health clinic in Zambia. Combined with relatively precise information on the latitude and longitude of each respondent in the survey data, I am able to calculate the distance from each respondent to each health facility. Third, I use newly assembled data for each health facility on the month and year it introduced PMTCT.

The quasi-experimental evidence I present in this paper suggests that PMTCT scale-up in Zambia generated a reduction in pregnancy rates for respondents residing near health facilities offering PMTCT. My estimates suggest that local PMTCT availability (i.e., at a clinic within 10 kilometers of a respondent) reduced the likelihood the respondent was pregnant by approximately 3 percentage points (i.e., roughly a 10 percent reduction). Larger estimated responses among women who were more likely to be HIV positive and in the medium term than in the short term support a causal interpretation of this estimated effect. Similarly, the estimated effect of local PMTCT availability on child mortality and a simple epidemiological calculation are consistent with the estimated fertility response to the local introduction of PMTCT. In addition to these findings, the results indicate that local PMTCT availability increased breastfeeding rates among infants (i.e., children ages 0-24 months) by more than 15 percentage points, suggesting that PMTCT generated increased investment in child quality.

These results indicate that the continued expansion of PMTCT in Sub-Saharan Africa may reduce pregnancy rates, as well as increase investments in child quality at a critical age. Because women and households likely will spend fewer resources in the pursuit of child quantity, this may release resources (including female labor) previously allocated to the production of child quantity for alternative uses. This suggests that PMTCT scale-up is not just a humanitarian success, but may also promote economic development and growth.

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Figure 1: PMTCT Availability in Zambia, 2000-2007

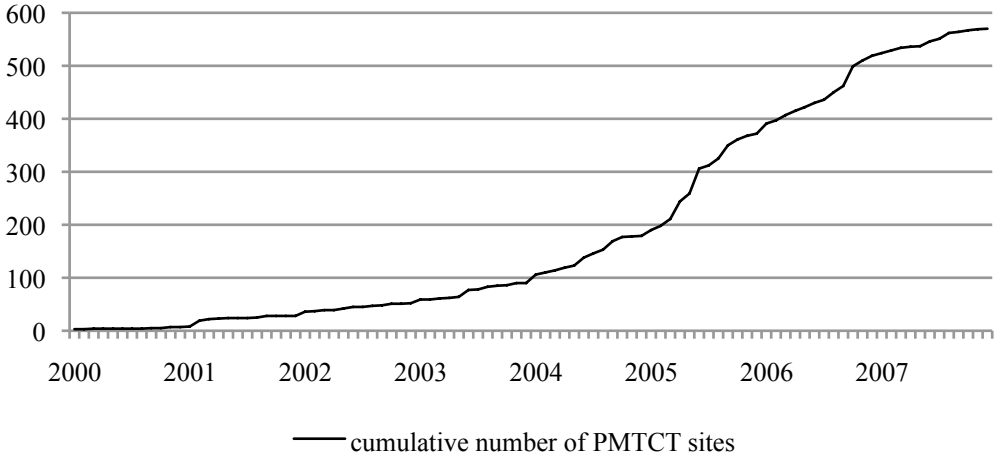

Figure 2: PMTCT Sites by Year of Service Initiation

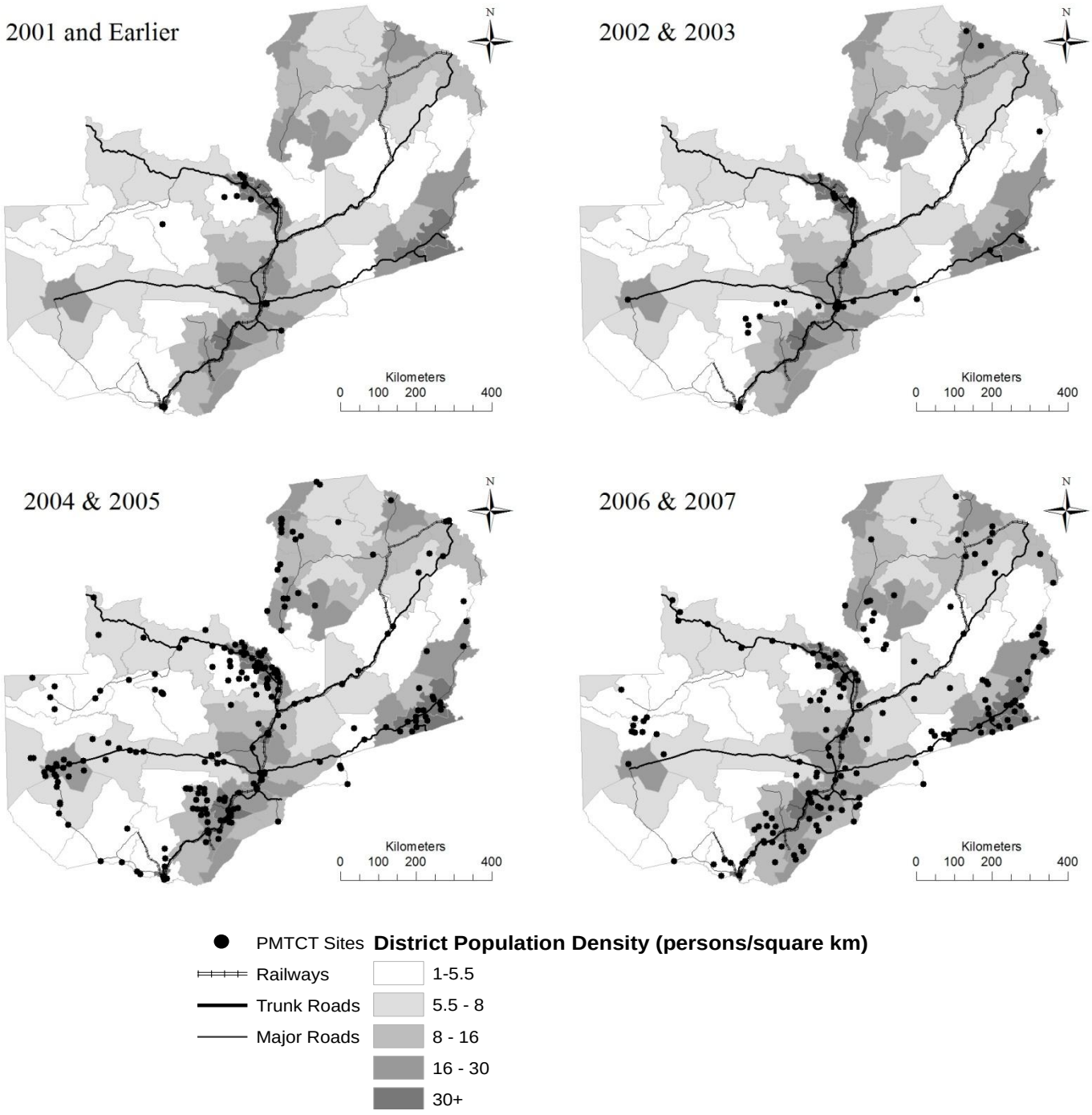

Figure 3: Event Study Analysis of Effect of Local PMTCT on Fertility

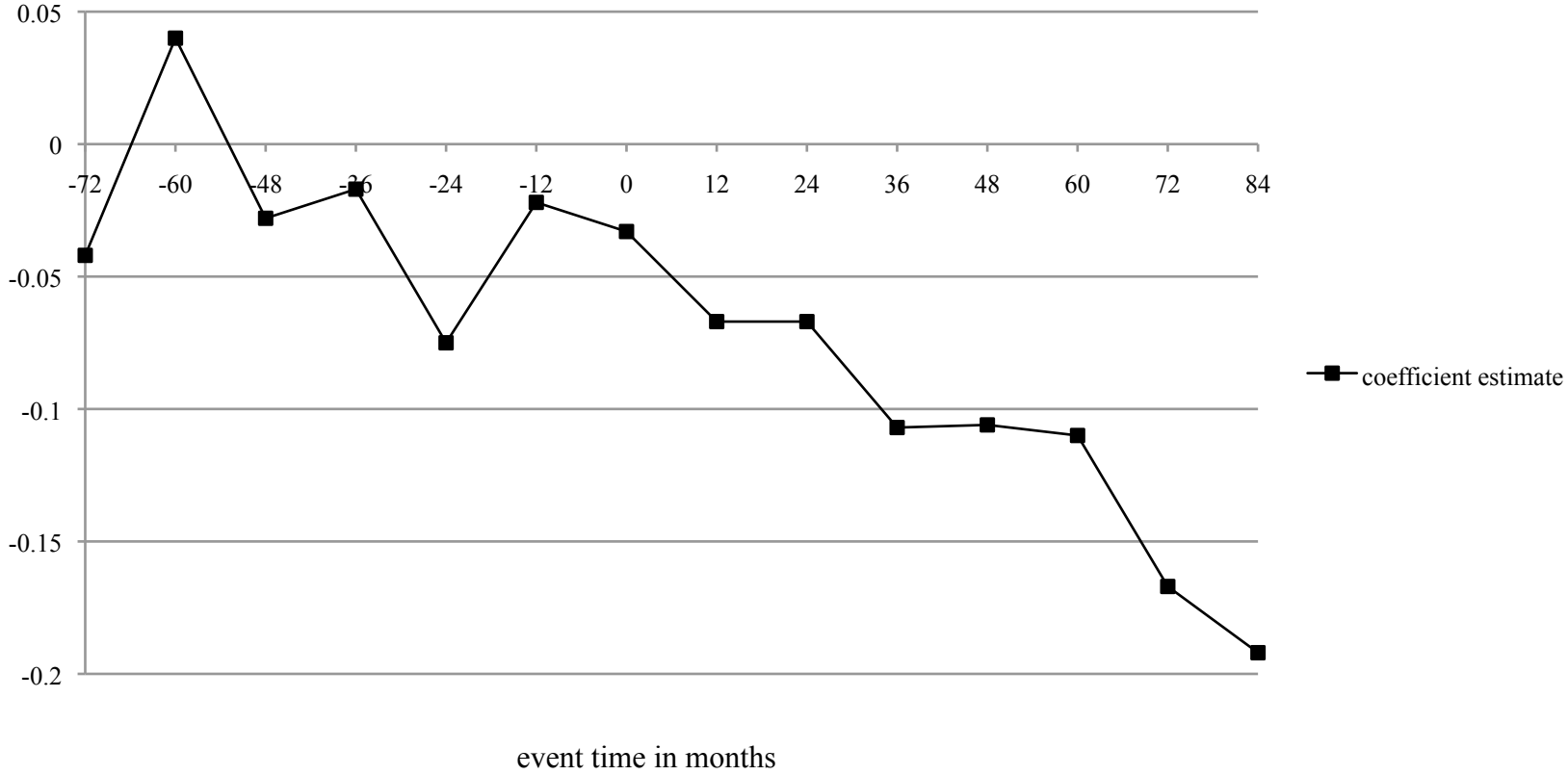

Table 1: Hierarchy of HIV/AIDS Service Expansion

	ART		PMTCT		VCT	
	number	percent	number	percent	number	percent
	(1)	(2)	(3)	(4)	(5)	(6)
December 2001:						
All health facilities	4	0.3	28	2.0	76	5.4
PMTCT sites	2	7.1	28	100.0	27	96.4
December 2003:						
All health facilities	43	3.1	90	6.4	187	13.4
PMTCT sites	35	38.9	90	100.0	84	93.3
December 2005:						
All health facilities	166	11.9	372	26.6	513	36.7
PMTCT sites	145	39.0	372	100.0	342	91.9
December 2007:						
All health facilities	300	21.4	582	41.6	661	47.2
PMTCT sites	287	49.3	582	100.0	551	94.7

Notes: Reports number and percentage of sites by end of year.
Data come from augmented JICA 2006 HFC.

Table 2: Mean Characteristics of Female DHS and ZSBS Respondents by Age and Education

	pregnant	number of children ever born	HIV positive	under-1 child death	know MTCT	know PMTCT	currently breastfeeding
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Age							
15-19	0.22	0.31	0.06	0.10	0.81	0.26	0.82
20-24	0.42	1.54	0.13	0.09	0.89	0.32	0.79
25-29	0.43	2.87	0.21	0.09	0.92	0.36	0.77
30-34	0.38	4.19	0.25	0.08	0.93	0.37	0.81
35-39	0.29	5.51	0.25	0.09	0.92	0.34	0.81
40-44	0.15	6.48	0.20	0.09	0.91	0.31	0.83
45-49	0.04	6.97	0.14	0.09	0.90	0.32	0.64
Education							
Did not complete primary	0.37	3.52	0.13	0.09	0.85	0.27	0.82
Completed primary school	0.27	2.71	0.20	0.08	0.93	0.37	0.78
Completed secondary school	0.24	2.08	0.22	0.07	0.92	0.41	0.67
All females	0.31	3.00	0.17	0.09	0.89	0.33	0.80
Observations	17,391	17,376	5,341	12,868	17,204	16,676	3,628

Notes: Pregnancy data come from the 2001 and 2007 DHS survey rounds and the 2003 and 2005 ZSBS survey rounds.
Number of children ever born and child mortality data come from the 2001 and 2007 DHS survey rounds.
HIV positive comes from HIV testing module in 2007 DHS.
Pregnant is an indicator variable equal to one if the respondent reported being pregnant at any time in the past twelve months.
HIV positive is an indicator variable equal to one if the respondent tested positive.
"Under-1 child death" is an indicator variable defined as one if a child died aged 1 or younger and defined as zero if a child aged 1 or younger has not died.
KnowMTCT is an indicator variable equal to one if the respondent knows that HIV may be transmitted from mother to child.
KnowPMTCT is an indicator variable equal to one if the respondent is aware that it is possible to prevent mother-to-child transmisison of HIV.
Currently breastfeeding is an indicator variable equal to one a child age 24 months or younger is currently breastfeeding.

Table 3: Mean Characteristics of Female DHS and ZSBS Respondents by Proximity to PMTCT Site

Sample:	within 10km of eventual PMTCT site	greater than 10km from eventual PMTCT site
	(1)	(2)
Panel A: Females age 15-49		
Age	27.5	28.3
Completed primary	0.64	0.37
Completed secondary	0.16	0.07
Married	0.57	0.66
Any partner	0.72	0.77
Sex in past month	0.58	0.60
Proportion unprotected sex	0.85	0.91
Pregnant	0.28	0.36
Number of children	2.74	3.40
HIV positive	0.20	0.11
Know PMTCT	0.37	0.25
Observations	10,315	7,077
Panel B: Children age 0-24 months		
Breastfeeding	0.72	0.82
Under-one month mortality	0.04	0.04
Under-1 mortality	0.08	0.10
Under-2 mortality	0.11	0.11
Observations	6,322	5,682

Notes: Data come from the 2001 and 2007 DHS survey rounds and the 2003 and 2005 ZSBS survey rounds.
Data on HIV status come from a single cross-section, the 2007 DHS.
Data on child mortality from the 2001 and 2007 DHS and are child-level data.

Table 4: Effect of Local PMTCT on Fertility

Dependent variable:	pregnant			
	(1)	(2)	(3)	(4)
PMTCT within 10km	-0.046***	-0.039**	-0.037*	-0.032
	(0.015)	(0.019)	(0.019)	(0.024)
Linear trends	NO	YES	NO	YES
Controls for other HIV/AIDS services	NO	NO	YES	YES
Observations	17,392	17,392	17,392	17,392

Notes: Data come from the 2001 and 2007 DHS survey rounds and the 2003 and 2005 ZSBS survey rounds.
Pregnant is an indicator variable for being pregnant sometime in the twelve months prior to the survey date, inclusive.
"PMTCT within 10km" is an indicator variable equal to one if a health clinic with 10 kilometers of the respondent offered PMTCT at least twelve months prior to the survey date.
All specifications include an indicator variable for whether PMTCT was ever introduced within 10km of the respondent.
All specifications include district fixed effects and month times year fixed effects.
Standard errors are in parentheses and are clustered by Standard Enumeration Area (SEA).
*** Significant at the 1 percent level, ** Significant at the 5 percent level, * Significant at the 10 percent level.

Table 5: Dynamic Effects of Local PMTCT on Fertility

Dependent variable:	pregnant
	(1)
PMTCT within 10km	-0.030
	(0.024)
PMTCT within 10km at least thirty-six months	-0.033
	(0.021)
P > F(PMTCT+PMTCT at least thirty-six months=0)	0.047
Observations	17,392

Notes: Data come from the 2001 and 2007 DHS survey rounds and the 2003 and 2005 ZSBS survey rounds.
Pregnant is an indicator variable for being pregnant sometime in the twelve months prior to the survey date, inclusive.
"PMTCT within 10km" is an indicator variable equal to one if a health clinic within 10 kilometers of the respondent offered PMTCT at least twelve months prior to the survey date.
"PMTCT within 10km at least thirty-six months" is an indicator variable equal to one if a health clinic within 10 kilometers of the respondent offered PMTCT at least thirty-six months prior to the survey date.
All specifications include an indicator variable for whether PMTCT was ever introduced within 10km of the respondent.
All specifications inlcude a secular linear trend and a separate linear trend for individuals residing with 10km of locations ever receiving PMTCT.
All specifications include controls for other HIV/AIDS services.
All specifications include district fixed effects and month times year fixed effects.
Standard errors are in parentheses and are clustered by Standard Enumeration Area (SEA).
*** Significant at the 1 percent level, ** Significant at the 5 percent level, * Significant at the 10 percent level.

Table 6: Heterogeneity by HIV Prevalence in Effect of Local PMTCT

Dependent variable:	pregnant
	(1)
PMTCT within 10km	-0.016
	(0.025)
PMTCT within 10km * HIV prevalence at median or above	-0.028*
	(0.015)
P > F(PMTCT+PMTCT*HIV prev=0)	0.072
Observations	17,390

Notes: Data come from the 2001 and 2007 DHS survey rounds and the 2003 and 2005 ZSBS survey rounds.
Pregnant is an indicator variable for being pregnant sometime in the twelve months prior to the survey date, inclusive.
"PMTCT within 10km" is an indicator variable equal to one if a health clinic within 10 kilometers of the respondent offered PMTCT at least twelve months prior to the survey date.
"HIV prevalence at median or above" is an indicator variable equal to one if HIV prevalence in the respondent's demographic group is equal to or greater than median HIV prevalence in Zambia, where demographic group is defined as the interaction betweeen five year age group and province of residence.
All specifications include an indicator variable for whether PMTCT was ever introduced within 10km of the respondent.
All specifications inlcude a secular linear trend and a separate linear trend for individuals residing with 10km of locations ever receiving PMTCT.
All specifications include controls for other HIV/AIDS services.
All specifications include district fixed effects and month times year fixed effects.
All specifications control for "HIV prevalence at median or above".
Standard errors are in parentheses and are clustered by Standard Enumeration Area (SEA).
*** Significant at the 1 percent level, ** Significant at the 5 percent level, * Significant at the 10 percent level.

Table 7: Heterogeneity by Age in Effect of Local PMTCT

Dependent variable:	pregnant
	(1)
PMTCT within 10km	-0.018
	(0.027)
PMTCT within 10km * age 20-29	-0.032*
	(0.019)
PMTCT within 10km * age 30-39	-0.016
	(0.021)
PMTCT within 10km * age 40-49	0.011
	(0.019)
P > F(PMTCT+PMTCT*age 20-29=0)	0.048
P > F(PMTCT+PMTCT*age 30-39=0)	0.229
P > F(PMTCT+PMTCT*age 40-49=0)	0.786
Observations	17,390

Notes: Data come from the 2001 and 2007 DHS survey rounds and the 2003 and 2005 ZSBS survey rounds.
Pregnant is an indicator variable for being pregnant sometime in the twelve months prior to the survey date, inclusive.
"PMTCT within 10km" is an indicator variable equal to one if a health clinic within 10 kilometers of the respondent offered PMTCT at least twelve months prior to the survey date.
Age 15-19 is the omitted age category.
"Age 20-29" is an indicator variable equal to one if the respondent is age 20-29.
"Age 30-39" is an indicator variable equal to one if the respondent is age 30-39.
"Age 40-49" is an indicator variable equal to one if the respondent is age 40-49.
All specifications include an indicator variable for whether PMTCT was ever introduced within 10km of the respondent.
All specifications inlcude a secular linear trend and a separate linear trend for individuals residing with 10km of locations ever receiving PMTCT.
All specifications include controls for other HIV/AIDS services.
All specifications include district fixed effects and month times year fixed effects.
All specifications include controls for five-year age group.
Standard errors are in parentheses and are clustered by Standard Enumeration Area (SEA).
*** Significant at the 1 percent level, ** Significant at the 5 percent level, * Significant at the 10 percent level.

Table 8: Heterogeneity by Education Level in Effect of Local PMTCT

Dependent variable:	pregnant
	(1)
PMTCT within 10km	-0.021
	(0.026)
PMTCT within 10km * completed primary school	0.002
	(0.018)
PMTCT within 10km * completed secondary school	-0.033
	(0.022)
P > F(PMTCT+PMTCT*primary=0)	0.443
P > F(PMTCT+PMTCT*primary+PMTCT*secondary=0)	0.066
Observations	17,390

Notes: Data come from the 2001 and 2007 DHS survey rounds and the 2003 and 2005 ZSBS survey rounds.
Pregnant is an indicator variable for being pregnant sometime in the twelve months prior to the survey date, inclusive.
"PMTCT within 10km" is an indicator variable equal to one if a health clinic within 10 kilometers of the respondent
offered PMTCT at least twelve months prior to the survey date.
All specifications include an indicator variable for whether PMTCT was ever introduced within 10km of the respondent.
All specifications inlcude a secular linear trend and a separate linear trend for individuals residing with 10km of locations ever receiving PMTCT.
All specifications include controls for other HIV/AIDS services.
All specifications include district fixed effects and month times year fixed effects.
All specifications include controls for completed primary and completed secondary school.
Standard errors are in parentheses and are clustered by Standard Enumeration Area (SEA).
*** Significant at the 1 percent level, ** Significant at the 5 percent level, * Significant at the 10 percent level.

Table 9: Effect of Local PMTCT on Knowledge of PMTCT and on Breastfeeding

Dependent variable:	know PMTCT		currently breastfeeding	
	(1)	(2)	(3)	(4)
PMTCT within 10km	0.048***	0.033	0.175***	0.171***
	(0.021)	(0.024)	(0.045)	(0.047)
PMTCT within 10km * completed primary school		-0.001		0.014
		(0.016)		(0.036)
PMTCT within 10km * completed secondary school		0.070***		-0.012
		(0.021)		(0.080)
P > F(PMTCT+PMTCT*primary=0)		0.153		0.000
P > F(PMTCT+PMTCT*primary+PMTCT*secondary=0)		0.000		0.045
Observations	16,677	16,677	3,380	3,380

Notes: Data on PMTCT knowledge come from the 2001 and 2007 DHS survey rounds and the 2003 and 2005 ZSBS survey rounds.
Data on breastfeding come from the 2001 and 2007 DHS survey rounds.
Currently breastfeeding is an indicator variable equal to one a child age 24 months or younger is currently breastfeeding.
"PMTCT within 10km" is an indicator variable equal to one if a health clinic within 10 kilometers of the respondent
offered PMTCT at least twelve months prior to the survey date.
All specifications include an indicator variable for whether PMTCT was ever introduced within 10km of the respondent.
All specifications inlcude a secular linear trend and a separate linear trend for individuals residing with 10km of locations ever receiving PMTCT.
All specifications include controls for other HIV/AIDS services.
All specifications include district fixed effects and month times year fixed effects.
Columns (2) and (4) include controls for completed primary and completed secondary school.
Standard errors are in parentheses and are clustered by Standard Enumeration Area (SEA).
*** Significant at the 1 percent level, ** Significant at the 5 percent level, * Significant at the 10 percent level.

Table 10: Effect of Local PMTCT on Child Survival

Dependent variable:	under-one month death	under-1 death	under-2 death
	(1)	(2)	(3)
PMTCT within 10km	-0.028***	-0.040***	-0.022
	(0.010)	(0.014)	(0.023)
Observations	12,004	10,474	8,848

Notes: Data come from the 2001 and 2007 DHS survey rounds.
"Under-one month child death" is an indicator variable defined as one if a child died aged 1 month or younger and defined as zero if a child aged one month or younger has not died.
"Under-1 death" and "under-2 death" defined similarly for 24 months and 36 months, respectively.
"PMTCT within 10km" is an indicator variable equal to one if a health clinic within 10 kilometers of the respondent offered PMTCT at least twelve months prior to the child birth date.
All specifications include an indicator variable for whether PMTCT was ever introduced within 10km of the respondent.
All specifications inlcude a secular linear trend and a separate linear trend for individuals residing with 10km of locations ever receiving PMTCT.
All specifications include controls for other HIV/AIDS services.
All specifications include district fixed effects and month times year fixed effects.
Standard errors are in parentheses and are clustered by Standard Enumeration Area (SEA).
*** Significant at the 1 percent level, ** Significant at the 5 percent level, * Significant at the 10 percent level.