Prevention of Mother-to-Child Transmission of HIV and Reproductive Behavior in Zambia *

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Abstract

Prevention of mother-to-child transmission of HIV (PMTCT) is the single most effective HIV prevention intervention in practice today. Nonetheless, little reliable empirical evidence exists on the behavioral effects of PMTCT. This paper documents the rapid expansion of access to PMTCT in Zambia during the period 2000-2007 and provides some of the first evidence on the change in reproductive behavior associated with PMTCT scale-up. The results of a primarily descriptive analysis suggest that PMTCT may have generated increases in knowledge about PMTCT and MTCT, large reductions in child mortality and pregnancy rates, and smaller changes in breastfeeding rates. However, additional research is required to address the potential endogeneity of PMTCT availability.

JEL classification: I10; J13

Keywords: Fertility; HIV/AIDS; PMTCT; reproductive technology; Zambia

*I would like to thank Quamrul Ashraf, William Dow, Lucie Schmidt, Lara Shore-Sheppard, Jeffrey Stringer, Anand Swamy, Waly Wane, Tara Watson, David Weil, seminar participants at the University of California, Berkeley, NBER Africa Project Zanzibar Conference, University of California, Santa Cruz, and Williams College, and an anonymous referee for many excellent comments. Special thanks to Elisa Pepe for tremendous support throughout this project. Madeleine Watson and Wentao Xiong provided superb research assistance. The NBER Africa Project provided generous financial and institutional support. This research would not be possible without the assistance of the Network of Zambian People Living with HIV/AIDS (NZP+). All errors are my own. The findings, interpretations, and conclusions expressed in this paper are those of the author and do not necessarily represent the views of the aforementioned individuals or the agencies that employ them.

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1 Introduction

The rapid expansion of prevention of mother-to-child transmission of HIV (PMTCT) in Sub-Saharan Africa in the past decade is one of the great humanitarian successes of this era. At the turn of the 21st century, PMTCT was virtually unavailable for the vast majority of women in Sub-Saharan Africa, the region of the world most affected by the HIV/AIDS pandemic. In 2009, 54 percent of HIV positive pregnant women in the region received PMTCT (WHO 2010).

This scale-up surely has saved millions of lives. Five percent of adults age 15-49 in Sub-Saharan Africa are HIV positive (UNAIDS 2010). In the absence of PMTCT, a HIV positive woman will transmit the virus in utero, during childbirth, or through breastfeeding with a cumulative probability of as much as 45 percent (Dabis and Ekpini 2002). A HIV positive infant will die with probability between 25 and 50 percent by age 1 (Spira et al 1999, Taha et al 1999, Dabis et al 2001, Brahmbhatt et al 2001). PMTCT can reduce the cumulative transmission probability from a HIV positive woman to her newborn child to as little as 3 percent (Dabis and Ekpini 2002, Canning 2006).

This paper documents the expansion of PMTCT in Zambia over the period 2001-2007 and examines changes in reproductive behavior associated with the local introduction of PMTCT. In doing so, it provides some of the first evidence on reproductive behavior in the context of the widespread availability of the single most effective HIV prevention intervention we know of in practice today, an intervention that dramatically reduces child mortality risk. Although the current analysis is mostly descriptive and does not attempt to identify the causal effects of PMTCT availability, it provides suggestive evidence that the rapid scale-up of PMTCT has generated large changes in reproductive behavior.

Between 2001 and the end of 2007, the number of health facilities in Zambia offering PMTCT increased from fewer than 6 to nearly 600. By the end of this period, more than 40 percent of health facilities offered PMTCT. Because the expansion occurred with greater intensity in urban areas than in rural areas, individual level coverage rates increased even more rapidly.

Although it is clear that PMTCT changes the incentives that women and couples face in making decisions about reproductive behavior, *a priori* the sign of the fertility response to PMTCT is ambiguous. For example, the standard quantity-quality model following Becker and Lewis (1973) illuminates a mechanism by which PMTCT reduces fertility and one by which PMTCT increases fertility. First, PMTCT reduces the shadow price of child quantity. Because each birth is more likely to survive into older ages, the expected number of births to achieve a desired number of surviving children has fallen, in turn reducing the shadow price of child quantity and leading to an increase in fertility. Second, PMTCT simultaneously reduces the shadow price of child quality. Because each child is more likely to survive into older ages, household investments in children's human capital made at a young age are more likely to realize a larger return. That is, the shadow price of child quality has fallen, inducing a reduction in fertility due to the quantity-quality tradeoff embedded in this model.

I use newly assembled data on the expansion of HIV/AIDS services in Zambia to examine changes in reproductive knowledge and behavior associated with the local introduction of PMTCT. A primarily descriptive analysis of conditional means yields three main findings. First, the local introduction of PMTCT was associated with an increase in knowledge of mother-to-child transmission (MTCT) and an increase in knowledge of prevention of mother-to-child transmission (PMTCT). Second, the local introduction of PMTCT was associated with a decrease in child mortality and pregnancy rates. Third, the local introduction of PMTCT was associated with (proportionally) smaller reductions in breastfeeding rates. An analysis of the heterogeneity in these changes by the likelihood the respondent was HIV positive provides mixed support for a causal interpretation of these differences in conditional means. In addition, I uncover several significant differences by age and education level of the respondent.

Future research will address the endogeneity of PMTCT expansion. PMTCT largely was introduced at existing health clinics and PMTCT expansion occurred with greater intensity in urban areas. Thus, it is reasonable to believe that time-invariant as well as time-varying factors affecting reproductive behavior varied systematically with the intensity of PMTCT expansion. In the interim, the results of this analysis provide some of the first evidence on PMTCT expansion and reproductive behavior.

The rest of the paper is organized as follows. In Section 2, I describe the existing literature in three related topics: (i) PMTCT and fertility, (ii) HIV/AIDS and fertility, and (iii) child mortality risk and fertility. Section 3 provides a few clinical facts about PMTCT and discusses some possible behavioral responses. Section 4 describes the data collected for this project. Section 5 discusses PMTCT scale-up in Zambia. Section 6 presents five sets of outcomes related to PMTCT expansion: (i) knowledge of mother-to-child transmission (MTCT), (ii) knowledge of prevention of mother-to-child transmission (PMTCT), (iii) child mortality, (iv) pregnancy, and (v) breastfeeding. Section 7 discusses the implications of these findings as well as an agenda for future research on PMTCT and reproductive outcomes.

2 Existing literature

2.1 PMTCT and fertility

There is no existing economic literature on the behavioral effects of PMTCT. Moreover, there is only a nascent literature in public health on the behavioral effects of PMTCT. However, a small number of studies examine fertility intentions in the context of PMTCT.

The limited empirical evidence on fertility intentions in the context of PMTCT suggests that access to PMTCT may increase fertility among HIV positive women with known HIV status. Cooper et al (2007) conducted in-depth interviews with 61 HIV positive men and women in Cape Town, South Africa. Providing information about PMTCT during the course of the interview increased the desire to have (more) children. However, female interviewees expressed additional concern about the availability of ART to ensure that they would be alive to take care of their children. Peltzer et al (2009) investigate fertility intentions among a sample of women with known HIV status receiving postnatal care in Tembo District, South Africa. Among HIV positive women, knowledge of PMTCT was associated with increased desire for pregnancy.

2.2 HIV/AIDS and fertility

A variety of studies examine the impact of HIV/AIDS on fertility in Sub-Saharan Africa. These studies generally investigate the total effect of HIV/AIDS on fertility, rather than focusing on the child mortality risk channel. Because PMTCT only directly reduces child mortality risky without directly affecting adult mortality risk, it is unlikely that PMTCT simply will reverse the effects of HIV/AIDS. Nonetheless, these studies represent an important related literature, particularly because of the dearth of evidence on the fertility response to PMTCT.

The initial economic analyses of the fertility response to the HIV/AIDS pandemic suggested that fertility in much of Sub-Saharan Africa may have fallen in response to the HIV/AIDS pandemic. Young (2007) found that demand for children, and in turn fertility, fell in response to the HIV/AIDS pandemic. Similarly, Juhn et al (2009) found that although community-level HIV prevalence had no effect on fertility, HIV positive women in Sub-Saharan Africa had fewer children.

A second wave of economic research on this topic presents new evidence seemingly contradicting these initial findings. Kalemli-Ozcan and Turan (2010) revisited Young's (2007) study and found that restricting the empirical analysis to the period for which HIV data are actually available suggests that HIV actually increased fertility.[1] Fortson (2009) and Fink and Linnemayr (2009) present evidence suggesting that the HIV/AIDS pandemic has not affected fertility on average. However, Fink and Linnemayr (2009) also argues that fertility fell among more educated women in response to HIV/AIDS. More generally, Kalemli-Ozcan (2010) shows that the estimated relationship between HIV prevalence and fertility is very sensitive to the source of variation in HIV prevalence (e.g., cross-sectional versus time series) and suggests that HIV/AIDS has had little effect on fertility.

In contrast, it appears that the majority of public health and medical studies on HIV/AIDS and fertility find lower fertility among HIV positive women than among HIV negative women. For example, Gray et al (1998) found that pregnancy rates in Uganda were lower among HIV

[1] In the absence of complete data on HIV prevalence at the start of the pandemic, Young (2007) assumed that HIV prevalence was zero from 1980 through 1998.

positive women than among HIV negative women, partly due to an increased likelihood of pregnancy loss and partly due to lower rates of conception. Likewise, Carpenter et al (1997), Zaba and Gregson (1998), Glynn et al (2000), Fabiani et al (2006), Kongnyuy and Wiysonge (2008), and Chen and Walker (2010) present evidence indicating that fertility is lower among HIV positive women than among HIV negative women. In a study examining changes in fertility among women receiving a HIV positive test result in Malawi, Hoffman et al (2008) found that pregnancy rates fell among HIV positive women who learned of their HIV status.

2.3 Child mortality risk and fertility

A broader economic literature examines the effect of child mortality on fertility. Using data from three different settings, Ben-Porath (1976) found that in each setting increased (realized) child mortality was associated with higher subsequent fertility, consistent with households engaging in replacement fertility. In contrast, Wolpin (1984) found evidence of only a small replacement fertility effect. However, Wolpin (1984) found a large negative effect of child mortality *risk* on fertility.

Among more recent studies, Doepke (2005) examined the relationship between child mortality and fertility in a model following Barro and Becker (1989), as well as in several variants of this model. Doepke (2005) found that the existence of replacement fertility may produce a positive relationship between child mortality risk and fertility. However, for child mortality risk to have a positive effect on net fertility, households must practice precautionary fertility (i.e., "child hoarding"). Similarly, Angeles (2010) found that child mortality increased gross fertility, but had little effect on net fertility. In contrast, Soares

(2005) shows that the existence of a quantity-quality tradeoff for household investments in children yields the result that a reduction in child mortality risk reduces fertility.

3 Prevention of mother-to-child transmission

3.1 Background

Prevention of mother-to-child transmission of HIV (PMTCT) is the single most effective HIV prevention intervention in practice today. When administered in accordance with World Health Organization (WHO) recommendations, PMTCT can reduce 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 doing so, the availability of PMTCT has the potential to substantially reduce child mortality risk in high HIV prevalence environments.

The WHO recommends "combination therapy" (i.e., a multiple-drug therapy) for HIV-positive mothers and infants (WHO 2006). The drugs in this combination therapy include azidothymidine (AZT) and nevirapine (NVP). In Zambia, as in much of Sub-Saharan Africa (UNAIDS 2010), PMTCT consists of single-dose NVP (i.e., NVP without AZT) administered to a HIV positive pregnant woman at diagnosis, at the onset of childbirth, and to her infant child during the first week or two of breastfeeding (Stringer et al 2003, Stringer et al 2005).

By reducing child mortality risk, PMTCT changes the incentives that women and households face in their reproductive decisions. In a standard quantity-quality model following Becker and Lewis (1973), PMTCT reduces the shadow price of child quantity because it decreases the number of births required to achieve a desired number of surviving children. The reduction in the shadow price of child quantity should increase fertility. However, PMTCT simultaneously reduces the shadow price of child quality because household investments in a child's human capital made at a young age are more likely to realize a return as that child is more likely to survive into older ages. Through the quantity-quality tradeoff embedded in this model, this reduction in the shadow price of child quality should decrease fertility. PMTCT may affect fertility through other channels as well, including reducing the need for precautionary or replacement fertility or by providing information to a HIV positive woman about her HIV status.[2]

A change in fertility due to the availability of PMTCT may induce changes in other reproductive behaviors as well. For example, if PMTCT reduces fertility, then women may increase breastfeeding durations, possibly further reducing fertility due to increased lactational amenorrhea. Moreover, the availability of PMTCT may directly affect breastfeeding behavior. Mother-to-child transmission of HIV through breastfeeding comprises roughly one-half of the cumulative risk of mother-to-child transmission (Dabis and Ekpini 2002) and PMTCT reduces the risk of transmission associated with breastfeeding.

3.2 Scale-up in Sub-Saharan Africa

In the early 21st century, in conjunction with global donor governments, many Sub-Saharan African counties dramatically expanded access to PMTCT. Prior to the authorization of the United States President's Emergency Plan for AIDS Relief (PEPFAR) in 2004 and the Global

[2]Personal communication with Dr. Jeffrey Stringer indicates that there do not appear to be any biochemical pathways linking NVP and fecundity.

Fund to Fight HIV/AIDS, Tuberculosis, and Malaria, PMTCT was virtually unavailable to the vast majority of the world's population in this region. Between 2005 and 2009, the proportion of pregnant women living with HIV in this region who received PMTCT drugs increased from 15 percent (WHO 2007) to 54 percent (WHO 2010).

Early scale-up has been greater in Eastern and Southern Africa, the area of Sub-Saharan Africa with the highest HIV prevalence, than in Western and Central Africa. For example, in 2009, the fraction of pregnant women living with HIV who received PMTCT drugs was more than two-thirds in Eastern and Southern Africa and less than one-quarter in Western and Central Africa (WHO 2010).

Coverage for infants to pregnant women living with HIV has increased as well. Relative to coverage for women, scale-up for infants has lagged. In Sub-Saharan Africa, the proportion of infants born to mothers living with HIV who received PMTCT drugs increased from 11 percent in 2005 (WHO 2007) to 35 percent in 2009 (WHO 2010).

As one of the 14 PEPFAR focus countries, Zambia has been among the leaders in PMTCT rollout. Between 2005 and 2009, PMTCT drug coverage for pregnant women living with HIV increased from 15 percent (WHO 2007) to nearly 70 percent (WHO 2010). By 2009, nearly 40 percent of infants born to mothers living with HIV received PMTCT drugs (WHO 2010).

4 Data

Despite the central role PMTCT has played in HIV/AIDS policy in Sub-Saharan Africa, there has been little effort to document PMTCT expansion at a sub-national level. Thus, in conjunction with the Network of Zambian People Living with HIV/AIDS (NZP+), I collected data documenting the expansion of PMTCT at the health facility level from the beginning of HIV/AIDS services time in Zambia through June 2008.[3]

The Japanese International Cooperation (JICA) 2006 Health Facilities Census (HFC) formed the foundation for our data collection. The 2006 HFC enumerated every health facility in Zambia and recorded the precise GPS coordinates of each facility. Using this information on the universe of health facilities in Zambia, we collected information from each facility on the month and year (if any) it began offering PMTCT, as well as similar information for the other two main HIV/AIDS services (i.e., voluntary counseling and testing (VCT) and antiretroviral therapy for adults (ART)).

This processes yielded a retrospective monthly health facilities panel documenting the expansion of the three main HIV/AIDS services for an entire high HIV prevalence country. To the best of my knowledge, these are the first such data that exist. Not only do they document HIV/AIDS service expansion at the health facility level, but in conjunction with nationally representative household survey data on reproductive behavior they will provide evidence on the behavioral responses to HIV/AIDS service expansion (including PMTCT expansion).

Data on reproductive behavior come from four nationally representative household surveys. These are the 2001 and 2007 Demographic Health Surveys (DHS) and the 2003 and 2005 Zambia Sexual Behavior Surveys (ZSBS). Several key variables I use in the empirical analysis are: (i) knowledge (yes/no) of mother-to-child transmission of HIV, (ii) knowledge

[3]Data collection continued past the middle of 2008. However, the panel only reliable captures PMTCT expansion through the middle of 2008. Data collection effectively began in June 2008 and facilities reporting no PMTCT at that time may have subsequently introduced it. Because our data collection process does not update expansion in real time, we are unable to track PMTCT expansion after June 2008 until we update the health facilities panel.

(yes/no) of prevention of mother-to-child transmission of HIV (PMTCT), (iii) child death (yes/no) by age one, (iv) pregnant (yes/no) at any point in the twelve months leading up to the interview date, (v) breastfeeding (yes/no) for a child age zero to twenty-four months.

Information on the location of the survey respondents allow me to calculate the distance from each survey respondent to each health facility. The 2007 DHS contains respondents' GPS coordinates (intentionally coded with a small error component to ensure respondent confidentiality). I use administrative records on the locations of the primary sampling units in the 2001 DHS, the 2003 ZSBS, and the 2005 ZSBS. These tend to be Statistical Enumeration Areas (SEAs), which are administrative units designed to capture approximately 1,000 residents. I calculate the centroid of each SEA and record its GPS coordinates as the location of the survey respondents who reside in that SEA. After calculating the distance from each survey respondent to each health facility, I am left with 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 ZSBS, and 7,146 adult females in the 2007 DHS.[4]

5 Zambian scale-up

Before turning to an analysis of the association between local PMTCT introduction and reproductive behavior, I briefly describe the expansion of access to PMTCT as documented in the data collected for the current analysis. Between 2000 and the end of 2007, the number of health facilities in Zambia offering PMTCT increased from virtually zero to nearly six

[4] The Zambia Central Statistical Office provided a digitized census map which I use to identify the location of each Statistical Enumeration Area (SEA). However, this map is missing roughly seven percent of the SEAs in Zambia and I am unable to calculate the location of approximately seven percent of the 2001-2005 survey respondents.

hundred. Figure 1 shows the number of health facilities that introduced PMTCT by the year of introduction. Although expansion was fairly steady over this period, the expansion occurred with greatest intensity in 2005.

[INSERT FIGURE 1 HERE]

Facilities coverage rates increased from close to zero to more than 40 percent over this time period. Figure 2 shows the proportion of health facilities at the end of each calendar year offering PMTCT from 2000 through 2007.

[INSERT FIGURE 2 HERE]

Individual coverage rates increased even more rapidly over this same time period. I calculate the individual coverage rate as the fraction of females age 15-49 residing within 20 kilometers of a PMTCT site. Figure 3 shows the individual coverage rate at the end of each calendar year from 2000 through 2007. Because PMTCT expansion occurred with greater intensity in urban areas, the individual coverage rate tended to be higher than the facilities coverage rate during this time period.

[INSERT FIGURE 3 HERE]

6 Results

6.1 Knowledge of MTCT

I begin by examining the change in knowledge of mother-to-child transmission of HIV (MTCT) associated with the local introduction of PMTCT. By local introduction, I mean PMTCT was introduced at a health clinic within 20 kilometers of the respondent at least eleven months prior to the interview date.[5] Unless most women were already informed about mother-to-child transmission of HIV, the local introduction of a service designed to prevent this transmission presumably should have increased knowledge of MTCT. If it did not, that might suggest that local availability does not translate into local access because of lack of information about local availability.

Table 1 shows the proportion of female respondents who reported knowing of MTCT, disaggregated by (eventual) proximity to PMTCT. For respondents in (eventual) PMTCT locations, these sample means are further disaggregated by whether PMTCT has been available for at least eleven months. The sample means presented in Table 1 suggest that PMTCT may have increased knowledge of mother-to-child transmission. Although respondents in (eventual) PMTCT locations had higher knowledge of MTCT prior to local PMTCT introduction than did respondents in non-PMTCT locations, knowledge of MTCT increased by approximately 7 percentage points (p-value=0.00) among respondents in locations receiving PMTCT.

[INSERT TABLE 1 HERE]

This response may have been larger among women who were more likely to be HIV positive. Women who believed they were more likely to be HIV positive may have been more likely to be introduced to PMTCT (or the concern about MTCT) through a local health clinic. On the other hand, women who believed they were more likely to be HIV positive may have been more likely to have prior information about MTCT and hence would

[5] In an analysis of the determinants of maternal health care usage in Zambia, Stekelenberg et al (2004) found that willingness to visit a maternal health clinic fell rapidly when the clinic was more than a two hour walk. I use a cut-off date of eleven months prior to the interview date because that is roughly when the representative conception occurred for pregnancies measured during the twelve months leading up to the interview date.

have had less scope for increasing their awareness.

Table 2 presents information similar to that in Table 1, except now I disaggregate the sample means by whether the respondent is in a demographic group with HIV prevalence above the median HIV prevalence by demographic group. For these purposes, I define demographic group as the interaction of gender, five-year age group, and province of residence. Data on HIV prevalence come from a single cross-section, the 2007 Demographic Health Survey (DHS). This table shows that knowledge of MTCT was indeed higher among women in high HIV prevalence demographic groups. Moreover, MTCT knowledge rates approaching the high nineties for women in high HIV prevalence demographic groups suggest that the scope for increased knowledge was limited. Consistent with this observation, the increase in MTCT knowledge among respondents in (eventual) PMTCT locations associated with the local introduction of PMTCT was smaller among women in high HIV prevalence demographic groups than among women in low HIV prevalence demographic groups (i.e., 0.06 versus 0.07 percentage points).

[INSERT TABLE 2 HERE]

Social networks likely vary systematically across age groups, suggesting that social learning about MTCT through local PMTCT availability may vary by age as well. Table 3 explores this possibility, by further disaggregating knowledge about MTCT by the respondent's age group. These results suggest that the increase in knowledge of MTCT among respondents in (eventual) PMTCT locations associated with the local introduction of PMTCT was greater among younger age groups. For example, the increase among women age 15-19 in (eventual) PMTCT locations was approximately 11 percentage points, or roughly twice that for women age 20-29. Again, high prior knowledge of MTCT among older respondents might explain the smaller increase among older age groups.

[INSERT TABLE 3 HERE]

Finally, I examine how the association between PMTCT availability and knowledge of MTCT varied by the education level of the respondent. Table 4 represents the results of this analysis. There do not appear to be particularly large differences by education level in the change in knowledge of MTCT associated with the local introduction of PMTCT. The proportion of women who reported knowing about MTCT increased by between 2 and 8 percentage points in locations receiving PMTCT after the local introduction of PMTCT, regardless of the respondent's education level. Although more educated women may be more knowledgeable about MTCT even in locations never receiving PMTCT, even these differences do not exhibit a consistent pattern of increased education associated with increased knowledge of MTCT. However, the small number of women in locations never receiving PMTCT who have completed secondary school means we should interpret these simple differences in means with caution.

[INSERT TABLE 4 HERE]

6.2 Knowledge of PMTCT

Now I turn to the question of whether knowledge about prevention of mother-to-child transmission (PMTCT) increased in areas receiving PMTCT. Table 5 shows the proportion of female respondents who reported knowing of PMTCT, disaggregated by (eventual) proximity to PMTCT. In locations eventually receiving PMTCT, the change in knowledge of PMTCT associated with the local introduction of the service was nearly 50 percentage points (p-value=0.00). Much of this may be a secular change that was shared by individuals in locations greater than twenty kilometers from an eventual PMTCT site. However, the fact that only 25 percent of respondents in locations greater than twenty kilometers from an eventual PMTCT were aware of PMTCT also suggests that the local introduction of this service had a large impact on knowledge of the existence of an intervention aimed at reducing mother-to-child transmission of HIV.

[INSERT TABLE 5 HERE]

Table 6 allows average knowledge of PMTCT to vary by HIV prevalence in the respondent's demographic group. The results suggest that the local introduction of PMTCT did not increase knowledge of its existence substantially more among women who were more likely to be HIV positive. The proportion of women aware of the existence of PMTCT increased by approximately 47 percentage points in low and high HIV prevalence demographic groups alike.

[INSERT TABLE 6 HERE]

Partly because the change in knowledge of MTCT associated with local PMTCT varied by age, it is reasonable to believe that the change in knowledge of PMTCT did as well. Table 7 examines this possibility. The results indicate that the increase in knowledge of PMTCT associated with local PMTCT introduction was greater among women who were in age groups that were already more likely to know about PMTCT. For example, the proportion of women age 15-19 in areas eventually receiving PMTCT who were knowledgeable about PMTCT increased by 42 percentage points, whereas the increase among women age 20-29 in the same areas was 50 percentage points.

[INSERT TABLE 7 HERE]

Table 8 examines whether the change in knowledge of PMTCT associated with local introduction of the service varied by the education level. As was the pattern with MTCT, there were only small-to-moderate differences by education level in the change in knowledge of PMTCT.

[INSERT TABLE 8 HERE]

6.3 Child mortality

The local introduction of PMTCT may have affected knowledge about MTCT and PMTCT even if respondents accessed these services at low rates. Without data on use of PMTCT, the best information on access to PMTCT is information on child mortality. If respondents were receiving PMTCT, then presumably we should see a reduction in child mortality in these data.

Table 9 reports under age 1 child mortality rates, disaggregated by (eventual) proximity to PMTCT. The local introduction of PMTCT was associated with a one percentage point (i.e., ten percent) reduction in under age 1 child mortality rates (significant at the 5 percent level).

[INSERT TABLE 9 HERE]

Table 10 disaggregates child mortality rates by whether the respondent (i.e., the child's mother) was more or less likely to be HIV positive. Child mortality appears to have fallen by one percentage point, invariant of the likelihood the mother was HIV positive.

[INSERT TABLE 10 HERE]

Table 11 examines whether the association between PMTCT availability and child mortality varied by the age of the respondent (i.e., the child's mother). Child mortality appears to have fallen the most for the youngest respondents. Child mortality fell by five percentage points for women age 15-19. In contrast, it fell by one percentage point for all other age groups.

[INSERT TABLE 11 HERE]

Table 12 disaggregates the change in child mortality associated with local PMTCT availability by the education level of the mother. There is some evidence of a larger reduction in child mortality for more educated women.

[INSERT TABLE 12 HERE]

6.4 Pregnancy

The availability of PMTCT changes the incentives that women and couples face in making decisions about reproductive behavior. In the standard Becker and Lewis (1973) model, PMTCT simultaneously reduces the shadow prices of child quantity and child quality. These price changes would affect fertility decisions. Similarly, PMTCT should reduce the need for replacement or precautionary fertility. Table 13 examines changes in pregnancy rates associated with the local introduction of PMTCT. Although pregnancy rates were already lower in locations eventually receiving PMTCT than in locations never receiving PMTCT, pregnancy rates fell by an additional 5 percentage points (p-value=0.00) in association with the local introduction of PMTCT.

[INSERT TABLE 13 HERE]

Presumably the reduction in pregnancy rates associated with the local introduction of

PMTCT should have been larger among women who were more likely to be HIV positive. Table 14 explores this possibility by further disaggregating pregnancy rates by the whether the respondent was in a demographic group with HIV prevalence above the median. Perhaps surprisingly, these results do not suggest that the response was larger among women who were more likely to be HIV positive.

[INSERT TABLE 14 HERE]

Table 15 allows pregnancy rates to vary by the age of the respondent. The results indicate the reduction in pregnancy rates associated with the local introduction of PMTCT was concentrated among younger women (i.e., age 15-19 and age 20-29). These groups demonstrated roughly 5 percentage point reductions each in pregnancy rates (p-value=0.00 and 0.00), whereas older age groups demonstrated slightly smaller reductions in pregnancy rates.

[INSERT TABLE 15 HERE]

The change in pregnancy rates associated with the local introduction of PMTCT may have varied by the education level of the mother. If more educated women were better able to access this service, then they may have demonstrated a larger response. On the other hand, pregnancy rates were higher at lower levels of education so less educated women may mechanically have greater scope for reducing pregnancy rates. Table 16 provides evidence on whether the change in pregnancy associated with the local introduction of PMTCT varied by the education level of the respondent. The results indicate that women who had not completed primary school reduced their likelihood of being pregnancy by 2 percentage points, roughly twice as large as most educated women. Furthermore, the reduction for secondary school completers was not statistically significant at conventional levels (p-value=0.65). The simple difference in means was roughly the same for primary school completers and for women who had not completed primary school.

[INSERT TABLE 16 HERE]

6.5 Breastfeeding

PMTCT expansion likely affected breastfeeding behavior as well. There are at least three reasons to think that breastfeeding habits might have changed after the local introduction of PMTCT. First, PMTCT appears to have reduced pregnancy rates and breastfeeding is an important contraceptive mechanism in Zambia. Among sexually active females age 15-49 in the 2007 DHS, approximately 4 percent report using the lactational amenorrhea method (Central Statistical Office et al 2009). Because the denominator in this calculation includes many women who do not have infants of breastfeeding age, this understates the true prevalence of breastfeeding as a contraceptive method.

Second, PMTCT reduces the shadow price of child quality which should induce households to increase investment in children's human capital (e.g., health and education). Because PMTCT increases the likelihood a newborn will survive into older ages, household investments in children's human capital made at a young age (e.g., breastfeeding) are more likely to realize a greater return. Thus, PMTCT should increase breastfeeding rates as part of an overall increase in household investment in children's human capital.

Third, PMTCT directly reduces the expected cost of breastfeeding. Breastfeeding is one of the three stages at which a mother may transmit HIV to her child and comprises roughly one-half of the cumulative transmission probability (Dabis and Epkini 2002). PMTCT reduces the probability of transmission through breastfeeding and hence should increase breastfeeding rates among women receiving the service.

Table 17 investigates the relationship between PMTCT availability and breastfeeding behavior among women with children ages 0 to 24 months.[6] A simple comparison of conditional means suggests that PMTCT availability was associated with a small decrease in breastfeeding. Breastfeeding rates were approximately five percentage points lower after the local introduction of PMTCT (significant at the 1 percent level).

[INSERT TABLE 17 HERE]

In Table 18, I allow the association between PMTCT availability and breastfeeding to vary by the likelihood the respondent was HIV positive. Breastfeeding rates appear to have fallen by five percentage points (significant at the 1 percent level) invariant of the likelihood the respondent was HIV positive.

[INSERT TABLE 18 HERE]

Breastfeeding behavior and the change therein associated with PMTCT expansion may vary by age of the mother. Differences by cohort in education levels or in exposure to particular reproductive health policies might generate differences in the breastfeeding response to PMTCT. Likewise, life cycle differences in labor supply might condition the responsiveness of breastfeeding to PMTCT. Table 19 explores these possibilities by disaggregating the change in breastfeeding by the age of the mother. Breastfeeding appears to have fallen more among women in the middle of the age distribution. For women ages 20-29 and 30-39, breastfeeding rates fell by five to seven percentage points (significant at the one percent

[6] Approximately 20 months is the median breastfeeding duration in Zambia (Central Statistical Office et al 2009).

level). In contrast, the simple difference in means suggests that breastfeeding rates fell by two to three percentage points for women ages 15-19 and 40-49, although these changes are not statistically significant for these groups (p-values=0.29 and 0.73, respectively).

[INSERT TABLE 19 HERE]

Finally, Table 20 presents breastfeeding rates in PMTCT and non-PMTCT locations further disaggregated by the education level of the mother. Breastfeeding rates appear to have fallen more among women who had completed more schooling, although the change for women who had completed secondary school was not statistically significant at conventional levels.

[INSERT TABLE 20 HERE]

7 Discussion and Conclusion

Prevention of mother-to-child transmission of HIV (PMTCT) is the single most effective HIV prevention intervention we know of in practice today. PMTCT reduces the probability a HIV positive mother transmits the virus to her child from as much as 45 percent in the absence of PMTCT to as little as 3 percent (Dabis and Ekpini 2002, Canning 2006). During the past ten years or so, the proportion of HIV positive pregnant women in Sub-Saharan Africa receiving PMTCT increased from virtually zero to more than one-half (WHO 2010).

This paper documents the rapid expansion of PMTCT in Zambia over the period 2000-2007 and provides descriptive evidence on the association between PMTCT expansion and reproductive behavior. I use a newly assembled monthly health facilities panel identifying the expansion of access to the three main HIV/AIDS services, including PMTCT. In conjunction with four nationally representative household surveys spanning this time period, these data allow me to examine the change in reproductive knowledge and behavior associated with the local introduction of PMTCT. I find that local PMTCT introduction was associated with: (i) increased knowledge about mother-to-child transmission (MTCT) and about PMTCT, (ii) reduced child mortality and pregnancy rates, and (iii) a small reduction in breastfeeding rates. The reduction in pregnancy rates suggests that not only has PMTCT expansion been a humanitarian success, but it may have reduced total fertility rates, possibly promoting economic growth and development.

These results are partly consistent with the standard Becker and Lewis (1973) model of fertility. In the Becker model, a fall in child mortality directly reduces the shadow price of child quality because household investments in children's human capital are more likely to realize a return as the child is more likely to survive into older ages. Through the quantity-quality tradeoff embedded in this model, fertility should fall in response to the decrease in the shadow price of child quality. It is somewhat puzzling that breastfeeding rates appear to have decreased, as a mortality induced fertility reduction should be accompanied by an increase in children's human capital investment.

Future research is required to address the endogeneity of PMTCT expansion. For example, PMTCT expansion may have occurred with greater intensity in areas with fundamentally different time trends in fertility than the rest of Zambia and the empirical methodology used in the current analysis does not address this concern. In addition, the data assembled for this project allow for the investigation of several other important research questions about PMTCT expansion and reproductive health, including the interaction between PMTCT and ART availability in the process determining reproductive behavior.

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Figure 1: PMTCT Expansion in Zambia, 2000-2007

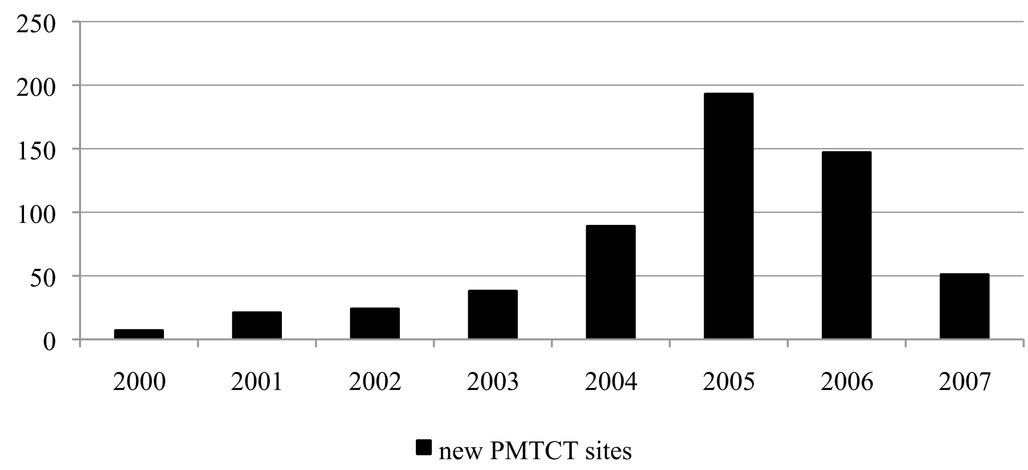
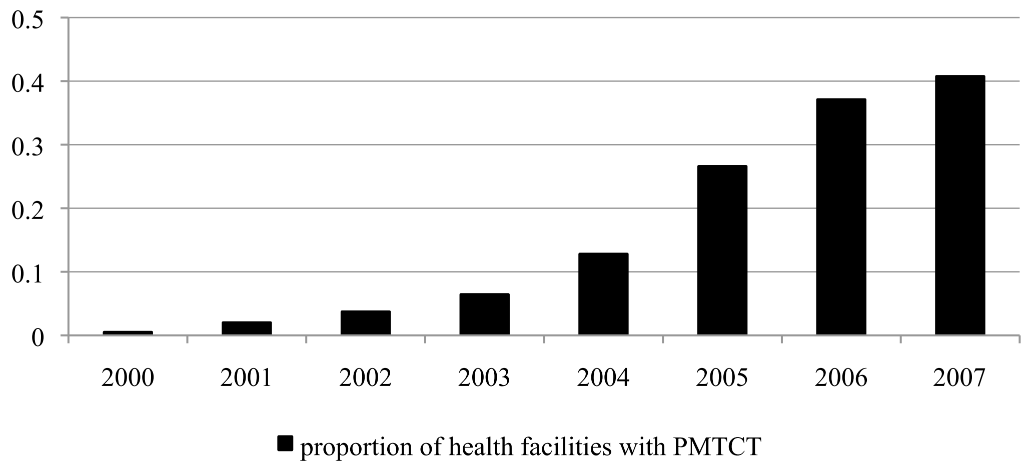


Figure 2: Facilities Coverage Rate for PMTCT, 2000-2007



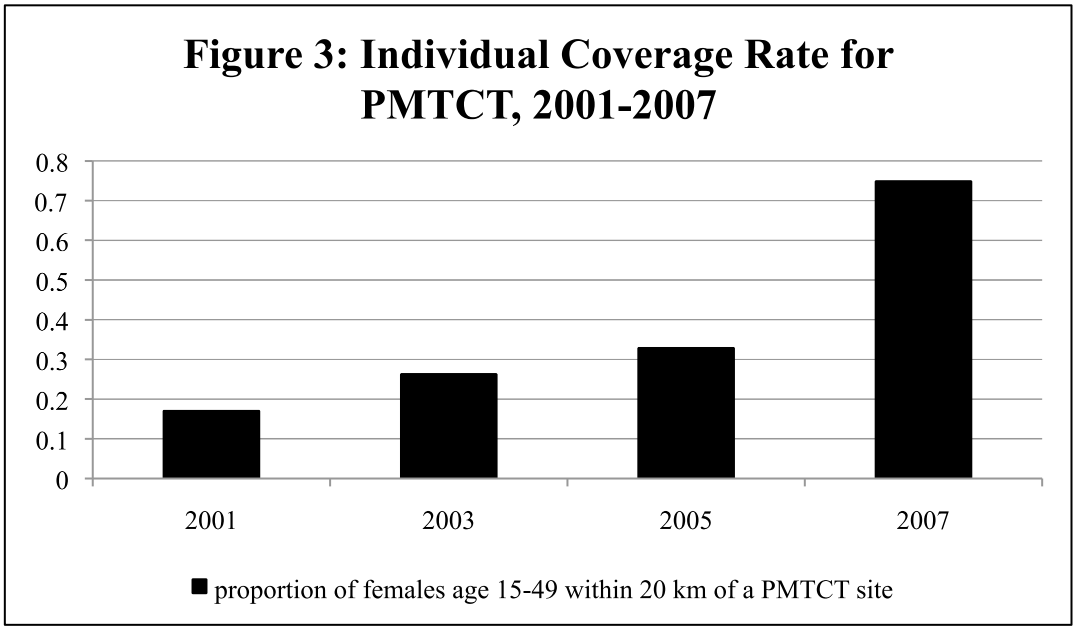


Figure 3: Individual Coverage Rate for PMTCT, 2001-2007
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2001
2003
2005
2007
proportion of females age 15-49 within 20 km of a PMTCT site

Table 1: Knowledge of MTCT by Access to Prevention of Mother-to-Child Transmission of HIV

Sample:	greater than 10km from eventual PMTCT site	within 10km of eventual PMTCT site			
		before local introduction	after local introduction	change	p-value
	(1)	(2)	(3)	(4)	(5)
All adult females	0.84	0.86	0.93	0.07	0.00
Observations	3,992	6,063	7,596	-	-

Notes: Data on knowledge of mother-to-child transmission (MTCT) come from the 2001 and 2007 DHS survey rounds and the 2003 and 2005 ZSBS survey rounds.

Table 2: Knowledge of MTCT by HIV Prevalence and Access to Prevention of Mother-to-Child Transmission of HIV

Sample:	greater than 20km from eventual PMTCT site	within 20km of eventual PMTCT site			
		before local introduction	after local introduction	change	p-value
	(1)	(2)	(3)	(4)	(5)
HIV prevalence					
Below median	0.83	0.84	0.91	0.07	0.00
Median or above	0.86	0.89	0.95	0.06	0.00

Notes: Data on knowledge of mother-to-child transmission (MTCT) come from the 2001 and 2007 DHS survey rounds and the 2003 and 2005 ZSBS survey rounds.

Table 3: Knowledge of MTCT by Age and Access to Prevention of Mother-to-Child Transmission of HIV

Sample:	greater than 20km from eventual PMTCT site	within 20km of eventual PMTCT site			
		before local introduction	after local introduction	change	p-value
	(1)	(2)	(3)	(4)	(5)
Age					
15-19	0.73	0.77	0.88	0.11	0.00
20-29	0.85	0.88	0.94	0.05	0.00
30-39	0.87	0.90	0.96	0.06	0.00
40-49	0.88	0.88	0.95	0.06	0.00

Notes: Data on knowledge of mother-to-child transmission (MTCT) come from the 2001 and 2007 DHS survey rounds and the 2003 and 2005 ZSBS survey rounds.

Table 4: Knowledge of MTCT by Education and Access to Prevention of Mother-to-Child Transmission of HIV

Sample:	greater than 20km from eventual PMTCT site	within 20km of eventual PMTCT site			
		before local introduction	after local introduction	change	p-value
	(1)	(2)	(3)	(4)	(5)
Education level					
Did not complete primary	0.81	0.82	0.90	0.08	0.00
Completed primary	0.91	0.90	0.94	0.04	0.00
Completed secondary	0.89	0.96	0.98	0.02	0.09

Notes: Data on knowledge of mother-to-child transmission (MTCT) come from the 2001 and 2007 DHS survey rounds and the 2003 and 2005 ZSBS survey rounds.

Table 5: Knowledge of PMTCT by Access to Prevention of Mother-to-Child Transmission of HIV

Sample:	greater than 20km from eventual PMTCT site	within 20km of eventual PMTCT site: before local introduction	within 20km of eventual PMTCT site: after local introduction	change	p-value
	(1)	(2)	(3)	(4)	(5)
All adult females	0.21	0.11	0.59	0.48	0.00
Observations	3,833	5,989	7,287	-	-

Notes: Data on knowledge of prevention of mother-to-child transmission (MTCT) come from the 2007 DHS survey rounds and the 2003 and 2005 ZSBS survey rounds. Knowledge of PMTCT in the 2001 DHS survey round is assumed to be zero.

Table 6: Knowledge of PMTCT by HIV Prevalence and Access to Prevention of Mother-to-Child Transmission of HIV

Sample:	greater than 20km from eventual PMTCT site	within 20km of eventual PMTCT site: before local introduction	after local introduction	change	p-value
	(1)	(2)	(3)	(4)	(5)
HIV prevalence					
Below median	0.21	0.10	0.57	0.47	0.00
Median or above	0.21	0.12	0.60	0.48	0.00

Notes: Data on knowledge of prevention of mother-to-child transmission (MTCT) come from the 2007 DHS survey rounds and the 2003 and 2005 ZSBS survey rounds. Knowledge of PMTCT in the 2001 DHS survey round is assumed to be zero.

Table 7: Knowledge of PMTCT by Age and Access to Prevention of Mother-to-Child Transmission of HIV

Sample:	greater than 20km from eventual PMTCT site	within 20km of eventual PMTCT site			
		before local introduction	after local introduction	change	p-value
	(1)	(2)	(3)	(4)	(5)
Age					
15-19	0.16	0.07	0.49	0.42	0.00
20-29	0.25	0.11	0.61	0.50	0.00
30-39	0.22	0.12	0.65	0.53	0.00
40-49	0.20	0.12	0.59	0.48	0.00

Notes: Data on knowledge of prevention of mother-to-child transmission (MTCT) come from the 2007 DHS survey rounds and the 2003 and 2005 ZSBS survey rounds. Knowledge of PMTCT in the 2001 DHS survey round is assumed to be zero.

Table 8: Knowledge of PMTCT by Education and Access to Prevention of Mother-to-Child Transmission of HIV

Sample:	greater than 20km from eventual PMTCT site	within 20km of eventual PMTCT site			
		before local introduction	after local introduction	change	p-value
	(1)	(2)	(3)	(4)	(5)
Education level					
Did not complete primary	0.27	0.12	0.59	0.46	0.00
Completed primary	0.32	0.11	0.67	0.56	0.00
Completed secondary	0.36	0.15	0.66	0.50	0.00

Notes: Data on knowledge of prevention of mother-to-child transmission (MTCT) come from the 2007 DHS survey rounds and the 2003 and 2005 ZSBS survey rounds. Knowledge of PMTCT in the 2001 DHS survey round is assumed to be zero.

Table 9: Under 1-year Child Mortality by Access to Prevention of Mother-to-Child Transmission of HIV

Sample:	greater than 20km from eventual PMTCT site	within 20km of eventual PMTCT site			
		before local introduction	after local introduction	change	p-value
	(1)	(2)	(3)	(4)	(5)
All adult females	0.11	0.10	0.09	-0.01	0.05
Observations	4,077	3,826	8,167	-	-

Notes: Child mortality data come from the 2001 and 2007 DHS survey rounds.

Table 10: Under 1-Year Child Mortality by HIV Prevalence and Access to Prevention of Mother-to-Child Transmission of HIV

Sample:	greater than 20km from eventual PMTCT site	within 20km of eventual PMTCT site			
		before local introduction	after local introduction	change	p-value
	(1)	(2)	(3)	(4)	(5)
HIV prevalence					
Below median	0.11	0.11	0.10	-0.01	0.32
Median or above	0.10	0.10	0.09	-0.01	0.18

Notes: Child mortality data come from the 2001 and 2007 DHS survey rounds.

Table 11: Under 1-Year Child Mortality by Age and Access to Prevention of Mother-to-Child Transmission of HIV

Sample:	greater than 20km from eventual PMTCT site	within 20km of eventual PMTCT site			
		before local introduction	after local introduction	change	p-value
	(1)	(2)	(3)	(4)	(5)
Age					
15-19	0.15	0.15	0.09	-0.05	0.11
20-29	0.11	0.11	0.10	-0.01	0.25
30-39	0.10	0.09	0.08	-0.01	0.57
40-49	0.11	0.11	0.09	-0.01	0.43

Notes: Child mortality data come from the 2001 and 2007 DHS survey rounds.

Table 12: Under 1-Year Child Mortality by Education and Access to Prevention of Mother-to-Child Transmission of HIV

Sample:	greater than 20km from eventual PMTCT site	within 20km of eventual PMTCT site			
		before local introduction	after local introduction	change	p-value
	(1)	(2)	(3)	(4)	(5)
Education level					
Did not complete primary	0.11	0.11	0.10	-0.01	0.27
Completed primary	0.09	0.10	0.09	-0.01	0.32
Completed secondary	0.07	0.10	0.07	-0.03	0.23

Notes: Child mortality data come from the 2001 and 2007 DHS survey rounds.

Table 13: Pregnancy Rates by Access to Prevention of Mother-to-Child Transmission of HIV

Sample:	greater than 20km from eventual PMTCT site	within 20km of eventual PMTCT site: before local introduction	within 20km of eventual PMTCT site: after local introduction	change	p-value
	(1)	(2)	(3)	(4)	(5)
All adult females	0.37	0.32	0.28	-0.05	0.00
Observations	4,073	6,125	7,641	-	-

Notes: Pregnancy data come from the 2001 and 2007 DHS survey rounds and the 2003 and 2005 ZSBS survey rounds.

Table 14: Pregnancy Rates by HIV Prevalence and Access to Prevention of Mother-to-Child Transmission of HIV

Sample:	greater than 20km from eventual PMTCT site	within 20km of eventual PMTCT site: before local introduction	within 20km of eventual PMTCT site: after local introduction	change	p-value
	(1)	(2)	(3)	(4)	(5)
HIV prevalence					
Below median	0.37	0.32	0.27	-0.05	0.00
Median or above	0.38	0.32	0.28	-0.04	0.00

Notes: Pregnancy data come from the 2001 and 2007 DHS survey rounds and the 2003 and 2005 ZSBS survey rounds. HIV data come from 2007 DHS. HIV prevalence refers to HIV prevalence in the respondent's demographic group as defined by the interaction of gender, five-year age group, and province of residence.

Table 15: Pregnancy Rates by Age and Access to Prevention of Mother-to-Child Transmission of HIV

Sample:	greater than 20km from eventual PMTCT site	within 20km of eventual PMTCT site			
		before local introduction	after local introduction	change	p-value
	(1)	(2)	(3)	(4)	(5)
Age					
15-19	0.26	0.23	0.18	-0.05	0.00
20-29	0.49	0.44	0.38	-0.05	0.00
30-39	0.41	0.35	0.31	-0.04	0.01
40-49	0.15	0.10	0.07	-0.04	0.00

Notes: Pregnancy data come from the 2001 and 2007 DHS survey rounds and the 2003 and 2005 ZSBS survey rounds.

Table 16: Pregnancy Rates by Education and Access to Prevention of Mother-to-Child Transmission of HIV

Sample:	greater than 20km from eventual PMTCT site	within 20km of eventual PMTCT site			
		before local introduction	after local introduction	change	p-value
	(1)	(2)	(3)	(4)	(5)
Education level					
Did not complete primary	0.39	0.37	0.34	-0.02	0.09
Completed primary	0.33	0.28	0.25	-0.03	0.01
Completed secondary	0.33	0.20	0.19	-0.01	0.65

Notes: Pregnancy data come from the 2001 and 2007 DHS survey rounds and the 2003 and 2005 ZSBS survey rounds.

Table 17: Breastfeeding Rates by Access to Prevention of Mother-to-Child Transmission of HIV

Sample:	greater than 20km from eventual PMTCT site	within 20km of eventual PMTCT site			
		before local introduction	after local introduction	change	p-value
	(1)	(2)	(3)	(4)	(5)
All adult females	0.84	0.83	0.77	-0.05	0.00
Observations	1,511	1,745	2,264	-	-

Notes: Breastfeeding data come from the 2001 and 2007 DHS survey rounds.

Table 18: Breastfeeding Rates by HIV Prevalence and Access to Prevention of Mother-to-Child Transmission of HIV

Sample:	greater than 20km from eventual PMTCT site	within 20km of eventual PMTCT site			
		before local introduction	after local introduction	change	p-value
	(1)	(2)	(3)	(4)	(5)
HIV prevalence					
Below median	0.84	0.84	0.79	-0.05	0.01
Median or above	0.84	0.81	0.76	-0.05	0.00

Notes: Breastfeeding data come from the 2001 and 2007 DHS survey rounds.

Table 19: Breastfeeding Rates by Age and Access to Prevention of Mother-to-Child Transmission of HIV

Sample:	greater than 20km from eventual PMTCT site	within 20km of eventual PMTCT site			
		before local introduction	after local introduction	change	p-value
	(1)	(2)	(3)	(4)	(5)
Age					
15-19	0.88	0.84	0.81	-0.03	0.29
20-29	0.83	0.81	0.76	-0.05	0.00
30-39	0.85	0.85	0.78	-0.07	0.00
40-49	0.80	0.80	0.78	-0.02	0.73

Notes: Breastfeeding data come from the 2001 and 2007 DHS survey rounds.

Table 20: Breastfeeding Rates by Education and Access to Prevention of Mother-to-Child Transmission of HIV

Sample:	greater than 20km from eventual PMTCT site	within 20km of eventual PMTCT site			
		before local introduction	after local introduction	change	p-value
	(1)	(2)	(3)	(4)	(5)
Education level					
Did not complete primary	0.85	0.84	0.80	-0.04	0.02
Completed primary	0.82	0.81	0.76	-0.05	0.02
Completed secondary	0.91	0.76	0.68	-0.08	0.23

Notes: Breastfeeding data come from the 2001 and 2007 DHS survey rounds.