Published in final edited form as:

J Acquir Immune Defic Syndr. 2015 November 1; 70(3): e94–e101. doi:10.1097/QAI.0000000000000739.

Distance from household to clinic and its association with the uptake of prevention of mother-to-child HIV transmission regimens in rural Zambia

Veronica Escamilla, PhD[1], **Carla J. Chibwesha, MD, MSc**[2,3], **Matthew Gartland, MD**[2,4], **Namwinga Chintu, MBChB, MMed**[5], **Mwangelwa Mubiana-Mbewe, MBChB, MMed, MBA**[2], **Kebby Musokotwane, MBChB, MSc**[6], **Patrick Musonda, PhD**[7], **William C. Miller, MD, PhD**[8,9], **Jeffrey S. A. Stringer, MD**[2,3], and **Benjamin H. Chi, MD, MSc**[2,3]

[1]Department of Obstetrics and Gynecology, University of Chicago, IL USA

[2]Centre for Infectious Disease Research in Zambia; Lusaka, Zambia

[3]Department of Obstetrics and Gynecology, University of North Carolina; Chapel Hill, NC USA

[4]Departments of Medicine and Pediatrics, Massachusetts General Hospital; Boston, MA, USA

[5]Society for Family Health; Lusaka, Zambia

[6]Zambian Ministry of Community Development and Mother-Child Health; Lusaka, Zambia

[7]Department of Public Health, University of Zambia School of Medicine; Lusaka, Zambia

[8]Division of Infectious Diseases, Department of Medicine, School of Medicine, University of North Carolina; Chapel Hill, NC, USA

[9]Department of Epidemiology, Gillings School of Public Health, University of North Carolina; Chapel Hill, NC USA

Abstract

Background—In rural settings, HIV-infected pregnant women often live significant distances from facilities that provide prevention of mother-to-child transmission (PMTCT) services.

Methods—We implemented a pilot project to offer universal maternal combination antiretroviral regimens in 4 clinics in rural Zambia. To evaluate the impact of services, we conducted a household survey in communities surrounding each facility. We collected information about HIV status and antenatal service utilization from women who delivered in the past two years. Using household global positing systems coordinates collected in the survey, we measured Euclidean (i.e., straight line) distance between individual households and clinics. Multivariable logistic regression and predicted probabilities were used to determine associations between distance and uptake of any PMTCT regimen and combination antiretroviral regimens specifically.

Results—From March to December 2011, 390 HIV-infected mothers were surveyed across four communities. Of these, 254 (65%) had household geographical coordinates documented. 168

Correspondence to: Dr. Ben Chi, 5032 Great North Road, Lusaka, Zambia, +260 977 859 179, ; Email: bchi@med.unc.edu

Conflict of interest statement: None declared.

women reported use of a PMTCT regimen during pregnancy, including 102 who initiated a combination antiretroviral regimen. The probability of PMTCT regimen initiation was highest within 1.9 km of the facility and gradually declined. Overall, 103 of 145 (71%) who lived within 1.9 km of the facility initiated PMTCT, versus 65 of 109 (60%) who lived farther away. For every kilometer increase, the association with PMTCT regimen uptake (adjusted odds ratio [AOR]: 0.90, 95%CI: 0.82—0.99) and combination antiretroviral regimen uptake (AOR: 0.88, 95%CI: 0.80—0.97) decreased.

Conclusions—In this rural African setting, uptake of PMTCT regimens was influenced by distance to health facility. Program models that further decentralize care into remote communities are urgently needed.

Keywords

Prevention of mother-to-child transmission of HIV; GIS; HIV/AIDS; Zambia; Option B

INTRODUCTION

Provision of antiretroviral therapy has yielded significant gains in the prevention of mother-to-child transmission of HIV (PMTCT) worldwide.[1] Combination antiretroviral regimens markedly reduce HIV transmission during pregnancy and breastfeeding, with rates less than 5%.[2–5] As recommended by the World Health Organization, the so-called “Option B” approach provides universal combination antiretroviral regimens starting at 14 weeks gestation and continues until cessation of breastfeeding.[6, 7] Many countries have adopted this strategy as national policy and, in fact, some have extended it to lifelong antiretroviral therapy for all HIV-infected pregnant women (i.e., Option B+).[8] Despite their ambitious scope, however, the impact of such strategies may be attenuated by inadequate and unequal access to comprehensive PMTCT services.[9]

Geographical barriers, including transportation costs and physical distance to clinic, may reduce healthcare access, particularly in rural settings.[10–15] Distance estimates have often been based on self-report, [16, 17] but such measures can be imprecise and biased.[18] While more advanced geographical methods have been used to examine distance in relation to general HIV care, the impact of distance on antenatal care has not been extensively studied; however, available studies suggest that distance does not influence timing of first visit or frequency of visits.[19, 20] Because HIV itself is potentially stigmatizing and because of the additional visits required to minimize HIV transmission from mother to infant, results from antenatal studies may not apply directly to PMTCT access. To date, few have examined this potential relationship, particularly in the context of universal maternal antiretroviral therapy. As national programs seek to “virtually eliminate” pediatric AIDS,[21] barriers to Option B/B + uptake in the field must be clearly identified. In this report, we examine geospatial patterns of combination antiretroviral regimen use in four rural Zambian communities, to better understand the role of distance in the uptake of PMTCT services at the population level.

METHODS

The Kafue PMTCT Pilot Program

In 2009, we implemented a four-site pilot program in Zambia's rural Kafue District, approximately 50 km south of the capital city of Lusaka. Designed before the 2010 World Health Organization guidelines for PMTCT,[6] we offered what would later become Option B (universal combination antiretroviral regimens to HIV-infected women through pregnancy and breastfeeding) in a very under-resourced, rural setting. These services have been described elsewhere.[22] Briefly, women testing HIV-positive were immediately evaluated for HIV treatment eligibility based on CD4 screening and clinical staging. Women who met Zambian national guidelines criteria for eligibility to initiate HIV treatment (CD4 count of <350 cells/μL or WHO clinical stage of 3 or 4) started lifelong antiretroviral therapy immediately. Women who did not meet these criteria were offered combination antiretroviral regimens, which started at 28 weeks gestation and continued until the cessation of breastfeeding. Women who declined combination antiretroviral regimens were offered PMTCT according to the Zambian national guidelines at the time, which recommended zidovudine [ZDV] monotherapy from 28 weeks of gestation with peripartum single-dose nevirapine [NVP] to mother and neonate, and no additional antiretroviral prophylaxis during breastfeeding.[23] Women presenting to antenatal care after 28 weeks were initiated accordingly at time of presentation.

Survey design and data collection

A cross-sectional household survey was conducted to evaluate the community impact of the pilot program on infant HIV-free survival. A full description of the primary methods has been published elsewhere.[24] Two survey rounds were conducted: the first was implemented prior to the pilot program and the second was implemented two years later. Households were eligible to be surveyed if a current member was reported to have given birth in the last 24 months. This population comprised women who lived in the clinic catchment area, but may or may not have sought care through the pilot PMTCT program. Written informed consent was obtained and a 165-question survey was administered. The survey captured household demographic and wealth characteristics, and medical history of the child's mother. Blood specimens were collected from eligible mothers and children for HIV testing.[24] For the current analysis, we evaluated only those data from the "post-implementation" survey, as it was the only round in which household Global Positioning Systems (GPS) coordinates were collected. This study was approved by ethical review committees at the University of Zambia (Lusaka, Zambia) and the University of North Carolina at Chapel Hill (Chapel Hill, NC, USA).

Statistical Analysis

Our study population comprised women who reported a delivery in the past two years and tested positive for HIV infection. Our primary outcome of interest was self-reported uptake of a PMTCT regimen. We also looked specifically at uptake of a combination antiretroviral regimen. Categorical variables were compared using Pearson's chi-squared test; continuous variables were compared using Wilcoxon rank-sum test or a two-sample t-test. We compared

the proportion of PMTCT uptake across the four clinics and between individuals with and without GPS coordinates to test for bias.

Geospatial patterns of community level uptake of any PMTCT regimen and combination antiretroviral regimen among HIV-infected mothers were examined using kernel density estimates.[25] As part of this methodology, a roving window or kernel with a 1 km radius is passed across the study area, and the density of events is computed within the window. Density was estimated at the window centroid and was based on the weighted values of all events in the window, with greater weight assigned to events near the center. We selected this approach to visually examine geographical patterns of access represented as the density of uptake per square kilometer, while protecting participant confidentiality. We then measured Euclidean distances (i.e., straight line distance; does not account for topographical features) to clinic and to the main road for all households. Density estimates and distance calculations were computed and mapped using ArcGIS version 10.0 (Environmental Systems Research Institute, Redlands, USA). We determined associations between clinic distance and our outcomes of interest using logistic regression with clustered robust standard errors to correct for correlation among observations from mothers surveyed for more than one child. We tested for within site correlation using the intraclass correlation coefficient, to ensure that a hierarchical model was not necessary (none detected) and therefore included health facility as a dummy variable. Variables selected a priori for inclusion in multivariable models included distance to clinic, maternal age, parity, education, institutional delivery, and household wealth. We also considered distance to main road, maternal employment, time of initial antenatal visit, and knowledge of HIV prior to the survey as factors associated with uptake of any PMTCT regimen or combination antiretroviral regimen at a statistical significance level of $p<0.10$. A categorical household wealth variable comprising multiple household variables was generated using principal components analysis.[26] Household wealth reflects a composite of seven binary variables of ownership of household assets (phone, television, refrigerator, pit/flush toilet, piped water) and a finished floor. We divided the composite score into quintiles with higher quintiles reflecting higher wealth.[26] We plotted predicted probabilities from the logistic regression models to examine uptake patterns as a function of distance to clinic. In primary analysis, we included data from all four communities. Because one site had significantly lower ascertainment for GPS information (see below), we also conducted a sensitivity analysis whereby that community was excluded. Statistical analyses were conducted using Stata version 13.1 (College Station, Texas, USA).

RESULTS

Survey participants

Between March and December 2011, 5801 households were approached, and 2441 (42%) households were found to be eligible. A total of 2,444 women from eligible households were enrolled in the community survey, of which 390 (16%) were HIV-infected. Of these, 254 had household geographical coordinates successfully documented. This varied greatly by community. Three had ≥80% ascertainment of GPS information sites (Chipapa 93%, Kafue Mission 80%, Mt. Makulu 97%); a fourth (Kafue Estates) had comparatively low

ascertainment at 25%. Overall, the proportion of participants reporting initiating a PMTCT regimen did not significantly differ between those with available geographical coordinates and those without (66% vs. 68%, p= 0.76). Proportions of reported combination antiretroviral use did not differ according to available coordinates either (40% vs. 37%, p= 0.47). Comparisons of other demographic and medical information are shown in Supplemental Table 1.

Overall, 168 (66%) reported uptake of any PMTCT regimen during pregnancy, 61% of who (n=102) initiated a combination antiretroviral regimen. Within each community, uptake of any PMTCT regimen reached as high as 78% (Kafue Estates); reported use of maternal combination regimens reached only 46% (Mt. Makulu). Areas with high density estimates of uptake were located near health centers, and generally declined in more remote areas (Figure 1). When compared to those who did not access PMTCT services, those initiating a PMTCT regimen were older, had higher parity and education, had prior knowledge of their HIV status, attended an ANC clinic for their previous pregnancy, delivered in a health institution, and lived near a health facility. Household wealth was not associated with uptake of PMTCT regimens.

The median distance for a patient reporting any PMTCT regimen was 1.9 km and ranged from <1 km to 20 km. Patients who did not report any PMTCT lived as far as 24 km from a clinic (Table 1). Women receiving combination antiretroviral regimens had similar characteristics to women receiving any PMTCT regimen (Table 1). Clinic distance ranged from <1 km to 15 km, with a median of 1.8 km, among patient's initiating a combination antiretroviral regimen.

Uptake of any PMTCT regimen

Greater distance to clinic was significantly associated with reduced uptake of a PMTCT regimen in bivariable (odds ratio [OR]: 0.90, 95% confidence interval [CI]: 0.84, 0.97) and multivariable (adjusted OR: 0.90, 95%CI: 0.82, 0.99) models. Each one-kilometer increase in distance was associated with a 10% reduced odds for PMTCT regimen uptake. Findings were consistent in sensitivity analyses limited to communities with high ascertainment of GPS information (adjusted OR: 0.90, 95%CI: 0.82, 0.99). This model suggested that women who were older, had obtained education beyond primary school, and who delivered at a facility were more likely to have taken up a PMTCT intervention (Table 2). The probability of initiating any PMTCT was highest among participants living within 1.9 km of the facility and steadily declined with increased distance (Figure 2A). Overall, 103 of 145 (71%) who lived within 1.9 km of the facility initiated PMTCT, compared to 65 of 109 (60%) who lived farther away.

Uptake of combination antiretroviral regimens

As the distance between clinic and household increased by one kilometer, the odds for combination antiretroviral regimen uptake decreased in bivariable (OR: 0.89, 95%CI: 0.82, 0.97) and multivariable (adjusted OR: 0.88, 95%CI: 0.80, 0.97) models. Each one-kilometer increase in distance was associated with a 12% decreased odds for combination antiretroviral regimen uptake. Findings were consistent in sensitivity analyses limited to

communities with high ascertainment of GPS information (adjusted OR: 0.87, 95%CI: 0.78, 0.96). Our model suggested that older women were more likely to uptake a combination antiretroviral regimen, while those who initiated antenatal care later in pregnancy were less likely (Table 2). The probability of initiating a combination antiretroviral regimen declined gradually as distance increased. The probability of initiating a combination antiretroviral regimen was highest among participants living within 1.9 km of the facility and steadily declined with increased distance (Figure 2B). Overall, 65 of 145 (45%) who lived within 1.9 km of the facility initiated PMTCT, compared to 37 of 109 (34%) who lived farther away.

DISCUSSION

We observed reduced uptake of PMTCT services, including maternal combination antiretroviral regimens, as the distance between home and clinic increased. Uptake of PMTCT was highest within 1.9 km of a clinic and steadily declined as distance increased. This finding is consistent with previous work in the field of HIV treatment, where long distance and travel costs are recognized barriers to care and treatment in resource-constrained settings.[10, 12, 15] However, it contrasts past studies of antenatal care, in which distance did not appear to influence the timing or frequency of antenatal visits.[19, 20] We expected this contrast due to potential fear of stigma associated with PMTCT uptake.[14] Since PMTCT bridges these two health services, dedicated studies such as this – focused on PMTCT utilization at the population level – provide important supporting evidence for the design of future programs.

We used precise GPS household location information, which allowed us to calculate distance from home to clinic and examine geospatial patterns of uptake. However, we were unable to measure path distance – or to estimate travel time – to clinic because of limited data on the rural road network in our study area. Instead, we used Euclidean distance, which has been found to be highly correlated with path distance in other rural settings.[18, 27] In addition, we did not have the necessary data to weight distance measures by costs associated with travel (e.g., car, bus, bicycle, foot). This analysis thus assumes that potential modes of transportation have no influence on PMTCT uptake, which may not be realistic,[28] since cost would likely increase with distance.

More than one-third of the GPS coordinates were missing from participating households. This is a potential limitation of this analysis; if this missing data was not at random, it could unduly bias the study results. To address this issue, we compared individuals with and without recorded GPS coordinates and found that there were few differences between these populations, including by uptake of PMTCT services. Missing data appeared to be concentrated in the Kafue Estates community, due to technical difficulties with the instruments themselves that were discovered only after the survey had finished. When we excluded this single site in a sensitivity analysis, we were reassured to find that the results were consistent. While not definitive, these supporting analyses do provide a degree of reassurance about our primary findings.

Negative perceptions about clinical care and fear of stigma, could have been associated with service uptake in the antenatal setting.[14, 29] It is also possible that the use of self-reported

PMTCT uptake measures influenced our primary outcome. These factors may explain the overall low uptake of services, with fewer than 50% of participants receiving combination antiretroviral regimens, and more than 30% never initiating PMTCT at all. However, we were unable to examine potential cultural or social factors that may influence a mother's decision to start a PMTCT regimen. Mixed methods approaches may be of particular promise for future work, as program managers and researchers seek to identify and understand the host of potential obstacles for PMTCT service utilization. Such formative work is critical to the design of interventions and implementation strategies appropriate to the local context.

Long distance and travel costs have been linked to poor program outcomes among HIV-infected adults in several settings, and are recognized barriers to HIV testing, timely antiretroviral therapy initiation, and consistent drug adherence.[30–33] The impact of distance in this PMTCT context is particularly important, as PMTCT and general HIV treatment become increasingly aligned through innovative strategies such as Option B+. Interestingly, our distance threshold of 1.9 kilometers – after which the uptake of PMTCT services steadily declined – is similar to those observed in other settings. In South Africa, for example, ART uptake was highest among individuals living within 1 km of a health facility, after which a decline in uptake was observed.[34] In Kenya, clients living within 1 km of the main road (correlated with hospital distance) were less likely to be lost to follow up after registering for HIV care, compared to individuals living 1–5 km and >5 km from the main road.[35] This distance threshold is important to consider in planning for health care availability, as it appears to apply across diverse settings in sub-Saharan Africa.

Several aspects of our pilot program may have influenced PMTCT uptake. We incorporated CD4 screening and triage, as mandated by the Zambian national guidelines.[23] CD4 evaluation significantly delays antiretroviral therapy initiation during pregnancy in many settings.[36] Guided by national guidelines [23] to initiate ZDV at 28 weeks gestation, we waited until at least 28 weeks gestation to start combination antiretroviral regimens for those women who did not immediately qualify for antiretroviral therapy based on maternal health. Thus, those who presented early in pregnancy and learned their HIV status were required to return later in pregnancy to start combination prophylaxis. The need for a second visit may have negatively influenced uptake. While newer PMTCT policies for Option B/B+ largely address these bottlenecks (e.g., antiretroviral therapy initiation from 14 weeks onward, elimination of CD4 triage) – and thus should improve uptake of services – distances between home and clinic will continue to have an important and ongoing role in drug adherence and clinical care engagement.

Our pilot program integrated HIV treatment within the framework of maternal-child health services, a strategy that has been shown to increase the timely initiation of antiretroviral therapy among pregnant women.[36, 37] However, decentralization to primary care settings alone may not be enough to maximize coverage of services. In rural settings, new models may be needed to extend the existing health system. Mobile clinics, for example, have been shown to be effective for ongoing monitoring and drug distribution.[38] Community health workers and other outreach personnel can also reliably increase service uptake, enhance

adherence (through counseling and drug delivery), and improve program retention over time.[39, 40]

In summary, we observed an important association between home-to-clinic distance and uptake of PMTCT services. These results are consistent with other studies in the HIV treatment literature, and highlight the need for greater investments in health infrastructure beyond primary health care facilities and into communities. As national programs seek to further reduce the number of new pediatric HIV infections, the enhancement of existing PMTCT services must be accompanied by new strategies to decentralize care and maximize coverage across rural and remote settings.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Sources of support: The work reported herein was funded by Clinical Scientist Development Award from the Doris Duke Charitable Foundation (2007061). Additional trainee support was provided by the National Institutes of Health (NIH 5 T32AI07001–36, R24 HD050924, R24 TW007988).

References

1. Global Report: UNAIDS Report on the Global AIDS Epidemic: 2012. UNAIDS; 2012.
2. Kesho Bora Study Group. Triple antiretroviral compared with zidovudine and single-dose nevirapine prophylaxis during pregnancy and breastfeeding for prevention of mother-to-child transmission of HIV-1 (Kesho Bora study): a randomised controlled trial. Lancet Infectious Diseases. 2011; 11:171–180. [PubMed: 21237718]
3. Thomas TK, Masaba R, Borkowf CB, et al. Triple-antiretroviral prophylaxis to prevent mother-to-child HIV transmission through breastfeeding—the Kisumu Breastfeeding Study, Kenya: a clinical trial. PLoS medicine. 2011; 8:e1001015. [PubMed: 21468300]
4. Shapiro R, Hughes M, Ogwu A, et al. Antiretroviral regimens in pregnancy and breast-feeding in Botswana. N Engl J Med. 2010; 362:2282–2294. [PubMed: 20554983]
5. Chasela CS, Hudgens MG, Jamieson DJ, et al. Maternal or Infant Antiretroviral Drugs to Reduce HIV-1 Transmission. N Engl J Med. 2010; 362:2271–2281. [PubMed: 20554982]
6. World Health Organization. Antiretroviral therapy for treating pregnant women and preventing HIV infection in infants; recommendations for a public health approach - 2010 revision. Geneva, Switzerland: WHO Press; 2010.
7. World Health Organization. Consolidated guidelines on the use of antiretroviral drugs for and preventing HIV infection: Recommendations for a public health approach. 2013.
8. Schouten EJ, Jahn A, Midiani D, et al. Prevention of mother-to-child transmission of HIV and the health-related Millennium Development Goals: time for a public health approach. The Lancet. 2011; 378:282–284.
9. Gourlay A, Birdthistle I, Mburu G, Iorpenda K, Wringe A. Barriers and facilitating factors to the uptake of antiretroviral drugs for prevention of mother-to-child transmission of HIV in sub-Saharan Africa: a systematic review. J Int AIDS Soc. 2013; 16:18588. [PubMed: 23870277]
10. Zachariah R, Harries AD, Manzi M, Gomani P, Teck R, Firmenich P. Acceptance of anti-retroviral therapy among patients infected with HIV and tuberculosis in rural Malawi is low and associated with cost of transport. PloS one. 2006; 1:e121. [PubMed: 17205125]
11. Chinkonde JR, Sundby J, Martinson F. The prevention of mother-to-child HIV transmission programme in Lilongwe, Malawi: why do so many women drop out. Reprod Health Matters. 2009; 17:143–151. [PubMed: 19523591]

12. Tuller DM, Bangsberg DR, Senkungu J, Ware NC, Emenyonu N, Weiser SD. Transportation costs impede sustained adherence and access to HAART in a clinic population in southwestern Uganda: a qualitative study. AIDS and Behavior. 2010; 14:778–784. [PubMed: 19283464]
13. O'Gorman DA, Nyirenda LJ, Theobald SJ. Prevention of mother-to-child transmission of HIV infection: views and perceptions about swallowing nevirapine in rural Lilongwe, Malawi. BMC Public Health. 2010; 10:354. [PubMed: 20565930]
14. Duff P, Kipp W, Wild TC, Rubaale T, Okech-Ojony J. Barriers to accessing highly active antiretroviral therapy by HIV-positive women attending an antenatal clinic in a regional hospital in western Uganda. J Int AIDS Soc. 2010; 13:37. [PubMed: 20863399]
15. Skinner D, Mfecane S, Gumede T, Henda N, Davids A. Barriers to accessing PMTCT services in a rural area of South Africa. African Journal of AIDS Research. 2005; 4:115–123. [PubMed: 25870888]
16. Cook RE, Ciampa PJ, Sidat M, et al. Predictors of successful early infant diagnosis of HIV in a rural district hospital in Zambezia, Mozambique. J Acquir Immune Defic Syndr. 2011; 56:e104–9. [PubMed: 21266912]
17. Iroha E, Esezobor CI, Ezeaka C, Temiye EO, Akinsulie A. Adherence to antiretroviral therapy among HIV-infected children attending a donor-funded clinic at a tertiary hospital in Nigeria. African Journal of AIDS Research. 2010; 9:25–30. [PubMed: 25860410]
18. Siedner MJ, Lankowski A, Tsai AC, et al. GPS-measured distance to clinic, but not self-reported transportation factors, are associated with missed HIV clinic visits in rural Uganda. AIDS. 2013; 27:1503–1508. [PubMed: 23435294]
19. Prudhomme O'Meara W, Platt A, Naanyu V, Cole D, Ndege S. Spatial autocorrelation in uptake of antenatal care and relationship to individual, household and village-level factors: results from a community-based survey of pregnant women in six districts in western Kenya. International journal of health geographics. 2013; 12:55. [PubMed: 24314170]
20. Kyei NN, Campbell OM, Gabrysch S. The influence of distance and level of service provision on antenatal care use in rural Zambia. PloS one. 2012; 7:e46475. [PubMed: 23056319]
21. Chi BH, Stringer JS, Moodley D. Antiretroviral drug regimens to prevent mother-to-child transmission of HIV: a review of scientific, program, and policy advances for sub-Saharan Africa. Current HIV/AIDS Reports. 2013; 10:124–133. [PubMed: 23440538]
22. Gartland MG, Chintu NT, Li MS, et al. Field effectiveness of combination antiretroviral prophylaxis for the prevention of mother-to-child HIV transmission in rural Zambia. AIDS. 2013; 27:1253–1262. [PubMed: 23324656]
23. Zambian Ministry of Health. National protocol guidelines: integrated prevention of mother-to-child transmission of HIV/AIDS. Available at: http://www.aidstar-one.com/sites/default/files/treatment_documents/hiv_treatment_guidelines_zambia_pmtct_2007.pdf
24. Chi BH, Musonda P, Lembalemba MK, et al. Universal combination antiretroviral regimens to prevent mother-to-child transmission of HIV in rural Zambia: a two-round cross-sectional study. Bull World Health Organ. 2014; 92:582–592. [PubMed: 25177073]
25. Silverman, BW. Density Estimation for Statistics and Data Analysis. New York: Chapman and Hall; 1986.
26. Filmer D, Pritchett LH. Estimating wealth effects without expenditure Data—Or tears: An application to educational enrollments in states of india*. Demography. 2001; 38:115–132. [PubMed: 11227840]
27. Perez-Heydrich C, Furgurson JM, Giebultowicz S, et al. Social and spatial processes associated with childhood diarrheal disease in Matlab, Bangladesh. Health Place. 2013; 19:45–52. [PubMed: 23178328]
28. Stout BD, Leon MP, Niccolai LM. Nonadherence to antiretroviral therapy in HIV-positive patients in Costa Rica. AIDS Patient Care STDS. 2004; 18:297–304. [PubMed: 15186713]
29. Van Eijk AM, Bles HM, Odhiambo F, et al. Use of antenatal services and delivery care among women in rural western Kenya: a community based survey. Reproductive health. 2006; 3:2. [PubMed: 16597344]

30. Ramadhani HO, Thielman NM, Landman KZ, et al. Predictors of Incomplete Adherence, Virologic Failure, and Antiviral Drug Resistance among HIV-Infected Adults Receiving Antiretroviral Therapy in Tanzania. Clinical Infectious Diseases. 2007; 45:1492–1498. [PubMed: 17990233]

31. Sowah L, Turrene F, Delva G, et al. B112 An Evaluation of Distance and its Impact on Long-term Follow up Outcomes in a Rural HIV Clinic in Northern Haiti. JAIDS J Acquired Immune Defic Syndromes. 2013; 62:40.

32. Lankowski A, Siedner M, Bangsberg D, Tsai A. Impact of Geographic and Transportation-Related Barriers on HIV Outcomes in Sub-Saharan Africa: A Systematic Review. AIDS and Behavior. 2014; 18:1199–1223. [PubMed: 24563115]

33. Govindasamy D, Ford N, Kranzer K. Risk factors, barriers and facilitators for linkage to antiretroviral therapy care: a systematic review. AIDS. 2012:26.

34. Cooke GS, Tanser FC, Barnighausen TW, Newell ML. Population uptake of antiretroviral treatment through primary care in rural South Africa. BMC Public Health. 2010; 10 585-2458-10-585.

35. Hassan AS, Fielding KL, Thuo NM, Nabwera HM, Sanders EJ, Berkley JA. Early loss to follow-up of recently diagnosed HIV-infected adults from routine pre-ART care in a rural district hospital in Kenya: a cohort study. Tropical Medicine & International Health. 2012; 17:82–93. [PubMed: 22943164]

36. Killam WP, FAU TB, Chintu NF, et al. Antiretroviral therapy in antenatal care to increase treatment initiation in HIV-infected pregnant women: a stepped-wedge evaluation. AIDS. 2010; 24:85–91. [PubMed: 19809271]

37. Chi BH, Bolton-Moore C, Holmes CB. Prevention of mother-to-child HIV transmission within the continuum of maternal, newborn, and child health services. Curr Opin HIV AIDS. 2013; 8:498–503. [PubMed: 23872611]

38. Moon, TD.; Jequicene, T.; Blevins, M., et al. Mobile clinics for antiretroviral therapy in rural Mozambique. Bull World Health Organ. 2014. http://www.who.int/bulletin/online_first/BLT.13.129478.pdf

39. Chang LW, Alamo S, Guma S, et al. Two-year virologic outcomes of an alternative AIDS care model: evaluation of a peer health worker and nurse-staffed community-based program in Uganda. J Acquir Immune Defic Syndr. 2009; 50:276–282. [PubMed: 19194316]

40. Jaffar S, Amuron B, Foster S, et al. Rates of virological failure in patients treated in a home-based versus a facility-based HIV-care model in Jinja, southeast Uganda: a cluster-randomised equivalence trial. The Lancet. 2010; 374:2080–2089.

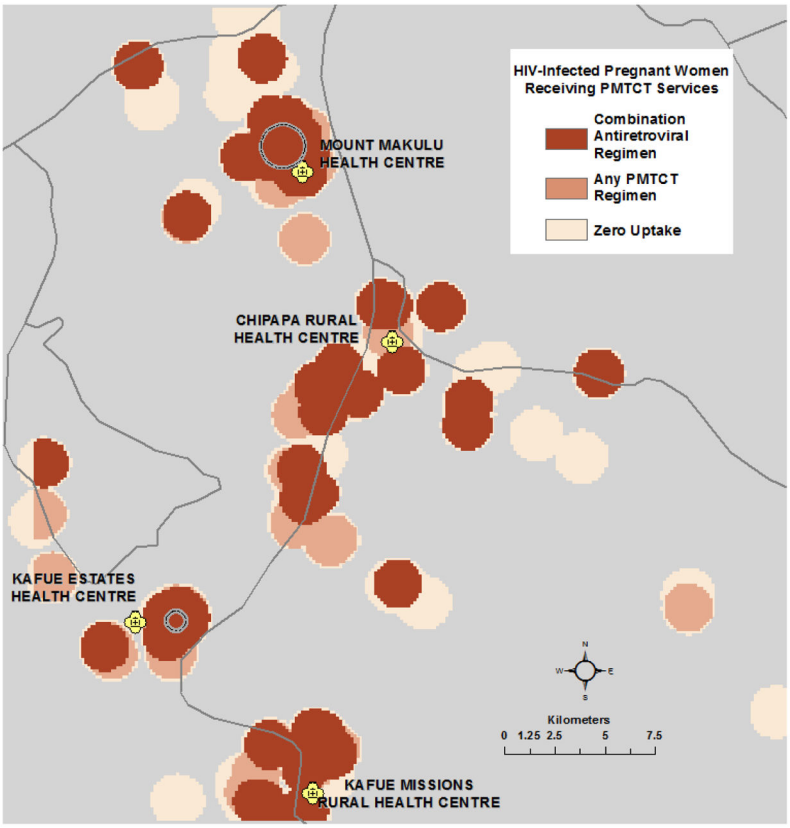

Figure 1.

Kernel density estimates representing the number of HIV-infected women per km2 who initiated PMTCT regimens. Clusters on the map represent all HIV-infected mothers who participated in the survey. The light peach clusters demarcate areas with zero uptake of PMTCT services, while the light and dark orange clusters represent areas where density of PMTCT uptake ranged from 1 to 10 persons per km2. The dark orange clusters represent uptake of combination antiretroviral regimens only, ranging from 1 to 10 persons per km2. Overall, areas with high density estimates of uptake were located near health centers, and declined in rural areas. The highest density estimates of uptake ranged from 10 to 20 per km2 near Kafue Estates Health Centre and Chipapa Rural Health Centre (demarcated by gray circle).

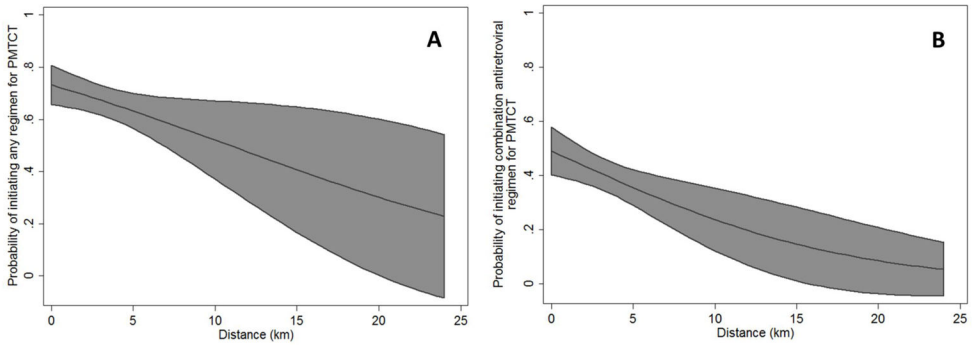

Figure 2.

Predicted probabilities of initiating PMTCT estimated from multivariable logistic regression models. The probability of initiating any PMTCT regimen was highest among participants living within 1.9 km of the facility and declined steadily with distance. Wider confidence intervals are observed at greater distances where few participants reported PMTCT. The probability of initiating a combination antiretroviral regimen had a steeper decline as distance increased due to zero uptake among participants living beyond 15 km.

Table 1

Household, demographic, and clinic characteristics stratified by PMTCT uptake of participating HIV-infected mothers in the post-implementation household survey (2011), Kafue District, Zambia

	Any PMTCT regimen (N=254)			Combination antiretroviral regimen (N=254)		
	Yes (N=168)	**No (N=86)**	**P**	**Yes (N=102)**	**No (N=152)**	**P**
Household characteristics	*N (%)*			*N (%)*		
Water supply to household			0.95			0.77
Piped water into house	18 (10.7)	4 (4.7)		11 (10.8)	11 (7.2)	
Piped water outside but available within plot	36 (21.4)	13 (15.1)		20 (19.6)	29 (19.1)	
Public tap	54 (32.1)	33 (38.4)		33 (32.4)	54 (35.5)	
Other	60 (35.8)	36 (41.8)		38 (37.2)	58 (38.2)	
Toilet facilities in household			0.52			0.08
Flush toilet or pit latrine	151 (89.9)	11 (12.8)		95 (93.1)	131 (86.2)	
No facility	17 (10.1)	75 (87.2)		7 (6.9)	21 (13.8)	
Main material of floor			0.07			0.29
Finished floor (cement/tiles/wood planks)	117 (69.6)	50 (58.1)		71 (69.6)	96 (63.2)	
Natural floor (earth/mud/dung/sand)	51 (30.4)	36 (41.9)		31 (30.4)	56 (36.8)	
Electricity in the household	60 (35.7)	29 (33.7)	0.75	36 (35.3)	53 (34.9)	0.94
Refrigerator in the household	40 (23.8)	9 (10.5)	0.82	26 (25.5)	23 (15.1)	0.04
Television in the household	61 (36.3)	30 (34.9)	0.05	40 (39.2)	51 (33.6)	0.36
Cell phone in the household	131 (78.0)	68 (79.1)	0.84	80 (78.4)	33 (21.7)	0.98
Maternal characteristics	*Median (IQR)*			*Median (IQR)*		
Age in years at survey	29 (25, 34)	26 (22, 31)	0.00	32 (26, 35)	27 (22, 32)	<0.001
Parity	3 (2, 4)	2 (1, 4)	0.05	3 (2, 4)	2 (1, 4)	<0.01
Gestational age when antenatal care started, months	5 (4, 6)	5 (4, 6)	0.25	4 (3, 5)	5 (4, 6)	0.01
	N (%)			*N (%)*		
Marital status			0.59			0.63
Married/cohabitating	136 (81.0)	72 (83.7)		85 (83.3)	123 (80.9)	
Other	32 (19.0)	14 (16.3)		17 (16.7)	29 (19.1)	
Education			0.010			0.20
No schooling or primary	84 (51.2)	58 (68.2)		51 (52.0)	91 (60.3)	

	Any PMTCT regimen (N=254)			Combination antiretroviral regimen (N=254)		
	Yes (N=168)	**No (N=86)**	**P**	**Yes (N=102)**	**No (N=152)**	**P**
Secondary or higher	80 (48.9)	27 (31.8)		47 (48.0)	60 (39.7)	
Mother currently employed	81 (48.2)	47 (54.7)	0.33	59 (57.8)	69 (45.4)	0.05
Reported knowing HIV status prior to survey	167 (99.4)	10 (11.6)	<0.001	102 (100.0)	75 (51.02)	<0.001
Enrolled into antenatal care last pregnancy	168 (100.0)	84 (97.7)	0.05	102 (100.0)	150 (98.7)	0.25
Delivery in a health institution	129 (76.8)	52 (60.5)	0.01	76 (74.5)	105 (69.1)	0.35
Catchment area clinic attended			0.17			0.18
Chipapa	22 (13.1)	17 (19.8)		15 (14.7)	24 (15.8)	
Kafue Estates	31 (18.5)	9 (10.5)		11 (10.8)	29 (19.1)	
Kafue Mission	28 (16.7)	19 (22.1)		17 (16.7)	30 (19.7)	
Mt. Makulu	87 (51.8)	41 (47.7)		59 (57.8)	69 (45.4)	
Geographical characteristics	*Median (range)*			*Median (range)*		
Distance to clinic in kilometers	2 (<1–20)	2 (<1–24)	<0.001	2 (<1–15)	2 (<1–24)	<0.001
Distance to main road in kilometers	2 (<1-–8)	2 (<1–10)	0.28	2 (<1–7)	2 (<1–10)	0.72

*Categorical variables compared via Pearson's chi-squared test; continuous variables compared via Wilcoxon rank-sum test, and a two-sample t-test if normally distributed

Table 2

Factors associated with uptake of any PMTCT regimen and/or uptake of a combination antiretroviral regimen among HIV-infected women across four communities in Kafue District, Zambia

	Any PMTCT regimen		Combination antiretroviral regimen	
	Unadjusted Odds Ratio (95% CI)	**Adjusted Odds Ratio (95% CI) ***	**Unadjusted Odds Ratio (95% CI)**	**Adjusted Odds Ratio (95% CI) ***
Distance to clinic (km)	0.90 (0.84, 0.97)	0.90 (0.82, 0.99)	0.89 (0.82, 0.97)	0.88 (0.80, 0.97)
Maternal age at time of survey, years				
15 to <25 years	Ref	Ref	Ref	Ref
25 to <35 years	2.02 (1.12, 3.65)	2.04 (0.95, 4.38)	3.17 (1.63, 6.15)	3.23 (1.46, 7.17)
35 years or older	3.18 (1.36, 7.44)	4.11 (1.50, 11.29)	5.43 (2.46, 12.0)	6.31 (2.28, 17.43)
Parity				
0–1	Ref	Ref	Ref	Ref
2–3	1.83 (0.96, 3.48)	1.41 (0.62, 3.20)	1.96 (0.99, 3.87)	1.20 (0.52, 2.77)
4 or more	2.08 (1.00, 4.33)	1.45 (0.55, 3.79)	2.72 (1.30, 3.87)	1.38 (0.53, 3.61)
Education				
No schooling or primary only	Ref	Ref	Ref	Ref
Secondary or higher	2.05 (1.17, 3.57)	2.03 (1.08, 3.80)	1.40 (0.83, 2.36)	1.79 (0.95, 3.36)
Institutional delivery				
No	Ref	Ref	Ref	Ref
Yes	2.16 (1.21, 3.85)	1.92 (0.98, 3.76)	1.31 (0.74, 2.32)	1.17 (0.58, 2.36)
SES score (continuous by quintile)§	1.15 (0.96, 1.38)	0.87 (0.68, 1.12)	1.12 (0.94, 1.34)	0.99 (0.76, 1.28)
Mother currently employed				
No	Ref	--	Ref	Ref
Yes	0.77 (0.45, 1.32)	--	1.65 (0.98, 2.77)	1.55 (0.85, 2.82)
Initial antenatal care visit (month)	0.89 (0.74, 1.08)	--	0.80 (0.64, 0.95)	0.83 (0.66, 1.03)

*Adjustments were made for health facility in multivariable analyses.

§Composite score of household assets and structural material