

# Using GIS to Understand Cervical Cancer Screening Behaviors among Women Living with HIV (WLWH) in Ghana

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## Abstract

**Objective:** This study used the Geographic Intelligent Systems to examine the location of cervical cancer screening (CCS) facilities and their proximity to the residential location of Women Living with HIV (WLWH) and how they could influence WLWH CCS behaviors. **Methods:** We used deidentified existing data from Komfo Anokye Teaching Hospital (KATH) on WLWH and geocoded them to their community of residence as points using Google Earth Pro version 7.3.0. Transport fares from KATH to communities identified in the screening database were also obtained. The location of KATH was digitized from google earth and validated from the GIS database from the Remote Sensing and GIS application Laboratory, University of Ghana. We calculated distances and other proximity information between each point from the KATH. We used the spatial-analytical tool of kernel density for the density analysis and fitted a smoothly tapered surface using Esri's ArcGIS Desktop 10.8. We performed Shapiro-Wilk normal distribution test to assess the significance of the clustering. **Results:** Data on 708 WLWH's residential locations and transportation fares were analyzed. We find a significant clustering near KATH. Close to 50% cluster within 5km from KATH whiles 85.8% of the respondents live within 10.2 km from KATH. Shapiro-Wilk normality test shows  $W=0.30221$ ,  $p\text{-value} < 0.05$ . The minimum cost per commercial transportation is approximately GHC 2.00 (US dollar ~ \$0.26 whiles those living beyond 3-5 km will pay approximately GHC 3.00 (~\$0.39). The highest cost payable by the farthest distance using a commercial bus is GHC 50.00. (~\$ 6.00). The majority of respondents will pay about GHC 10.00 (~\$1.50) for transportation (i.e., round trip) to access SCC facilities. **Conclusions:** In an economy where a family lives on less than \$2.00 per day, any additional cost resulting from transportation will likely create CCS hesitancy and that self-sampling may be a recommended solution.

**Keywords:** Women Living With HIV- Cervical Cancer Screening- Geographic Intelligent Systems- self-sampling

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## Introduction

Approximately 69,100 new cases of HIV were diagnosed and over 13,500 annual reported AIDS deaths in Ghana in 2019 [1]. Since the introduction of highly active antiretroviral therapy (HAART) in Ghana in 2003, the number of people living with HIV (PLWH) is increasing. It is estimated that a total of 342,307 PLWH were living in Ghana, out of which 36% were males and 64% were females [1,2].

Persons living with HIV (PLWH) are at significantly high risk for developing HPV-related cancers: Kaposi sarcoma, aggressive B-cell non-Hodgkin's lymphoma, and cervical cancer (CC) [3]. Evidence showed that women

living with HIV (WLWH) have a six-fold increased risk of developing CC compared to their uninfected counterparts [4]. CC remains the number one cancer burden among WLWH in low and middle-income countries (LMICs), [5] with over 80% of the burden concentrated in sub-Saharan Africans [4,6]. WLWH are at risk of developing CC up to 10 years earlier and require frequent screening [7-9].

The World Health Organization (WHO) recommends using Human Papilloma Virus (HPV) DNA detection as a primary cervical cancer screening (CCS) test for WLWH starting at the age of 25 years and subsequently every 3 to 5 years [10]. WHO also suggests using visual inspection

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with acetic acid (VIA) to triage women after positive HPV DNA test before treatment. Population-based CCS has resulted in early diagnosis and a reduction of CC burden in high-income countries (HICs) [11]. Despite the efficacy of cervical cancer screening in preventing cancer, LMICs such as Ghana have no specific cervical cancer screening program, [11-14] contributing to the high risk in Ghana [5,11,15-19]. Currently, Ghana recommends CCS with VIA for women between the ages of 25–45 years and treatment of lesions with cryotherapy, and Papanicolaou (Pap) tests for women over the age of 45.7, [20,21]. However, due to lack of coordination, the CCS process in Ghana is sometimes considered as an “opportunistic screening”, where Pap test and VIA are requested for patients in hospitals as part of general medical examination or for consultations related or unrelated to CC but not part of community-wide screening efforts [11,13]. The overall general cervical cancer rates among women in Ghana are very low [11,13] with participation rates around 2.7% of the eligible population [21]. There are no available national data on the screening behavior of WLWH in Ghana. Additionally, our understanding of how geographical locations of screening resources influence WLWH’s ability to access cervical cancer screening facilities are limited and inconclusive. Whereas some studies have shown that WLWH prefer screening centers which are distant from their place of residence, some have argued that transportation cost and time of travel, coupled with traffic congestion constitute a major hindrance to screening seeking behavior of WLWH. Understanding screening seeking behavior in relation to place of residence, time, and cost of travel requires spatial analysis using geospatial technologies such as Geographic Information Systems (GIS).

The use of GIS can help determine the association between the availability and accessibility of screening resources and WLWH screening behaviors.

The purpose of this study was to use GIS to examine if the location of screening facilities and their proximity to the residential location of WLWH could influence WLWH screening behaviors.

## Materials and Methods

### *The Study Area*

This study was conducted at the Komfo Anokye Teaching Hospital (KATH), located at the heart of the Kumasi Metropolitan Area, the second-largest city of Ghana and the capital of the Ashanti region. The Ashanti Region is located in southern Ghana, covering a total land surface area of approximately 24,389 km<sup>2</sup>. It is situated between longitudes 0.15W and 2.25W and latitudes 5.50N and 7.46N. It shares land borders with five (5) administrative regions; namely, the Eastern Region located at the east, the Western North Region facing the south-west, the Central Region (to the south), the Bono East Region (to the north), Ahafo Region (to the east) and Bono Region located at the North- West. The Ashanti region is sub-divided into 43 administrative districts, 24 of which are district assemblies, 18 of which are municipal

assemblies, and one metropolitan assembly, the Kumasi Metropolitan Assembly.

The Ashanti Region has the second largest population. The population increased to 5,440,463 people in the year 2021, according to the Ghana Statistical Service. Females represented 50.7 percent (2,760,549), while males formed 49.3 percent (2,679,914) of the population. Between 2010 and 2020, the population increased at a rate of 1.2 percent. Over half of the region’s populace live in urban zones, making it the second-most densely populated region in Ghana. The Asantes are the main indigenes of the Ashanti Region, but other ethnic groups live there as well. The Asante nation’s social administration is led by traditional chiefs and elders, and each division has its own chief or paramount chief.

Forestry and agriculture (the production of timber and livestock) are the region’s most important economic activities. Cocoa is an important crop cultivation in some parts of the region, and the region also has the country’s largest mining site. Furthermore, other residents provide other services such as food, lodging, manufacturing, retail, and wholesale. According to the National Population Council’s 2018 report, Ashanti Region had the highest employment rate for both males and females, at 19.7 percent and 18.8 percent, respectively. Due to the high level of employment opportunities, Kumasi the region’s capital is seen as the center of commerce where transportation arteries radiate towards different parts of Ghana, thereby facilitating intra and inter-urban commuting.

KATH is the primary referral hospital servicing different parts of the country. The hospital provides services to the hospitals in the Ashanti region and its population, however since it is a referral hospital, its catchment area covers six (6) other regions. It has facilities for cervical cancer screening (Pap smear and HPV testing) and an HIV clinic that caters for almost 4500 clients. Figure 1 is the map of the study area showing the location of KATH and Ghana inst.

### *Data Preparation and analysis*

The data on three variables of interest namely locality of residence, estimated age, and Out-patient Department (OPD) number, on WLWH were obtained from the deidentified database on attendants at the KATH HIV clinic in an excel spreadsheet. Data cleaning was done taking out observations with no stated locality, localities impossible to track and duplicates. There were 708 records remaining after the cleaning, out of a total of 1260 rows of data received. We also did informal checks on transport fares from KATH to some selected communities identified in the screening database.

The locality of residence for each subject was picked and places were recognized and geocoded as points using Google Earth Pro version 7.3.0. The location of KATH was digitized from google earth and validated from the GIS database of the Remote Sensing and GIS application Laboratory, University of Ghana.

In the analysis, the first task was to calculate distances and other proximity information between each of the points from the KATH, and the second task was to calculate a

magnitude-per-unit area from each point feature using a kernel density function to fit a smoothly tapered surface. Esri's ArcGIS version 10.8 was used for this approach. The first task was completed using the "generate near table" tool, while the second task was completed using the "kernel destiny" tool.

**Results**

Evaluable data from 706 WLWH were included in the analysis. The results of the analysis show that the farthest distance that WLWH travel to KATH for screening is approximately 179 km and the minimum distance is 0.3 km. The farthest town is Asuom in the Eastern region. Statistics on WLWH travel distance to KATH are shown on Table 1. The median distance is 5.2 km suggesting that over 50% of the respondents travel less than 6km to receive screening. Of the 706 respondents, the modal distance that WLWH travel to access care at KATH is 2.1 Km, suggesting that a high percentage of the respondents are within a walking distance from KATH.

In testing the distribution, we used Shapiro-Wilk normal distribution test and the results are plotted on Figure 2.

The test shows that the distribution is not normal and that it clusters close to the origin (KATH).

44.8% of the sample cluster within 5km from KATH while 85.8% of the respondents live within 10.2 km from KATH. Shapiro-Wilk normality test shows  $W = 0.30221$ ,  $p\text{-value} < 2.2e-16$ , and this suggests that the test is statistically significant since the p-value is less than 0.05.

Table 1. Distance that WLWH Travel to Access Care at KATH

Description	Distance
Mean	10.2633634
Median	5.208577036
Mode	2.153052064
Minimum	0.295236179
Maximum	178.8126202
Count	706

Results from the kernel density analysis performed (Figure 3) on the spatial distribution also shows that the respondents' clusters within 5 km from KATH.

Cost of travel to KATH is related to the type of road transport mode and distance from KATH. The minimum cost per minivan, popularly known locally as "trotro" and commercial buses is approximately GHC 2.00 (US dollar ~ \$0.26) while those living beyond 3-5 km will pay approximately GHC 3.00 (~\$0.39). The highest cost payable by the farthest distance using a commercial bus is GHC 50.00. (~\$ 6.00). On average, the majority of respondents will pay about GHC 10.00 (~\$1.50) for transportation (i.e., round trip) to access cervical cancer screening facilities.

**Discussion**

WLWH are disproportionately affected by cervical cancer, and they require regular screening [22,23] and yet those women are underrepresented in standard cervical

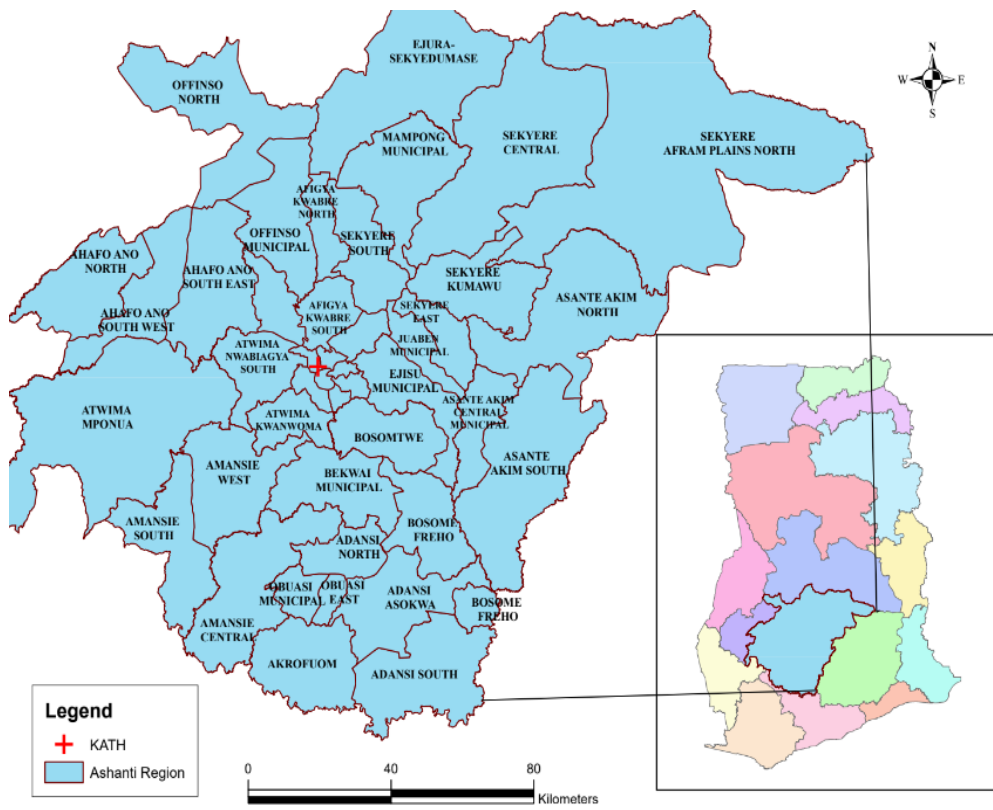


Figure 1. Map of Study Area Showing the Location of KATH

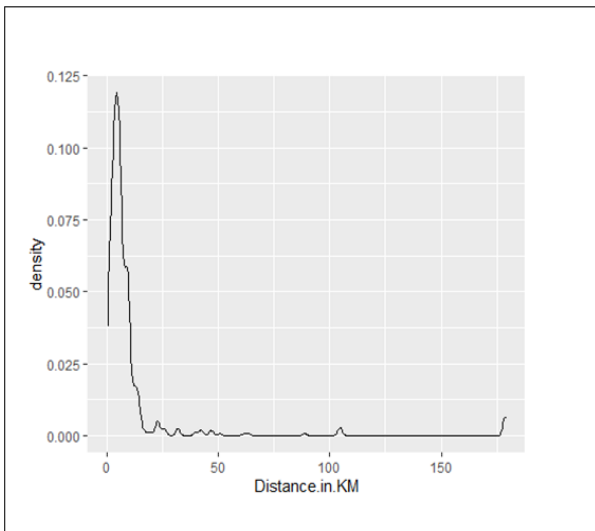


Figure 2. Clustering of WLWH Over Distance to KATH

screening [24,25]. In this study we examined if the location of cervical cancer screening facilities and their proximity to the residential location of WLWH can have an impact on WLWH screening behaviors. Using GIS capabilities, we estimated the distance for commuting from 706 WLWH residential locations to their screening facilities, the transportation cost for each round trip, and the time spent to visit the screening center.

Our main findings showed that half of our study participants live within a walking distance to access screening facilities, indicating distance, transportation

cost, and time are no barriers to their cervical cancer screening behavior. However, for about one-third of the women, distance, transportation cost, and time spent for accessing screening facilities present real challenges. This finding is consistent with other studies that showed transportation as an environmental barrier to cervical cancer screening among women in LMICs [26-28].

*The implications and recommendations*

The findings imply that in a country where 11.3% of the people live on less than 1.9 US dollars per day [29], and routine medical checkup is not standard practice, the transportation cost of more than \$1.00 will increase the economic burden on the women and therefore, they will be less inclined to participate in cervical cancer screening. With transportation issues coupled with other structural (delays at screening centers, traffic congestion, busy work schedules, geographical limitations, low socioeconomic status, lack of resources, and lack of health insurance) and environmental (stigma) challenges, [26-28] self-sampling can be an alternative life-saving cervical cancer screening tool for WLWH in Ghana. Self-sampling is a more recent innovation that enables women in under-screened communities to be screened in the privacy of their own homes using self-collected sampling. Self-collection of vaginal samples is a technique in which women collect their own samples and send them to a clinic or laboratory for examination. HPV self-collection is a convenient way of testing that addresses many of the barriers women face while also increasing screening participation, particularly in under-screened populations [29-31]. While

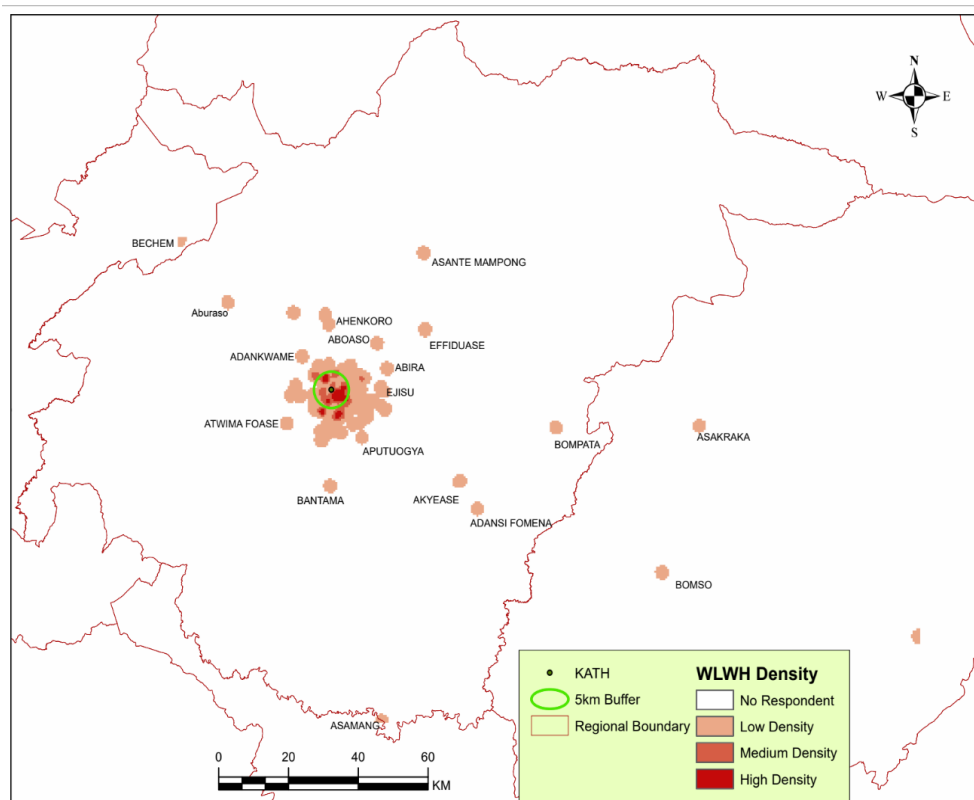


Figure 3. Kernel Density Analysis of WLWH at KATH

self-sampling may be difficult to implement in Ghana because of illiteracy and lack of understanding of self-sampling application, the use of community health nurses can help. The community health nursing visiting homes and communities can increase self-sampling utilization at the community and population levels [32]. Home visiting by community nurses is an integral component of healthcare systems in most LIMCs to increase vaccination and other health behaviors [32-34] and the use of home-visiting strategies has been advocated by WHO and UNICEF [33,35]. During the home or community visit, the community nurses can distribute the self-screening kits to the women in the community, explain how to collect the sample to the women, collect the sample back from the women, and take the samples to the lab for analysis. Though home visiting is labor-intensive, this approach can be critical to solving the transportation problem some women face and helping women to understand the self-collection procedure. Another complementary approach will be using Child Welfare Clinics (CWC) for educating women on self-screening. In Ghana lactating mothers attend CWC on monthly basis at close-to-home centers for immunization and weighing of their children. Attendant Community Health Nurses (CHN), often use these monthly clinics for health education and sharing of welfare benefits and these make the clinics attractive to mothers. CHN, when training could be used as facilitators of self-screening education.

#### *Limitations*

There are weaknesses to be considered when applying existing data to future endeavors. First, the use of existing public data limits our ability to analyze screening behavior among WLWH because the data did not collect screening behavior.

2. Existing intervening screening opportunities (predisposing, enabling, and reinforcing factors) between home and KATH screening center are not known and were not considered in this study. Its likely WLWH would change their screening center if there exist other options and vice versa, yet intervening screening centers were not considered. Future study may have to consider the existing predisposing, enabling, and reinforcing factors that may enhance or hinder WLWH's ability to access screening facilities.

3. The socio-cultural setting of WLWH may to a large extent influence their screening behavior through stigmatization and their belief system. However, the existing databases used for this study did not capture that and was not considered in this study. Future studies may have to consider and analyze how socio-cultural settings influence screening center preference – i.e., distant vs close-to-home. Sometimes choice of screening center may be influenced by the fact that a friend or close associate goes or work there and these should be important consideration in future studies.

Despite those limitations, this study contributes to our understanding of how WLWH's location of residence and the transportation cost could be a barrier to WLWH's ability to access cervical cancer screening.

In conclusions, this study was conducted against the background that understanding the potential screening-seeking behavior of WLWH in relation to place of residence and cost of travel is important for the promotion of HPV screen and vaccination. The study sought the use of GIS as spatio-analytical tool to examine the location of screening facilities and their proximity to the residential location of WLWH using publically available data from the KATH screening center. We observed that large majority of the WLWH live within walking distance from the center. However, there are others who travel close to 180 km to the center for screening. The minimum total travel cost of GHC 4.00 may not be much yet majority of the WLWH pay around GHC 10 roundtrip cost, which is more than a dollar per screening visit. In an economy where a family lives on less than 2 US dollars per day we believe the cost of travel is likely to create screening hesitancy. Perhaps the distance factor may be better understood if we include existing intervening screening centers, and also the socio-cultural setting and economic status of WLWH and their community.

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#### *Funding Statement*

N/A

#### *Approval*

N/A

#### *Conflict of Interest*

We declare no conflict of interest.

#### *Ethical Declaration*

Secondary data research with no individual identity.

#### *Authors Contribution*

This work is a collaborative effort among all authors (Alex Barimah Owusu (ABO), Matthew Asare (MA) and Ruth Owusu (RO)). ABO, took part in the study design, performed data cleaning and analysis. MA wrote the background, contributed to the discussion and conclusion sections of the first draft of the manuscript. Author RO was also involved in the study design, data cleaning and analysis. ABO and RO wrote the methodology and the results sections of the study. Author MA managed the literature searches and contributed to the discussion and conclusion sections. He also contributed to the references. All authors read and approved the final manuscript. ABO managed the corresponding authorship.

#### *Study Registration*

N/A

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