

Spatial Patterns and Associated Factors of HIV Seropositivity among Adults in Ethiopia from EDHS 2016: A Spatial and multilevel analysis

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Abstract

Background

HIV is a major public health problem, especially in developing countries including Ethiopia. Exploring the spatial pattern, distribution and associated factors of HIV Seropositivity is important to monitor, and design effective intervention programs. Therefore, this study showed associated factors and spatial variation of HIV Seropositivity in Ethiopia.

Method

This secondary data analysis, sampling technique and procedures were done by Ethiopian Central Statistical Agency. A total sample of 25,774 individuals data were extracted from the 2016 EDHS data mainly HIV biomarkers, IR, MR, and GPS. Spatial heterogeneity analysis were done using tools like Moran's I, Local G*, Interpolation, and Kulldorff's scan statistic. The spatial analysis was carried out by using open source software (QGIS, GeoDa, SaTScan). Multilevel logistic regression analysis was used to identify both individual and household level factors associated with HIV Seropositivity and the analysis was carried out by Stata 14. Finally AOR with 95% confidence interval of mixed-effect logistic regression result in the full model was used to report.

Result

The prevalence of HIV/AIDS was found 0.93% at the national level. The highest prevalence regions were Gambela, Addis Ababa, Harari, and Dire Dawa, which accounts for 4.79%, 3.36%, 2.65%, and 2.6%, respectively. Similarly, the most likely high-risk HIV Seropositivity spatial cluster was found in the Gambela region and Addis Ababa followed by Harari and Dire Dawa. In a multilevel analysis at the individual level being married [AOR = 2.19 95%CI: (1.11, 4.31)] and previously married [AOR = 6.45, 95%CI (3.06, 13.59)] were significantly associated with seropositivity. Regarding household level place of residence [urban: AOR = 6.13 CI: (3.12, 12.06)] were associated with HIV Seropositivity.

Conclusion

The distribution of HIV cases was not random. High cluster HIV cases were found in Gambela, Addis Ababa, Harari, and Dire Dawa. At the individual level, some characters are high risk like being previously married, start sex at a younger age, female household headed, urban residence, and lower household size is more affected by HIV/AIDS. So any concerned bodywork around this risk group and area can be effective in the reduction of transmission.

Background

Acquired Immune Deficiency Syndrome (AIDS) is a global epidemic which is caused by the virus called human immune deficiency virus (HIV). It affects the human immune system of the body. The epidemic was known in 1980 for the first time. The main mode of transmission is unsafe sexual intercourse though

it is different in different regions of the world. For example, homosexual sex and intravenous drug injection are usually considered to be the means of transmission in developed countries. On the other hand, heterosexual contact is the main mode of transmission in developing countries [1].

All countries are affected by the HIV epidemic. An estimated 0.8 percent of adults worldwide were living with HIV, although the burden of the epidemic endures varying considerably between countries and regions as well as wordas being higher in developing countries particularly sub-saharan Africa. According to recent UNAIDS (United Nations Programme on HIV/AIDS) estimates, adult national HIV prevalence is less than 2% in several countries of West and Central Africa, as well as in Ethiopia [2].

Globally 37.9 million people were living with HIV; 1.7 million new HIV infections (incidence) and 770,000 HIV and HIV-related deaths were occurred in the year of 2018. The majority of cases were in eastern and southern Africa [3]. About 5,000 HIV incidence happen per day in the glob; of which 61% of them are in Sub Sahara Africa (SSA) [3].

Ethiopia is hit hardly by this deadly pandemic and a large number of infected people have been living with HIV. HIV prevalence in Ethiopians was estimated at in 2010 (1.3%), in 2015 (1.1%), and in 2018 (1%) [3]. In Ethiopia, the annual HIV prevalence rate decreased from 3.3% in 2000 to 1% in 2018, and AIDS-related deaths from 83,000 deaths in 2000 to 11,000 in 2018 [3, 4].

Efforts to reduce HIV infections are off-track; the reduction of HIV incidence and prevalence is getting smaller year to year and the deadline for reaching the 2020 targets (fewer than 500,000 new infections). Although reductions in HIV/AIDS related deaths are good, but the reduction targets could be missed [3].

HIV/AIDS is common among adults (working age) [5]. Long-term illness due to HIV/AIDS demands a higher level of treatment costs for HIV-affected households. HIV/AIDS brings reduction of savings and fruitful asset buldings and increases the liability of the HIV-affected households [6]. Moreover, higher health care expenditure of the households and the comunity reduces investment for nutritious food for the family members, investment for farming or business, and the education of the children [7].

Measures of disease occurrence are commonly existing only by large geographical administrative units. Sparsely populated, large geographical areas (national and regional) can mask geographical heterogeneity and may potentially cause misinterpretation of true underlying geographical patterns [8].

Due to the existing socio-cultural diversity of Ethiopia, the pattern and distribution of HIV in the country vary widely. Recent reports indicated that there is a large discrepancy in HIV prevalence across regions of the country and place of residence [9, 10].

However, the majority of previous studies in Ethiopia focused on prevalence and factors associated with the disease at the individual level, using a small sample size and some specific areas [11–13].

Geographical space plays in the detection of populations at higher risk. This fundamental characteristic of an epidemic has been poorly explored in the context of HIV. Therefore, this study is done using 2016

EDHS to explore the spatial patterns and determinants of HIV Seropositivity in Ethiopia by using geographic-based analysis techniques to identify the risk at the regional level as well as zone level in addition to factors associated with different and the closest nested level (household and individual level rather than regional level).

Methods

Study area

The study was conducted in Ethiopia, which is located in the North-Eastern part of Africa. It is bounded by the north and south Sudan on the West, Eritrea, and Djibouti on the North East, Somalia on the East and South East, and Kenya to the South. Ethiopia lies between the 3⁰ N and 15⁰N Latitude and 33⁰ E and 48⁰ E Longitude.

The country occupies an area of approximately about 1,127,000 km². The Ethiopian landmass consists of a large, high elevated plateau bisected by the Rift Valley into the northwestern and the southeastern highlands, each with associated lowlands. The contrast in relief is remarkable as land elevation ranges between -155 m of Asal Lake in the Afar depression (the lowest point in Africa) to the peak of Mountain Ras-Dashn at 4,620 meters above sea level in the Semen Mountains [15]. There are nine regional states and two city administrations.

Study design

A population-based cross-sectional study was employed to examine HIV seropositivity, explore spatial distribution of HIV and identify factors associated with HIV seropositivity in Ethiopia.

Data Source

The data for this study were taken from the 2016 EDHS. The 2016 EDHS is the fourth comprehensive and nationally representative survey conducted in Ethiopia as part of the worldwide Demographic and Health Surveys (DHS) project. The EDHS 2016 data were downloaded from The DHS website after being granted permission.

Dependent variables: HIV Seropositivity (positive, negative)

The Interviewer collected capillary blood from a finger prick in women age 15-49 and men age 15-59 who consented to HIV testing. The protocol for blood specimen collection and analysis was based on the anonymous unlinked protocol developed for the DHS Program. If a respondent consented to HIV testing, five blood spots from the finger prick were collected on a filter paper card. A unique barcode label was affixed to the filter paper card, a duplicate label was attached to the biomarker questionnaire, and a third copy of the same barcode was affixed to the Dried Blood Spot Transmittal Sheet to track the blood samples from the field to the laboratory. Blood samples were dried overnight and packaged for storage the following morning. Samples were periodically collected from the field and transported to the

laboratory at the Ethiopian Public Health Institute (EPHI) in Addis Ababa. Upon arrival at EPHI, each blood sample was logged into the CSPro HIV Test Tracking System database, given a laboratory number, and stored at -20°C until tested [16].

Sample size and sampling procedures

A total of 25,774 individuals out of which 13,295 women and 12,479 men were included in to the analysis from 13,043 households. All sampling procedures, data collection, and data quality control were done by the DHS team [16].

Data processing and analysis

The data of 25,774 individuals were extracted from 2016 EDHS and analyzed using Stata 14. Descriptive statistics was computed using frequency and proportion.

Spatial statistics Analysis

Statistically significant clusters defined as geographic areas where the prevalence of the disease is disproportionately higher/lower compared to neighboring areas. Tests for global clustering detect the existence of at least one cluster, but not the specific place of the cluster(s) [reference].

Mapping Cluster

Mapping clusters was done using the Local Indicators of Spatial Association (LISA) analysis and GeoDa was used to conduct LISA analysis. LISA measures spatial autocorrelation, a measure of the degree to which features clustered or dispersed, and can be used as a method for cluster analysis. In cluster analysis objects in the same group (cluster) are more similar to each other than others [17, 18].

Local Moran's I used to map clusters of disease prevalence and identify significant clusters. This map has four classes. The clusters are the high-high (high disease prevalence rates whose neighbors also have high prevalence rates) and low-low (low disease prevalence rates whose neighbors also have low prevalence rates) locations. This showed positive spatial autocorrelation and explain clusters, the remaining are outliers [reference/s].

Hot Spot Analysis

Hot spot analysis was done using GeoDa. Mapping hot spot analysis apply local G^* statistic and used to identify and show cluster of areas with high prevalence rates (hot spot) and areas with low prevalence rates (cold spot). It is essential to assess the significance of the test [17, 18].

Mapping hot spot analysis uses local G^* statistic to map clusters of disease prevalence, because it identifies hot and cold spots. A map should show clusters of areas with high prevalence rates (hot spot) and areas with low prevalence rates (cold spot). It is essential to assess the significance of the test. This can increase the statistical significance with increasing the number of permutations of the results, so it

can be used 999 permutations. This means 999 times, which eliminates bias by producing random results [17, 18]. To conduct this analysis use GeoDa

Interpolation

Interpolation analysis was conducted using QGIS and it is based on the assumption that spatially distributed objects are spatially correlated. I.e.) things that are close together tend to have similar characteristics or based on measured area predict unmeasured area by using the Inverse Distance Weight (IDW) [19-21].

Kulldorff's Scan Statistic

Kulldorff's scan statistic is a method, which is spatial scan statistics for detecting and evaluating statistically significant spatial clusters risk factors for a specific disease. Final confirmatory spatial analysis was done using spatial analysis software SaTScan and QGIS. The SaTScan identify specific place spatially significant higher or lower rate of aggregates is found. Its output presents the hotspot areas in circular windows, indicating the areas in the windows are higher than expected distributions compared to the areas outside of the cluster windows [22-25].

Multilevel logistic regression

Multilevel analysis was considered appropriate to account for the hierarchical nature of the DHS data and to be able to estimate Individual level as well as household-level effects on the outcome variable [26-28].

Model building

The four model building and analysis were done using Stata 14. Overall, four models containing variables of interest were fitted for each of HIV Seropositivity adults. The first model (M_0) is an empty model which was fitted without independent variables to test random variability using Intra House Hold Correlation (IHHC) [29]. The second model (M_1) was fitted to all lower-level (individual level) factors; the third model (M_2) used for all higher-level (household level) factors; and the fourth model (M_3) used for both lower- and higher-level factors to report. Model fitness for the report selected by the Akaike Information Criterion (AIC).

Results

In this study, a total of 25,774 Ethiopian DHS participants whose age range 15 to 59 years for men and 15 to 49 years for female with HIV test result in 2016 was included in the analysis. Above half of (51.58%) were females and, according to age, 37% younger (15–24) age, about four fifth (79%) whose residence was from rural residential, about four-fifth (82%) whose household head was male and about two fifth (39%) of the respondent are uneducated.

Geographical distribution of HIV seropositivity

Regional risk of HIV per 10,000 adults

Regional risk of HIV Seropositive from the highest to the lowest is Gambella, Adis Ababa, Harari, Dire Dawa, Afar, Amhara, Tigray, Benishangul Gumz, Oromia, Southern Nation Nationality People (SNNP) and Somalia regions, which accounts 479, 336, 265, 260, 145, 116 and 115, 108, 67, 38 and 4% respectively (Figure 1).

Mapping Cluster

The LISA cluster map shows $p < 0.001$ with Moran's I was 0.432. The Moran's I indicated clustering patterns (Figure 2).

The red color indicates a high rate of HIV Seropositivity surrounded by high rates of similar cases. Such specific areas were zones of all Gambela regions except zone 1 at the boundary of the Oromia region and Addis Abeba (Figure 2).

Hot Spot Analysis

Hot spot analysis is done through a statistical test. To increase the statistical significance of the result, we used 999 permutations. The red color or HIV Seropositivity rates (hot spot) find in Gambela regions except zone 1 at the boundary of the Oromia region and Addis Abeba (Figure 3).

Spatial interpolation

The prediction areas show predicted risk areas and the people living in those quarters were vulnerable to HIV infection. The prediction showed high risk areas (red color) were Gambela region and its surrounded, Addis Abeba and its surrounded, Dire Dawa, Zone 1 in Afar region in the direction of Djibouti, In Amhara region from Oromia special zone to Alamata through cross country roads (asphalt), and sporadic in all regions except Somalia region (Figure 4).

SaTScan

A total of 6 clusters detected orderly from the SaTScan spatial analysis, but only 4 were statistically significant circular windows. The SaTScan spatial analysis result detected the most likely primary spatial clusters for HIV Seropositive where all zones of Gambela region, Addis Abeba, Most parts of Afar, Harari, Somalia at the boundary of Afar, and Amhara region at the boundary of Afar (Figure 5).

Multilevel logistic regression

Model comparison for report

In multilevel hierarchical data fit four multilevel logistic regression models to identify which estimation model is reported (model fitting for report), the four multilevel logistic regression models are. The first model is the null model which did not contain any individual or household level characteristics, the

second model included the individual characteristics. The third model included only household level characteristics and the fourth model included both individual and household level characteristics.

Table 1 Model selection for report

Model	IHHC	AIC	Loglikelihood
M ₀	42.74%	-36002	18003.8
M ₁	42.02%	-36779	18408.7
M ₂	41.87%	-36381	18200.7
M ₃	41.66%	-36974	18512.8

The fourth model (M₃) is final best model and included both individual and household level characteristics simultaneously, which is the only model included in the report. Because lowest of the AIC and largest of loglikelihoods are the best. If IHHC >5% indicates have varied between households (Table 1).

In the fourth EDHS survey Out of the total sample, 239 individuals from 152 households were HIV positive the rest were negative. The overall prevalence was 0.93% across the country out of which 0.29% were males and 0.64% were females, which accounts for 74 and 165 respectively are positive (Table 2).

After controlling for other individual and household level factors, The female-headed household had 2.42 times (AOR=2.42 CI 1.57– 3.73) higher risk than male-headed household headed family. additionally, female people are 80% (AOR=1.8, CI: 1.19– 2.72) more likely to infect with HIV as compared to male; population by age group middle 6.57 times ((AOR=6.57, CI: 3.67–11.75 and older 14.5 times (AOR=14.5, CI: 7.73–27.35) more likely to have HIV Seropositivity than younger age groups. Likewise the odds being HIV Seropositivity for married/living with partners and divorced/widowed/separated were about 2.19 and 6.45 times higher risk than unmarried within CI about (1.11–4.31) and (3.06–13.59) respectively. Looking at media exposure, low exposure was 47% (AOR=0.53, CI: 0.33–0.86) and no exposure was 61% (AOR=0.39, 95%CI: 0.23–0.65) decreased being Seropositivity compared to high media exposure. Regarding the educational level of respondents, who learn primary and secondary education the risk of being HIV Seropositivity 3.03 and 3.37 times more likely infected by HIV/AIDS than those who had no education within CI of (1.92–4.79) and (1.92–5.92) respectively. From urban households had 6.83 times (AOR = 6.83, 95%CI: 3.11–14.99) more likely infected by HIV Seropositivity than rural households. Looking at the age at first sex less than 16years and between 18 to 19 years were 4.39 and 2.67 times higher risk than those who were not start sex individuals. When the size of the household increased by one family member HIV/AIDS Seropositivity decreased by 28%. (Table 2)

Table 2 the distribution and multilevel logistic regression analysis of factor associated with HIV Seropositivity in Ethiopia, 2016

Characteristics	Frequency (%)	No Positive (%)	COR(95%CI)	AOR(95%CI)
Male	25774(100)	239(0.93)		M3
Individual level				
Marital status				
Married	8119(31.50)	24(0.30)	1	1
Living together	16132(62.59)	135(0.84)	3.93(2.3,6.73)	2.19(1.11,4.31)**
Separated	1523(5.91)	80(5.25)	48.55(25.12,93.83)	6.45(3.06,13.59)**
Sex				
Male	12479(48.42)	74(0.59)	1	1
Female	13295(51.58)	165(1.24)	2.46(1.76,3.44)	1.8(1.19,2.72)**
Sex at first sex				
Same sex	6776(26.29)	12(0.18)	1	1
Opposite	6932(26.90)	54(0.78)	8.95(4.13,19.43)	1.32(0.52,3.38)
19	3614(14.02)	51(1.41)	18.51(8.23,41.62)	2.67(1.05,6.8)**
17	3652(14.17)	44(1.20)	9.91(4.39,22.38)	2.16(0.83,5.63)
5	4800(18.62)	78(1.63)	11.43(6.38,18.38)	4.39(1.70,11.34)**
Working status				
At work	10293(39.94)	78(0.76)	1	1
Not at work	15481(60.06)	161(1.04)	1.41(1.01,1.97)	1.11(0.76,1.61)
Age				
Younger	9536(37.00)	19(0.20)	1	1
Older	8055(31.25)	81(1.01)	8.1(4.25,15.4)	6.53(3.67,11.75)**
Older	8183(31.75)	138(1.69)	16.8(9.01,31.35)	14.5(7.73,27.35)**
Education level				
Highly educated	10130(39.30)	56(0.55)	1	1
Secondary	10547(40.92)	114(1.08)	1.9(1.27,2.85)	3.03(1.92,4.79)**
Primary	3310(12.84)	50(1.51)	3.37(2.02,5.6)	3.37(1.92,5.92)**
Illiterate	1787(6.93)	19(1.06)	1.83(0.92,3.66)	1(0.5,2)
Knowledge				

e knowledge	9365(39.98)	106(1.13)	1	1
en't knowledge	14061(60.02)	121(0.86)	0.76(0.54, 1.05)	0.91(0.66,1.27)
at first mirage				
0	7737(43.82)	88(1.14)	1	
19	2763(15.65)	39(1.41)	1.26(0.76,2.22)	
17	2850(16.14)	30(1.05)	0.95(0.53,1.68)	
5	4305(24.38)	58(1.35)	1.25(0.78,2.01)	
umcise				
	1002(8.05)	5(0.50)	1	
	11445(91.95)	69(0.60)	0.51(0.15,1.83)	
<i><u>sehold level</u></i>				
ia exposure				
1 exposure	8199(31.81)	145(1.77)	1	1
exposure	5675(22.02)	40(0.70)	0.37(0.23,0.58)	0.53(0.33,0.86)**
exposure	11900(46.17)	54(0.45)	0.2(0.13,0.3)	0.39(0.23,0.65)**
dence				
al	20368(79.03)	86(0.42)	1	1
an	5406(20.97)	153(2.83)	17.68(10.8,28.95)	6.83(3.11,15)**
of household head				
ə	21094(81.84)	126(0.60)	1	1
ale	4680(18.16)	113(2.41)	6.2(4.1,9.39)	2.24(1.57,3.73)**
of household	25774(100)	239(0.93)	0.66(0.6,0.73)	0.72(0.65,0.8)**
lth of household				
rest	4217(16.36)	21(0.50)	1	1
er	4691(18.20)	11(0.23)	0.55(0.21,1.45)	0.45(0.2,1.01)
lle	4945(19.19)	17(0.34)	0.64(0.25,1.61)	0.55(0.25,1.22)
er	5292(20.53)	34(0.64)	1.38(0.61,3.08)	0.8(0.37,1.61)
rest	6629(25.72)	156(2.35)	11.7(5.75,23.88)	0.55(0.23,1.32)

Discussion

The overall prevalence of HIV/AIDS in Ethiopia was 0.93%. This figure shows lower than some countries like Uganda 6.5%, Kenya 5.4%, Rwanda 3.1%, and higher than most of the world countries like Somalia 0.4%, Sudan 0.2%, and Chile 0.5% in 2016. The top four highest prevalence regions are Gambella, Addis Ababa, Harari, and Dire Dawa. The next highest prevalence is all Northern, North West and North-East part of the country and some part of the western and eastern part of the country most of the result agree with the 2011 EDHS result [16].

Almost all of the spatial result indicates the first highest zones are found in the Gambela region. This result is in line with other findings and the DHS report [30]. The main reason is maybe male circumcision. In this area their cultures not accept male circumcision since ancient. Uncircumcised males is a high risk of HIV compared to counterparts [31]. The other reasons most people in this region, especially rural areas are not educated and not modernized even they will not know how about HIV because they are nomadic and they are far from modernize.

The next highest risk of HIV in Addis Abeba(Capital city of the country). This finding similar to the EDHS report [30]. The main reason will be, which is the largest city of the country and the main city of the Africa Union, So this area have different business one of the business is a commercial sex worker in different levels from lower for local lower-level peoples to higher those work in international hotels for higher-level peoples in business or politics and in this area traffic from outside and inside for different purposes like trade, politics, tourist and another purpose. For this reason, in this area is high.

The next high-risk areas are DireDawa and Harari region. In this area that not clear difference from other country towns, but maybe the only difference is in this area higher chewing chat compared to another counterpart of the country, In this region people higher interruption with chat (like traditional food). The study shows chewing person high risk of HIV [40]. But any study can not show the relation between chat and HIV. We think the “chat” may be one of the reasons this area because most chewing chat peoples sensitive for sex, especially females, and chat in nature divert personal attitude that means people with chewing chat are not wary for anything of their life, due to this reason during sex may be used condom or not nothing to them. So, this area have a high risk of HIV, but it is not scientifically approved and it needs further analysis of chat and sexual behavior. The remaining high-risk areas are in the Afar region at the border of Djibouti and in the Amhara region in Wollo through the main road of Tigray. This area is contacted with long vehicle drivers and higher traffics of people. This situation is more risk of HIV [32].

In multi-levels the outcome indicates that for the risk of being HIV seropositive relatively high among urban than rural residence this result strongly agrees with other studies [33, 34]. The reason might be those urban residents had communicated with other different areas for different reasons (trading, administration, migration) and the other reason is a commercial sex worker and gays are living in an

urban area they are highly risking for HIV [3]. Older age is a high risk of HIV. This finding is in line with other findings [33, 35, 36] but some researches strongly disagree with this finding [37]. The youngest age group expected to rush new HIV/AIDS infection and practicing unsafe sex due to some biological and economic reasons. Regardless of the fact, in this study shows a significantly higher risk of HIV Seropositivity is older age, followed by middle age, so younger age is a low risk of HIV Seropositive compared to those. The reason for this result is this data is collected prevalence not incidence (show current prevalence, but doesn't show at which age the first time respondents infected by HIV/AIDS) in the theoretical part most of the study shows incidence case. UNAIDS 2018 report indicates about 4,400 new HIV infected among adults (aged 15 and above) out of which about 32% are among young people (15–24) [3], it indicates incidence is high at a younger age but the prevalence in older age is the cumulative effect of from younger to older age.

In age at first sex not starts sex is protective compared that start sex at a younger age, this means people who start sex under sixteen years is a higher risk of HIV compared to others.

Gender in the individual and household head has strongly associated with HIV seropositivity, that means this analysis presents the risk of HIV seropositivity is higher risk for female rather than male, this finding similar to another finding The reason will be greater biological susceptibility of women to HIV infection is a possibly an important explanation [38]. Likewise, female-headed households more risk than male-headed households and which is similar to other research done in Sub Sahara Africa [39, 40]. Female-headed households, especially those who are themselves attacked by the epidemic, became widows after losing their partner to AIDS and therefore have a higher risk of being HIV positive.

The education of individuals is in this finding is the risk factor of HIV except higher educated primary and secondary is high risk compared to non-educated, some other findings are in line with these findings [34, 39] but others are contradicting [41]. One of the reason may be more educated persons move place to place and they can also afford paid for sex [42, 43], But most of the uneducated person is stable throughout their life.

As discussed in the theoretical part, the marital status of the individual has been found to have a significant effect on the prevalence of HIV/AIDS. In this study separated is a higher risk of HIV compared to never marrying followed by married. This finding strongly agrees with the theoretical part of divorced, separated, and widowed is a high risk than never married, but contradict married is higher risk than never married with our finding [44], this means the odds of being HIV/AIDS positive is highly affected married/living together next to previous married (widowed, divorced and separated) compared to individuals who are never married. On the other hand other studies are in line with our result which means married and separated high risk than never married [34]. Marital status has a different impact on women and men in many contexts because of cultural restrictions on women's autonomy in the public sphere. These constraints may contribute to HIV/AIDS reducing the capacity of unmarried women to engage in equitable relationships and negotiate safe sexual practices (condom use) or can live without sex with

their partners [45], which increases the risk of HIV infection. Other research showed that women who divorced an abusive marriage were likely to enter another one with new risks [46].

The media exposure indicates a person who has no media access or low media exposure, low risk of HIV/AIDS compared to that has more accesses or it means media is a risk factor of increasing HIV prevalence. A study done in 20 countries of SSA states that women at regional level relatively high media exposure have a higher risk of being HIV positive, again this research itself indicates being country level with higher media exposure is associated with a lower risk of HIV [40]. When we see another result of this finding in both spatial and determinants like urban residence, primary and secondary educated, big cities are highly affected by HIV to their similar counterparts; all of them are highest media exposure in other hands rural residence, no educated, Somalia region and Afar region have a lower risk of HIV compared to others; those regions are low media exposure. Based on the above reasons need to further study rely on media is a risk factor of HIV or not and media transmit what kind of message, is they're useful for HIV privation or useful for HIV transmission (by the initiation of sexual intercourse (like romance movies, announce indirect risk of HIV like alcohol).

The number of household members and HIV/AIDS are inverse relation that means the amount of household member increase in a family the risk of HIV decrease in the same household. This finding is in line with other researcher's ideas [30]. The reason for this out came maybe if the household size increases the adults of the household will carrying more responsibility for the family and they keep themselves and have no free time and economy to another act an important life. The other reason is many families collaborate and control the younger of the family by older others to control before the bad thing happening. On the other hand, the family size increases may be HIV risk increase, because most of developing country more families are underproductive age due to this reason the family may be under poverty to result in this burden younger lady needs to economic support from males and it may because of the commercial sex worker, so the household size is either positive or negative consequence in HIV prevalence [30].

Conclusion

For reducing the transmission government and any concerned body using less effort to find more achievement used to the high-risk area and group such as high cluster HIV cases were found in Gambela, Addis Abeba, Harari, and Dire Dawa. At the individual level, some characters are high risk like being previously married, start sex at a younger age, and at the household level, the female household headed, urban residence, and lower household size is more affected by HIV/AIDS. So any concerned bodywork around this risk group and area can be effective in the reduction of transmission.

Abbreviations

AOR: Adjusted Odds Ratio; **CI:** Confidence Interval; **DHS:** Demographic and Health Survey; **EDHS:** Ethiopia Demographic and Health Survey; **IHHC:** Intra House Hold Correlation; **SNNP:** South Nations Nationality

People; **AIC**: Akaike Information Criterion; **BIC**: Bayesian Information Criterion; **LISA**: Local Indicators of Spatial Association; **AIDS**: Acquired Immune Deficiency Syndrome; **HIV**: Human immune deficiency virus; **UNAIDS**: United Nations Program on HIV/AIDS; **SSA**: Sub Sahara Africa; EPHI: Ethiopian Public Health Institute; **IDW**: Inverse Distance Weight

Declarations

Ethics approval and consent to participate

Ethical clearance with written consent (*AuthLetter_123465*) was obtained from the Measure DHS International Program which authorized the data sets. All the data which used in this study are publicly available, aggregated secondary data with not having any personal identifying information that can be linked to particular individuals, communities, or study participants. Confidentiality of data maintained anonymously.

Consent for publication

Not Applicable

Availability of data and materials

The data set we used which is the '2016 Ethiopian Demographic and Health Survey' were obtained from the DHS program (www.dhsprogram.com), but the 'Dataset Terms of Use' do not permit us to distribute this data as per data access instructions (<http://dhsprogram.com/data/Access-Instructions.cfm>). To get access to the dataset you must first be a registered user of the website (www.dhsprogram.com), and download the 2016 Ethiopian Demographic and Health Survey datasets.

Competing interests

The authors declare that they have no conflicts of interest.

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Authors' contributions

BAH conceived the general research design and participated in data analysis, interpretation and wrote the first and final draft. **AM** coordinated the study, reviewed the manuscript and contributed to the critical comments manuscript. **FT** reviewed the manuscript coordinate multilevel parts and comment on the whole document. **GGB** coordinated the study, reviewed the manuscript and contributed with critical comments and drafted the manuscript. **BAM** coordinate the spatial part of the study and comments and drafted the manuscript based on geographical characteristics and comment on the whole document. **JB** participated in research design and refined the general research idea, reviewed the manuscript, and

contributed comments. All authors read, approved and contributed with critical comments and drafted the manuscript final paper.

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Figures

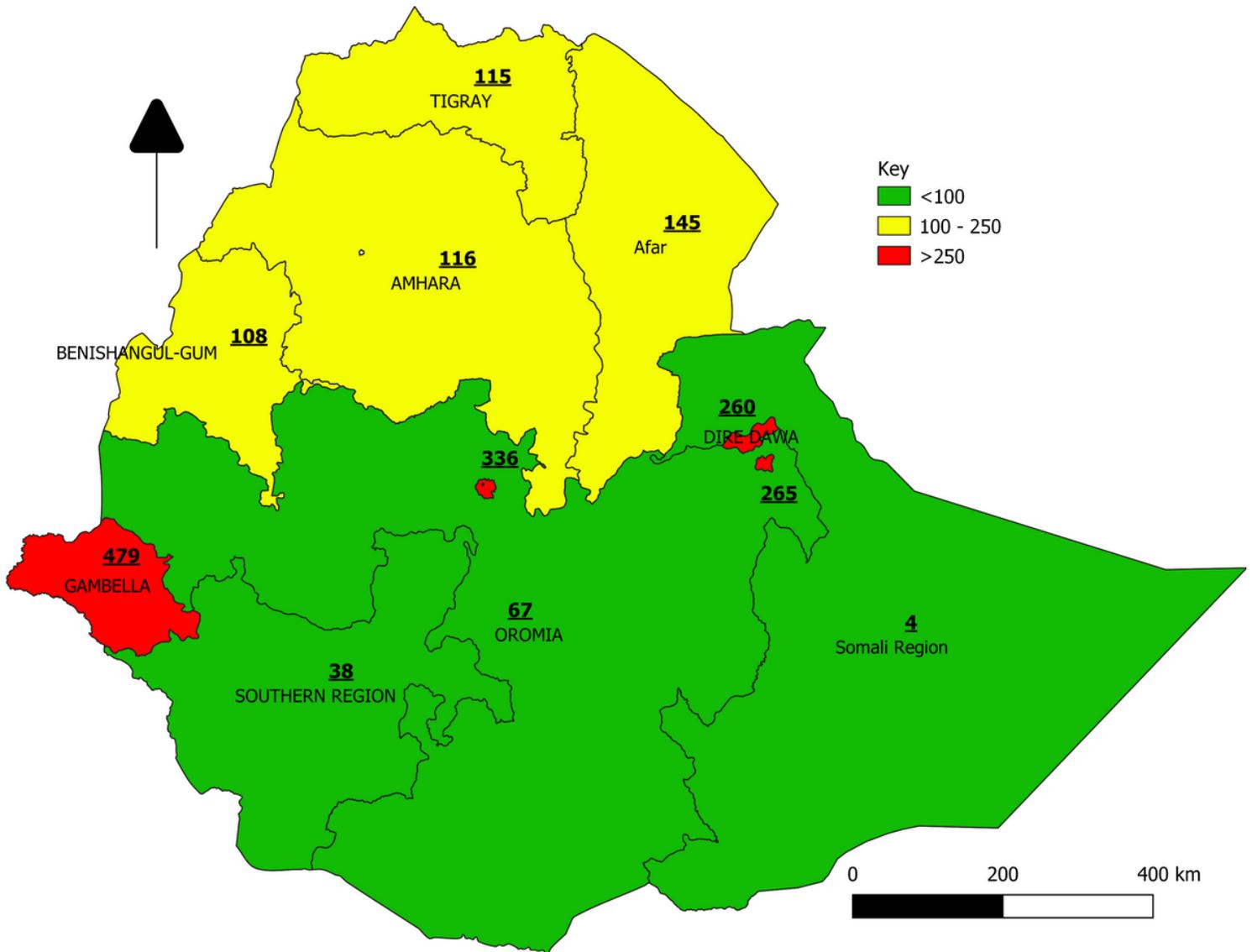


Figure 1

regional risk of HIV Seropositive per 10,000 adults in Ethiopia. The green color indicates risk of HIV below 100 per 1000; The yellow color indicates the risk of HIV between 100 and 250 per 1000; The red color indicates the risk of HIV above 250 per 1000 adults in Ethiopia. Additionally the risk of HIV per 1000 people in each region put on their site. This analysis is carried out QGIS 3.12.2 which available at <https://www.filecroco.com/download-quantum-gis/download/>

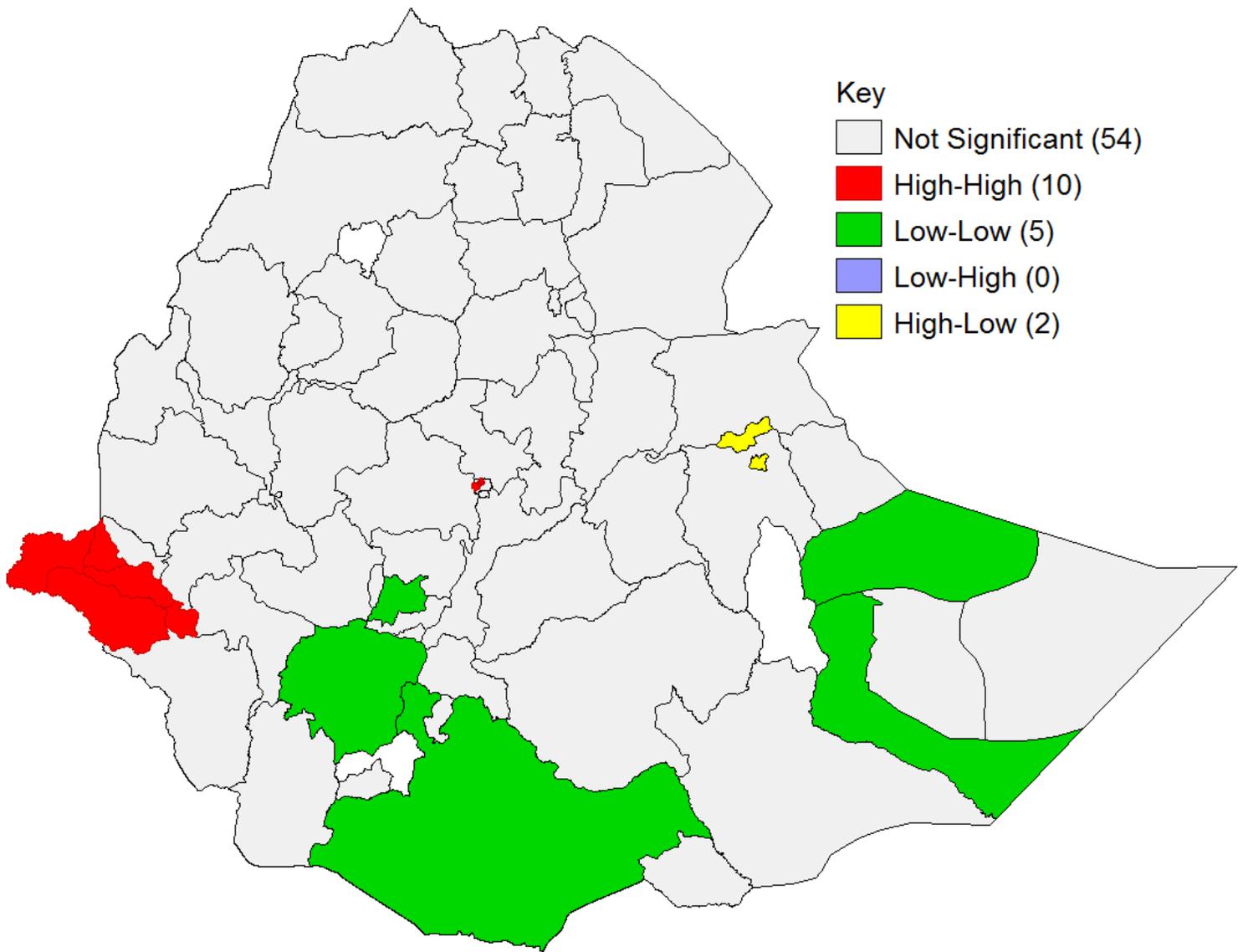


Figure 2

LISA cluster map of HIV Seropositivity in Ethiopia. Each polygon on the map represents a single zone area with a burden of HIV/AIDS. High-High (red color) means high rates of HIV/AIDS surrounded by similar characteristics; low-low (green color) means low rates of HIV/AIDS surrounded similar characteristics. High-low (yellow color) means high rates of HIV/AIDS surrounded by low rates of HIV/AIDS in adults; undefined (white color) indicates lakes and zones (not taken sample in this area). The red color indicates hotspot areas of HIV/AIDS; the green color indicates cold-spot areas of HIV/AIDS; and the yellow and dark-blue colors show outliers. The hotspots are public health importance. To conduct this analysis use GeoDa version 1.14, which is available at: https://geodacenter.github.io/download_windows.html

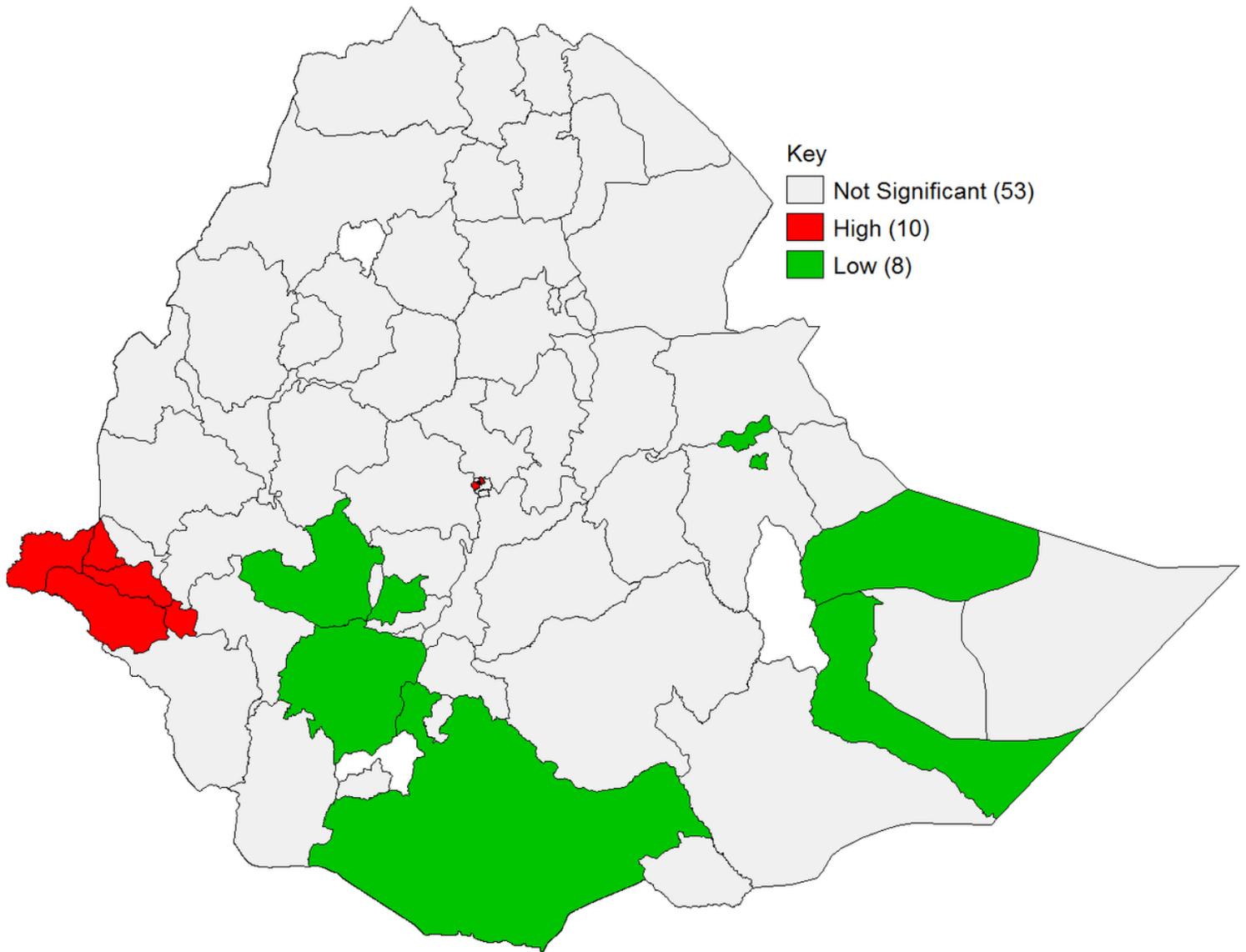


Figure 3

Hotspot map of HIV Seropositive in Ethiopia. Each polygon on the map represents a single zone area with a burden of HIV/AIDS. High (red color) means high rates (hot spot) of HIV/AIDS. Low (green color) shows a low rate (cold spot) of HIV/AIDS. Undefined (white color) indicates lakes and zones (did not sample taken in this area). To conduct this analysis use GeoDa version 1.14, which is available at: https://geodacenter.github.io/download_windows.html

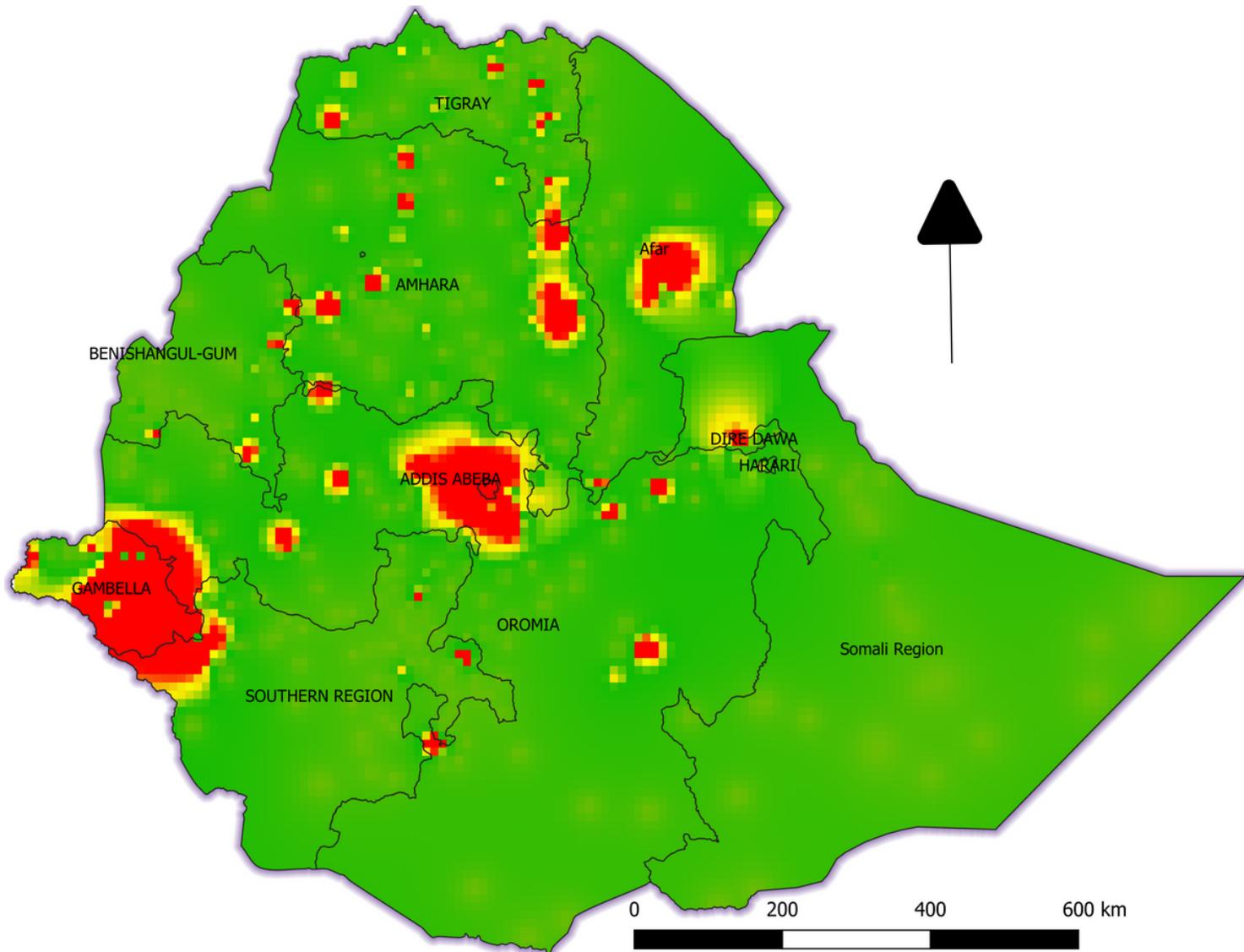


Figure 4

IDW interpolation HIV Seropositive prediction map in Ethiopia. Interpolated Continuous images produced by interpolating Inverse Distance Weight (IDW) HIV/AIDS among adults in Ethiopia. The red ramp color indicates the predicted HIV/AIDS high risk areas and green color indicates less risk areas of diarrhea. This analysis is carried out QGIS 3.12.2 which available at <https://www.filecroco.com/download-quantum-gis/download/>

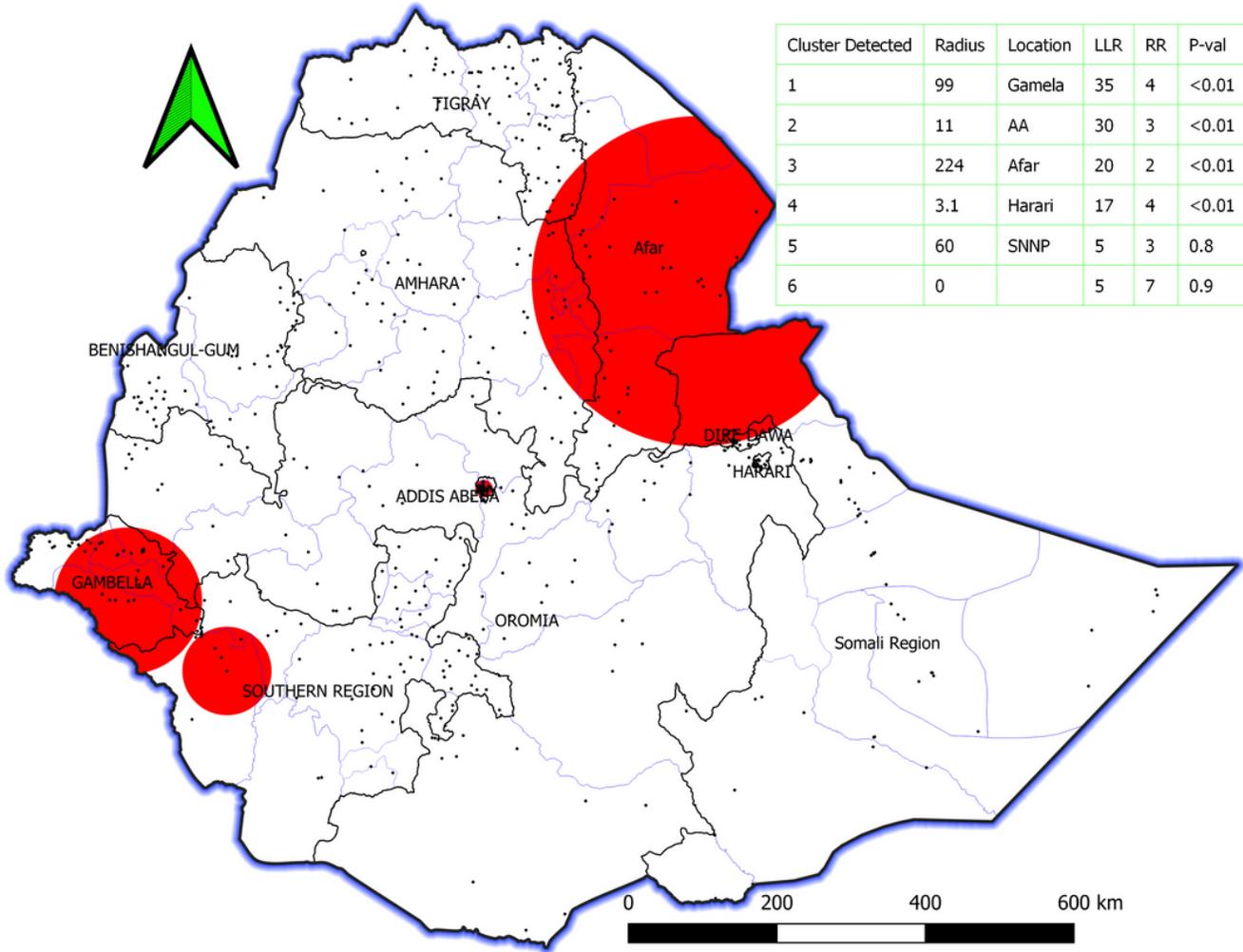


Figure 5

HIV Seropositivity hotspot clusters identified using SaTScan spatial analysis tool, in Ethiopia. The red color circle indicates hotspot windows. And the dot indicates enumeration cluster. The table legend identifies statistically significant (p value), location (site), relative risk, log likelihood ratio. To conduct this analysis use SaTScan v9.6, which is available at <https://www.satscan.org/download.html> and QGIS 3.12.2