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Social determinants of HIV infection, hotspot areas and sub-population groups in Ethiopia: Evidence from national population based survey in 2011

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Abstract

Objective: This study identifies social determinants of HIV, hotspot areas and sub-population groups in Ethiopia.

Design: The study used data from the 2011 Ethiopian Demographic and Health Survey. Spatial scan statistics and geographic information system tools were used to map hotspot areas of HIV prevalence. Bivariate and multivariate logistic regression models were used to identify social determinants.

Population: A total of 30,625 adults (16515 women and 14110 men) were included from 11 administrative states of Ethiopia.

Main outcome measures: Sample blood test from the finger prick collected on a filter paper card labeled with a barcode unique to the respondents.

Results: 24 administrative zones with relative risk of 2.8 and one zone with relative risk of 3.1 were found HIV hotspots. HIV prevalence reached 10-21% in certain geographic clusters. Multivariate analysis showed that individuals who were in the middle, richer and richest wealth quintiles had (AOR=1.7; 95%CI: 1.004-2.991), (AOR=2.3; 95%CI: 1.372-3.895) and (AOR=4.1; 95%CI: 2.284-7.390) odds of HIV than the poorest quintile. Adults who had primary, secondary and higher education were (AOR=1.7; 95%CI: 1.321-2.262) and (AOR=1.6; 95%CI: 1.113-2.362) more likely to have HIV than non-educated individuals. The odds of HIV was (AOR=3.4; 95%CI: 2.642-4.284) higher among adults who had multiple lifetime sexual partners. The odds of having HIV among age groups 25-29 years (AOR=1.7; 95%CI: 1.146-2.515), 30-34 years (AOR=2.0; 95%CI: 1.316-2.908) and 35-39 years (AOR=2.1; 95%CI: 1.406-3.069) were higher than age group of 45-49 years. Merchants had (AOR=1.8; 95%CI: 1.302-2.427) higher odds of HIV than non-working adults. The odds of HIV among urban residents (AOR=1.8; 95%CI: 1.236-2.661) and females (AOR=1.9; 95%CI: 1.444-2.632) were higher than their counterparts.

Conclusion: This study founds statistically significant HIV concentrations in 25 administrative zones of Ethiopia. Geo-spatial monitoring and targeting of prevention strategies for specific population groups is recommended based on the identified social determinants.

Key words: Hotspot, Social determinants, HIV, Ethiopia

Strength and limitation of the study

- One of the strengths of this study is the use of laboratory confirmed HIV sero-status data at the national level. Therefore, the study findings can be used to inform policy and program actions.
- However, the study has also limitations. Some regions and EDHS clusters had small sample sizes, which questions the accuracy of prevalence estimates per region, so that those should be interpreted in caution. Because the study was a secondary data analysis, it might lack other important social determinant variables which were associated with risk of HIV infection.
- This study also shares the limitation of the cross-sectional study design which makes difficult to demonstrate cause and effect relationships and longitudinal relationships.

Introduction

HIV/AIDS has been documented as one of the major public health challenges in the world[1]. Globally, there were approximately 35.0 million people living with HIV at the end of 2013 with 2.1 million people became newly infected. The sub-Saharan region of Africa is the most affected in the world with 24.7 million people living with HIV in 2013[2]. This region accounts for almost 70% of the global total of new HIV infections despite of having only 13% share of the world's populations [2]. Ethiopia is one of the sub-Saharan African countries with significantly high HIV infected populations[3]. There were totally 759,268 people living with HIV in Ethiopia in the year 2012. Of which, 168,598 were children age less than 15 years[4]. The national prevalence of HIV in Ethiopia has declined from estimated adult prevalence of 4.5% between 1998-1999[1]to 1.5% in 2011[5], which is an encouraging achievement for the country.

Although estimates suggest that the rate of new HIV infections is declining in many African settings, HIV incidence remains unacceptably high with striking sub-population and geographical differences[6]. Recently, there is a hypothesis indicating that the HIV epidemic is started to concentrate in certain geographic areas and population segments more than ever because of intensive efforts made at the global, national and lower levels. The HIV epidemic has been showing remarkable variations across population subgroups[7], regions and countries[6, 8], at sub-national level between provinces [9] and within sub-districts[10]. The geographical structure of the HIV epidemic is the consequence of drivers of the epidemic and the availability of susceptible population to the infection[11]. Strongest clustering was observed in countries with low prevalence of national HIV infection[11]. The 'know your epidemic' concept recognizes this geographical feature as a key element for identifying populations at higher risk of HIV infection where prevention interventions should be targeted[12].

The HIV/AIDS epidemic in Ethiopia is often classified as "generalized" among the adult population with significant heterogeneity among regions and population groups[13]. The rural epidemic appears to be relatively widespread but heterogeneous with most rural areas having a relatively low prevalence of HIV[13]. The concept of concentrated sub-epidemics within a generalized epidemic context has been relatively neglected topic to date[14]. Mapping hotspot areas, identifying affected population groups and predisposing social determinants, especially in resource limited settings, would assist in targeting and prioritizing interventions[15]. The hotspot

areas would be further examined for unobserved or unknown risk factors which are driving the HIV epidemic. Monitoring a localized epidemic is therefore essential for more effective prevention strategies[16].

Little information has been documented in Ethiopia to show social determinants of HIV, and concentrations of the epidemic in geographic areas and population groups. We hypothesize that low national prevalence of HIV hides the localized epidemics in Ethiopia. Therefore, this study is to identify social determinants of HIV, map hotspot areas, and identify sub-population groups to effectively target interventions with the limited resources available in the country.

Methods and materials

Data type and study design:

This analysis used secondary data from the 2011 Ethiopian Demographic and Health Survey (EDHS). The survey followed an international DHS methodology and is conducted at five years intervals. The EDHS was designed to provide population and health indicators at national (urban and rural) and regional levels. The 2011 EDHS samples were selected using a stratified and two-stage cluster sampling design. The survey included 624 samples of enumeration areas (clusters), of which 187 were in urban and 437 in rural areas. Representative samples of 16,702 households were actually interviewed from 11 administrative regions and 85 zones of which 11,590 were households from rural settings. A total of 30,625 adults aged between 15-59 years were included, among which 16,515 were women respondents. Overall, 86% of all EDHS respondents who were eligible for testing were interviewed and consented to HIV testing. Four percent of respondents were interviewed but refused to be tested for HIV and did not provide blood samples. Coverage rates for HIV testing were 89% for women and 82% for men. The detailed methodology is found elsewhere[17].

Data extraction:

The 2011 EDHS datasets were downloaded from the Measure DHS website (http://www.dhsprogram.com) in SPSS format with permission. After understanding the detailed datasets and coding, further data recoding was done. All potential social determinants and HIV/AIDS indicator variables were extracted from male and female datasets of EDHS 2011. Datasets of

HIV test result socio-demographic characteristics of men and women and GIS coordinates were merged accordingly for this analysis.

Measurement of variables:

Sample blood test through voluntary HIV counseling was done in the 2011 EDHS. Five blood spots from the finger prick were collected on a filter paper card labeled with a barcode unique to the respondents. The testing algorithm recommends testing all samples on the first ELISA assay test, the Vironostika® HIV Uni-Form II Plus O (Biomerieux). All positives were subjected to a second ELISA, the Murex HIV Ag/Ab Combination. If the first and second tests were discordant, a third confirmatory test, the HIV 2.2 western blot (DiaSorin), was conducted to resolve the discordance. The final result was rendered positive if the western blot confirmed the result to be positive and was rendered negative if the western blot confirmed it to be negative. When the western blot results were indeterminate, the sample result was recorded indeterminate. The detailed procedures can be accessed elsewhere [17]. The barcodes identifying the HIV test results were linked with other EDHS data sets of individual interviews. Based on literature review [16,18-20] and availability in the 2011 EDHS, social determinant variables were identified in the male and female datasets. For this study, the term "social determinants" encompass the socio-economic, cultural, residence and lifestyle conditions of people that may predispose to HIV infection. The chosen variables to potentially associate with HIV were wealth index that constructed from household assets and other characteristics, age groups, occupational status, comprehensive knowledge of HIV, use of alcohol and khat, migration status, religion,, residence, administrative region, educational status, mass media exposure indexed from reading newsletter, listening radio and television, gender, total number of lifetime sexual partner and marital status.

Statistical analysis:

The spatial scan statistics (SaTScan) software (version 9.1, www.satscan.org) was used to detect the potential excess of HIV cases[21] . The basic idea of SaTScan is to allow circular windows of various sizes to range across the study areas. At each location, the rate of disease inside the window is compared with that outside of it. For a given cluster (circular window), the software calculates the probability of a data point being a case inside or outside the circle under consideration. For each circle, a likelihood ratio is computed for the alternative hypothesis that

there is an increased risk of disease inside the circle, against the null hypothesis that the risk inside the circle is the same as that outside. In this context, a hotspot cluster is detected within a defined geographical area during a specific timeframe if the area has a disproportionate excess of HIV cases when compared with neighbouring areas under study. While satisfying assumptions of the statistical model, an unusual rise or reduction in cases in a specific spatial area can be characterized by statistical significance. The sets of potential clusters are then rank ordered according to the magnitude of their likelihood ratio test statistics. The user-defined maximum radius used by SaTScan was set to its default value of 50%, as recommended by Kulldorf[21]. In order to investigate the sensitivity of SaTScan results to the default setting, we ran the SaTScan spatial scan statistics 10 times, starting with a maximum size of 5% and increasing the parameter by an interval of 5% with each run until reaching the default maximum size value of 50%. Results were not affected by the choice of radius selected; we therefore used the default value of 50% in our analysis.

We also used "svy" command in STATA version 11 to weight the survey data and do all types of analyses. Sample weights were applied in order to compensate for the unequal probability of selection between the strata that has been geographically defined as well as for non-responses. A detailed explanation of the weighting procedure can be found in the EDHS methodology report [17]. Descriptive statistics were used to show the weighted prevalence of HIV across social determinant variables. Bivariate and multivariate logistic regressions were carried out to determine the factors associated with HIV prevalence. As recommended by Hosmer and Lemeshow, variables found statistically significant at p-value <0.25 during bivariate analysis could be candidates for multivariable logistic regression model[22]. This p-value cutoff point is important to retain variables that will have potential effect during multivariate analysis. All tests were two-sided and a p-value <0.05 was considered statistically significant in the multivariable statistical model. Both crude and adjusted odds ratios were calculated with 95% confidence interval.

Ethical consideration:

The original DHS data were collected in conformity with international and national ethical guidelines. Ethical clearance for the original survey was provided by the Ethiopian Health and

Nutrition Research Institute (EHNRI) Review Board, the National Research Ethics Review Committee (NRERC) at the Ministry of Science and Technology, the Institutional Review Board of ICF International and the Centers for Disease Control and Prevention (CDC). The data for this study were downloaded and used after the purpose of the analysis was communicated and approved by the Measure DHS.

Results

Characteristics of the study population:

The 2011 EDHS included a total of 30,625 adults in the age range of 15–59 years for men and 15-49 years for women. Among the respondents, 53.9% (16,515) were females. About 68.8% (21,080) respondents were from rural areas. Approximately 42% had not attended formal education and 41% had less than primary school education. The proportion of Christians (Orthodox, Protestant and Catholic) was 60.7% followed by Muslims accounted for 37.5%. The mean age of respondents was 29.0 with standard deviation of 10.5 years.

HIV prevalence by different population compositions:

The overall prevalence of HIV was 1.5% with 1.9% [95% CI: (1.696-2.123)] among females and 1.0% [95% CI: 0.838-1.178] in males. The prevalence of HIV in urban settings was 4.3% [95% CI: (3.814-4.813)] while in rural areas was 0.7% [95% CI: (0.596-0.813)]. The prevalence of HIV infection was 1.8% [95% CI: (1.624-1.992)] among Christian religion followers. The highest prevalence of HIV at 6.7% [95% CI: (3.511-12.60)] was recorded in the Gambella administrative region followed by Addis Ababa with 5.2% [95% CI: (4.138-6.453)] and Dire Dawa at 4.0% [95% CI: (1.639-9.533)]. The lowest prevalence, 1.0% [95% CI: (0.828-1.201)], was found in Oromiya region. Among the wealth quintiles, the highest prevalence of HIV of approximately 4.1% [95% CI: (3.646-4.581)] was found in the richest wealth quintile. Individuals who had attended secondary and above education level had the highest prevalence of HIV at 2.4% [95% CI: (1.952-2.937)]. The highest prevalence of HIV at 3.0% [95% CI: (2.466-3.615)]was documented among age group 35-39 years followed by age group 30-34 years at 2.7% [95% CI: (2.181-3.280)]. Among the different occupational groups, the highest prevalence of HIV at 5.7% [95% CI: (2.941-9.403)] was found among mobile workers followed by merchants at 5.4% [95% CI: (4.412-6.477)]. HIV prevalence was 4.1% [95% CI: (2.728-5.813)]

among service workers, 2.9% [95% CI: (0.098-9.291)] in construction and engineering workers and 2.7% [95% CI: (2.223-3.238)] in sales workers (**Table 1).**

Table1: HIV prevalence by different characteristics of respondents in Ethiopia, 2011

Characteristics of respondents	Prevalence 95%CI	Total weighted respondents	Weighted number of HIV Cases
Sex			
Male	1.0[0.838-1.178]	13,234	132
Female	1.9[1.696-2.123]	15,730	299
Residence			
Urban	4.3[3.814-4.813]	6,337	272
Rural	0.7[0.596-0.813]	22,628	158
Religion			
Christian	1.8[1.624-1.992]	20,147	363
Muslim	0.7[0.541-0.904]	8,231	58
Traditional and others	1.5[0.751-2.795]	587	9
Administrative regions			
Tigray	1.8[1.261-2.463]	1,901	34
Afar	1.8[0.523-3.901]	244	4
Amhara	1.6[1.338-1.894]	7,821	125
Oromiya	1.0[0.828-1.201]	10,983	110
Somali	1.5[0.730-2.951]	511	8
Benishangul gumuz	1.4[0.417-3.123]	306	4
SNNPR	1.1[0.847-1.403]	5,457	60
Gambella	6.7[3.511-12.60]	127	9
Harari	3.0[0.421-8.014]	80	2
Addis Ababa	5.2[4.138-6.453]	1,422	74
Dire Dawa	4.0[1.639-9.533]	113	5
Wealth Index			
Poorest	0.4[0.245-0.593]	5,117	20
Poorer	0.5[0.333-0.710]	5,451	27
Middle	0.7[0.505-0.946]	5,572	39
Richer	1.1[0.856-1.390]	5,913	65
Richest	4.1[3.646-4.581]	6,912	283
Education			
Not formal education	1.1[0.925-1.293]	12,391	136
Primary	1.6[1.391-1.825]	12,837	205
Secondary and higher	2.4[1.952-2.937]	3,738	90
Marital status			

Never married	0.4[0.291-0.550]	9,376	38
Currently married	1.4[1.236-1.584]	17,548	246
Formerly married	6.9[5.868-8.071]	2,041	141
Age groups			
15-19	0.2[0.109-0.327]	6,637	13
20-24	0.7[0.498-0.966]	4,975	35
25-29	2.1[1.732-2.517]	5,148	108
30-34	2.7[2.181-3.280]	3,346	90
35-39	3.0[2.466-3.615]	3,399	102
40-44	2.0[1.488-2.658]	2,238	45
45-49	1.8[1.271-2.434]	2,019	36
50+	0.7[0.309-1.259]	1,203	8
Number of life time sexual partners			
Single	0.9[0.751-1.077]	13,063	118
Multiple	3.7[3.297-4.147]	7,612	282
Ever alcohol drinking			
No	1.0[0.847-1.168]	14,727	147
Yes	2.0[1.782-2.243]	14,229	285
Comprehensive knowledge on HIV			
No	1.5[1.363-1.651]	27,505	413
Yes	0.3[0.049-0.974]	676	2
Exposure to mass media			
No	1.0[0.786-1.242]	7,341	73
Yes	1.7[1.532-1.878]	21,495	365
Occupational status			
Not working including house wives	1.3[1.056-1.580]	7,240	94
Corporate and general managers	1.2[0.058-5.537]	87	1
Teaching and associate professions	2.0[1.056-3.659]	483	10
Health and life science workers	2.4[0.635-6.598]	121	3
Construction and engineering workers	2.9[0.098-9.291]	51	1
Front line service workers	4.1[2.728-5.813]	640	26
Sales workers	2.7[2.223-3.238]	3,932	106
Agricultural workers	0.5[0.369-0.651]	9,692	48
Daily laborers	0.7[0.485-0.991]	4,258	30
Merchants	5.4[4.412-6.477]	1,842	99
Mobile workers including drivers, operators and assemblers	5.7[2.941-9.403]	199	11
Other occupations*	0.1[0.025-2.478]	197	1
Total	**1.5[1.353-1.633]**	**28,964**	**431**

*Students, armed, legal, higher officials and ill people

Geographic clusters of HIV prevalence in Ethiopia:

As shown on F**igure 1,** the prevalence of HIV reaches up to 10-21% in certain geographic clusters particularly in Central, Eastern and Western part of the country. There are also some clusters with a prevalence of HIV from 4-9% in parts of Ethiopia. Most geographic coverages of the country have had an HIV prevalence rate of less than 4.5%. There were no EDHS clusters (enumeration areas) included in the peripheral areas of the country, particularly in eastern parts of Somali region and as a result the HIV prevalence could not be estimated.

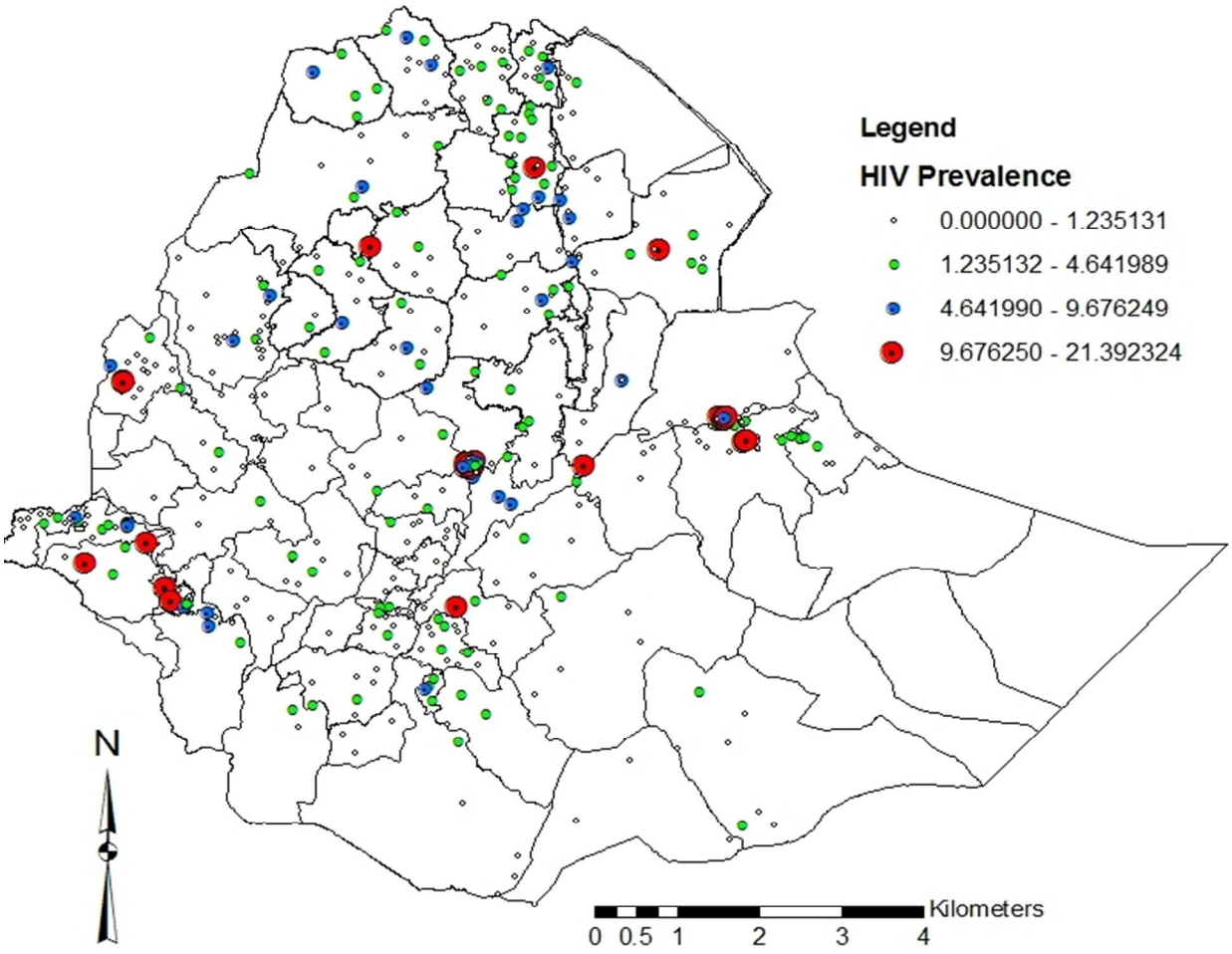


Fig 1: Map to show the prevalence of HIV in EDHS cluster areas in Ethiopian Zones, 2011

As indicated in **Table 2 and Fig 2**, six clusters were identified during SaTScan analysis. However, only cluster 1 and 2 were statistically significant hotspots with p-value at 0.000 and 0.003, respectively. In the first cluster, a total of 164 EDHS enumeration locations were circled

with 258 km radius. This hotspot covered a total of 24 administrative zones from Oromiya, Amhara, Tigray, Afar and Somali regions including Addis Ababa. A total of 252 cases were observed with relative risk of 2.6 and log likelihood ratio (LLR) of 48even if 153 cases were expected. In the second hotspot, only one EDHS enumeration location in Oromiya region of West Arsi zone was circled with 8.7 relative risk and 11.9 LLR.

Table 2: Statistical summaries from SaTScan clustering analysis in Ethiopian administrative regions and zones, 2011

Clusters	Regions/Zones in the cluster	Radius	LLR	P-value	RR	Observed	Expected
Cluster1	Addis Ababa, Oromiya*, Amhara^, Tigray[$], Afar[@] and Somali[#]	258	48.0	0.000	2.6	252	153
Cluster 2	Oromiya–West Arsi zone	0	11.9	0.003	8.7	9	1
Cluster 3	Gambella–Agnuak and Majanger zones SNNPR–Sheka, Bench maji and Keffa zones	49	6.0	0.413	3.1	13	4
Cluster 4	SNNPR – Gedio zone	0	4.9	0.719	4.3	7	2
Cluster 5	SNNPR – KT zone	0	3.7	0.975	3.1	8	3
Cluster 6	Oromiya – Borena zone	0	3.1	0.996	3.0	7	2

*East Shewa, West Shewa, South West Shewa, North Shewa, Oromiya Special Zone, HoroGuduru, Parts of East Wolega, parts of West Hararge zones
^North Shewa Special zone, South Wollo, East Gojam, West Gojam, South Gondar, Eastern parts of North Gondar, Wag Himira and AwiAgew zones
[$] South Tigray zone
[@] Zone 1, Zone 2 and Zone 3
[#] Site Zone
LLR=Log Likelihood ratio, OR=Odds ratio, RR=relative risk, Radius is in kilometer

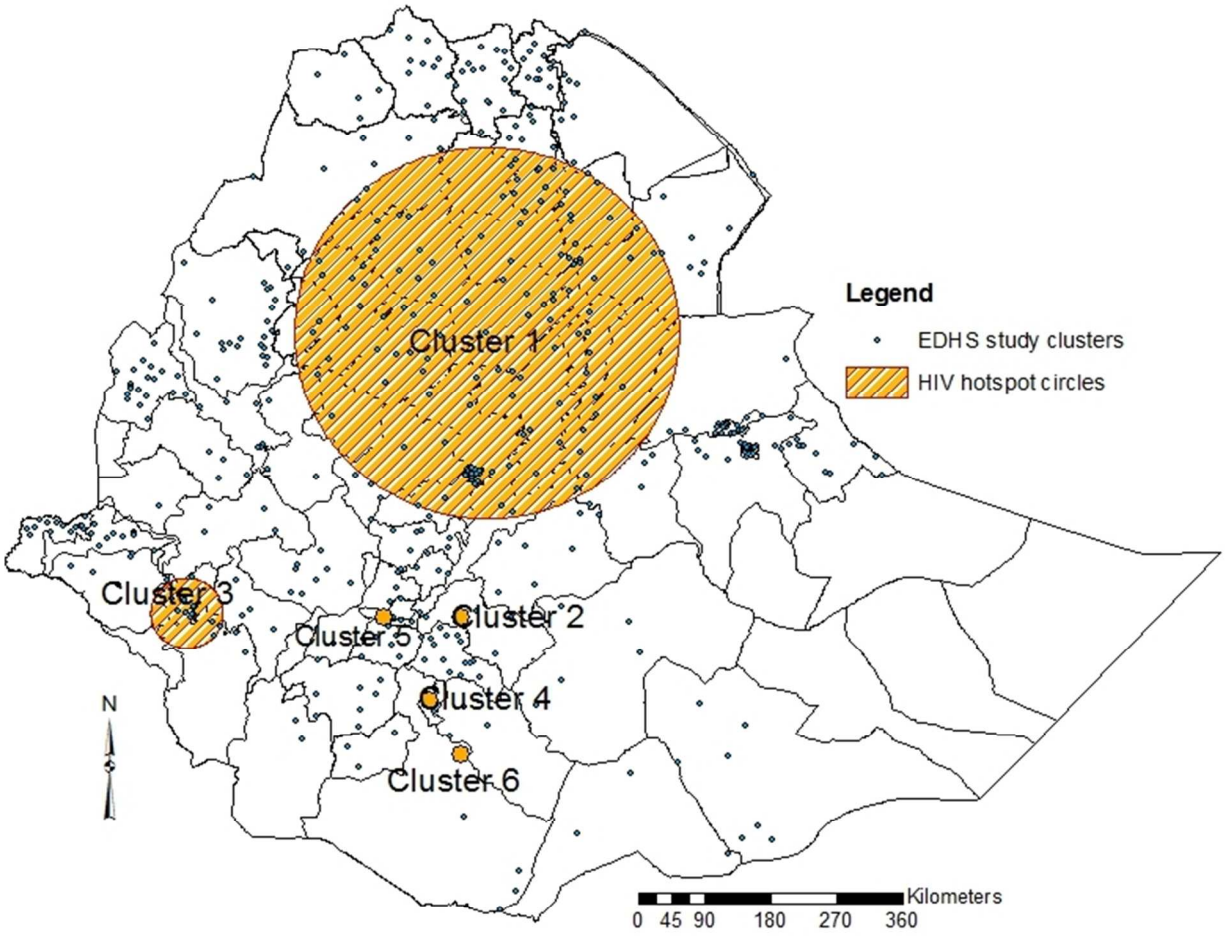


Fig 2: HIV hotspot clusters identified at zonal level using SaTScan spatial analysis tool, in Ethiopia 2011

Factors associated with HIV infection:

During bivariate analysis, ever use of khat and migration status had no statistically significant association with HIV based on the cutoff point p-value <0.25. Variables including exposure to mass media, ever use of alcohol and comprehensive knowledge on HIV were associated with HIV in the bivariate analysis; however; they were not found to be statistically significant in the final multivariate analysis. No variables were found to exceed to VIF value of 10 in the multicollinearity test

As shown in **Table 3 and Fig 3**, those individuals who were in the middle, richer and richest wealth quintiles had [AOR=1.7; 95% CI: (1.004-2.991)], [AOR=2.3; 95% CI: (1.372-3.895)] and [AOR=4.1; 95% CI: (2.284-7.390)] higher odds of having HIV as compared to the poorest wealth quintile. The odds of having HIV were higher among urban residents [AOR=1.8; 95% CI:

(1.236-2.661)] as compared to their rural counter parts. Compared to Tigray regional state, the odds of having HIV were [AOR=4.1; 95% CI: (1.703-9.875)] higher in Gambella region. Those individuals who were formerly married had [AOR=4.2; 95% CI: (2.476-7.158)] odds as compared to never married individuals. Similarly, those individuals who had primary education and secondary and higher education were [AOR=1.7; 95% CI: (1.321-2.262)] and [AOR=1.6; 95% CI: (1.113-2.362)] more likely to have HIV infection as compared to those who have no formal education.

Those Islamic religion followers had [AOR=0.58; 95% CI: (0.412-0.829)] less likely to have HIV infection as compared to Christian religions followers. The odds of having HIV infection was [AOR=3.4; 95% CI (2.642-4.284)] higher among adults who had multiple lifetime sexual partners than individuals with only one partner lifetime partner. Compared to adults in the age group 45-49 years, those adults in the age group 15-19 years had [AOR=0.12; 95% CI:(0.023-0.655)] less odds of having HIV infection. However, adults in the age group 25-29 years, 30-34 years and 35-39 years [AOR=1.7; 95% CI: (1.146-2.515)], [AOR=2.0;95% CI: (1.316-2.908)] and [AOR=2.1; 95% CI: (1.406-3.069)] were more likely to have HIV infection, respectively, as compared to adults in the age group 45-49 years.

Among the occupational categories, daily laborers had statistically significant lower odds of having HIV infection [AOR=0.55; 95% CI: (0.348-0.874)] as compared to non-working individuals. However, merchants had [AOR=1.8; 95% CI: (1.302-2.427)] higher odds of having HIV infection as compared to those adults who were not-working. The odds of having HIV infection among females [AOR=1.9; 95% CI: (1.444-2.632)] were higher as compared to male counter parts as depicted in **Table 3 and Fig 3**. The vertical line in **Figure 3** represents odds ratio of 1. Variables with odds ratio on this reference line have no association with HIV. Variables with odds ratio above the reference line have a higher odds of acquiring HIV whereas variables with odds ratio below the reference line have lower odds of having HIV infection (**Fig3**].

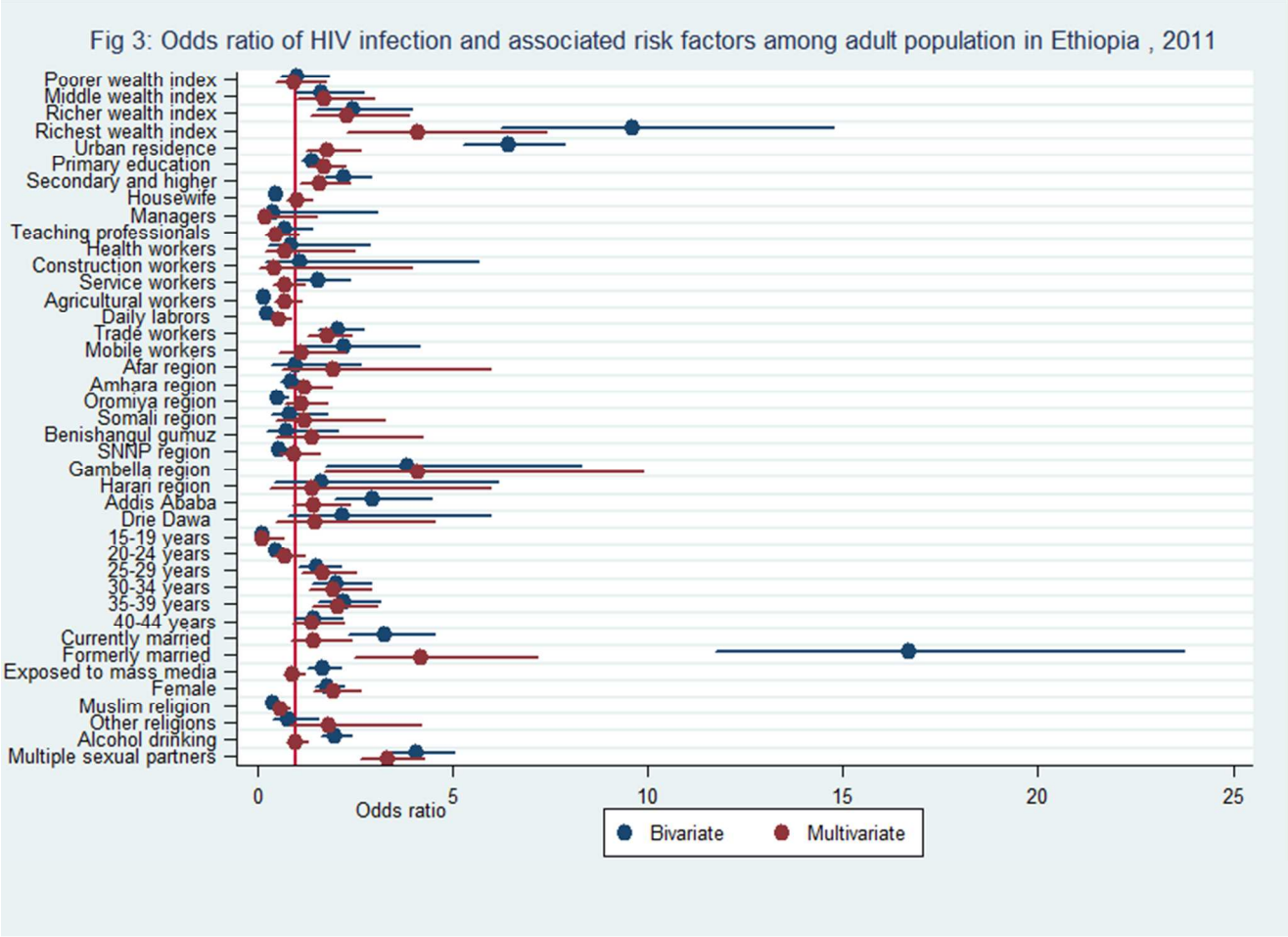
Table 3: Bivariate and multivariable logistic regression analysis to identify factors associated with HIV infection among adult population in Ethiopia, 2011

Independent risk factors	Crude OR with 95%CI	AOR with 95%CI
Wealth Index		
Poorest	1.00	1.00
Poorer	1.0[0.584-1.828]	.93[0.500-1.748]

Middle	1.6[0.968-2.722]	1.7[1.004-2.991]*
Richer	2.4[1.513-3.958]**	2.3[1.372-3.895]*
Richest	9.6[6.228-14.704]**	4.1[2.284-7.390]**
Residence		
Rural	1.00	1.00
Urban	6.4[5.277-7.834]**	1.8[1.236-2.661]*
Administrative regions		
Tigray	1.00	1.00
Afar	0.98[0.359-2.662]	2.0[0.635-5.993]
Amhara	0.87[0.596-1.271]	1.2[0.797-1.906]
Oromiya	0.54[0.365-0.787]*	1.1[0.726-1.781]
Somali	0.83[0.382-1.821]	1.2[0.466-3.275]
Benishangul gumuz	0.74[0.269-2.061]	1.4[0.470-4.238]
SNNPR	0.57[0.374-0.872]*	.95[0.572-1.591]
Gambella	3.8[1.779-8.330]*	4.1[1.703-9.875]*
Harari	1.6[0.431-6.185]	1.4[0.334-5.971]
Addis Ababa	2.9[1.960-4.432]**	1.5[0.900-2.360]
Dire Dawa	2.2[0.816-6.036]	1.5[0.498-4.551]
Marital status		
Not married	1.00	1.00
Currently married	3.3[2.365-4.583]**	1.5[0.881-2.403]
Formerly married	16.9[11.935-24.070]**	4.2[2.476-7.158]**
Education		
No formal education	1.00	1.00
Primary education	1.4[1.121-1.729]*	1.7[1.321-2.262]**
Secondary and higher	2.2[1.675-2.851]**	1.6[1.113-2.362]*
Religion		
Christian	1.00	1.00
Muslim	0.39[0.293-0.510]**	0.58[0.412-0.829]*
Others including traditional religions	0.80[0.403-1.579]	1.9[0.820-4.194]
Life time sexual partners		
One	1.00	1.00
Multiple	4.1[3.296-5.056]**	3.4[2.642-4.284]**
Age group		
15-19	0.13[0.067-0.243]**	.12[0.023-0.655]*
20-24	0.49[0.314-0.771]*	.71[0.420-1.199]
25-29	1.5[1.060-2.150]*	1.7[1.146-2.515]*
30-34	2.0[1.407-2.903]**	2.0[1.316-2.908]*
35-39	2.2[1.554-3.168]**	2.1[1.406-3.069]**
40-44	1.4[0.943-2.188]	1.4[0.894-2.214]
45-49	1.00	1.00
Occupation		
Not working	1.00	1.00
Corporate and general managers	0.88[0.121-6.415]	1.0[0.757-1.427]
Teaching and associate professions	1.5[0.777-2.986]	.20[0.027-1.532]

Health and life science workers	1.9[0.567-6.045]	.48[0.218-1.058]
Construction and engineering workers	2.3[0.437-11.814]	.73[0.213-2.493]
Front line service workers	3.2[2.081-5.022]**	.44[0.050-3.950]
Sales workers	2.1[1.579-2.766]**	.71[0.415-1.200]
Agricultural workers	0.36[0.257-0.519]**	.71[0.448-1.126]
Daily laborers	0.54[0.359-0.817])**	.55[0.348-0.874]*
Merchants	4.3[3.220-5.715]**	1.8[1.302-2.427]**
Mobile workers including drivers and operators	4.6[2.464-8.686]**	1.1[0.560-2.275]
Sex		
Male	1.00	1.00
Female	1.8[1.493-2.243]**	1.9[1.444-2.632]**

*p<0.0001, *p<0.00001



Discussion

This study found remarkable geographic and subpopulation variations that were not readily apparent judging by low national HIV prevalence in Ethiopia. Evidence also showed that there

are other countries with high HIV micro-level epidemics hidden by low national prevalence levels [11, 14, 16]. The presence of micro-level epidemics in certain localities could cause an emergence or reemergence of the epidemic at the national level.

The highest prevalence of HIV found in the Ethiopian Gambella administrative region could be attributed by higher prevalence of traditional practices such as polygamy and levirate marriage[23]. The other justification could be that this region is one of the regions where male circumcision is least practiced. Male circumcision has proved as protective effect on HIV infection[24, 25]. The next highest prevalence was found in Addis Ababa. This might be due to the fact that the city contains a relatively larger segment of commercial sexual workers in Ethiopia. There are also various types of 'hidden commercial sex workers' reported in Addis Ababa[26]. Furthermore, Addis Ababa is a rapidly growing city that attracts various tourists in turn pave the way to HIV epidemic. The practices of trans-generational and transactional sex are very common in Dukem and Bushoftu towns which are found around Addis Ababa. The majority of the clients for these two towns were from Addis Ababa[27]. Dire Dawa administrative city has also high prevalence of HIV which could be attributed by the fact that the town has been serving as a rest center for truck drivers from Djibouti port to Addis Ababa who would find sex workers

This study also revealed that there are certain occupational groups which had a high prevalence of HIV. The prevalence of HIV infection reaches up to 5.7% in mobile workers (drivers and mechanics operators). A significantly higher prevalence of HIV was also found among service workers, trade workers, construction and engineering workers. CDC defined MARPs as those groups that have higher than average HIV prevalence when compared to the general population[28]. According to CDC definition of Most-at-risk populations (MARPs) those occupation groups might be additional MARPs in addition to the previously described populations, at least in Ethiopia.

Those individuals who were in the wealthier category had higher odds of having HIV infection compared to the poorest category. Similar findings were reported from the decomposition analysis from sub-Saharan African countries[18]. Other studies from developing countries also showed that HIV is more prevalent in wealthier groups [19, 29-32]. A recent meta-analysis study revealed that risky sexual behaviour is associated with high economic status[33]. A study in Addis Ababa among taxi drivers and assistants also found income as one of the factors

associated with HIV risk behaviours[34]. The odds of having HIV infection was 80% higher among urban residents compared to their rural counter parts. This could be explained by the presence of large numbers of MARPS in urban than rural areas. Urban residency was also associated with risky sexual behaviour in developing countries[33].

The present study found higher odds of HIV infection among educated adults. Similarly, a systemic review studies showed that high HIV prevalence was found among highly educated groups than less educated groups [31, 35]. Educated groups had more sexual partners, non-marital sexual partners and the likelihood of premarital sex than less educated groups which are associated with HIV infection [32, 33, 36, 37]. As expected, this study also found that those individuals who had multiple sexual partners had higher odds of HIV infection as compared to individuals who had single lifetime sexual partners.

Formerly married adults had higher odds of having HIV infection as compared to non-married individuals. A similar finding was reported from many studies [38-41]. Those formerly married adults might engage in risky sexual behaviours[42, 43]. Divorced adults had higher risks of heavy alcohol consumption[44] and the drinking could result in HIV infection. Furthermore, divorced and widowhood women usually suffer from economic challenges that can explain to have risky sexual acts.

Females had also higher odds of having HIV infection as compared to males. This could be attributed by the biological disadvantage on the reproductive anatomy. Women are at a greater physiological risk of contracting HIV than men because of fluid receptors. This is in part because women have a greater mucosal surface area exposed to pathogens and infectious fluid for longer periods during sexual intercourse and are likely to experience increased tissue injury[20]. The other explanation could be sex for money. Many women also engaged in sex work in exchange for money, goods, or other benefits[45].

Public health implications

This study supports the hypothesis that risk factors for HIV are associated with certain specific socio-economic and demographic characteristics, which could be targeted to improve existing public health prevention measures in the general population. In the absence of studies attempted to quantify HIV infection and its spatial variation, the present study provides useful information.

There is evidence that the micro-epidemics started as localized in certain geographical location and subpopulation groups. Low national prevalence of HIV infection hides these localized epidemics. Trade, front line service and mobile workers had high prevalence rates of HIV infection and need to be considered as the key population for HIV. This study showed that the most productive age group is at risk for HIV infection which has its own development implication. HIV has been assumed as a disease of poor and non-educated people. This was the scenario which happened during the early stages of HIV epidemic. However, in Ethiopia wealthier groups had higher odds of having HIV infection. Therefore, monitoring the epidemics of HIV in accordance with population segmentation and localized intervention programs are paramount importance rather to depend on the national prevalence.

Conclusion

In Ethiopia, the prevalence of HIV was not randomly nor uniformly distributed and the epidemic has concentrated in geographic areas of 25 administrative zones in Oromiya, Amhara, Tigray, Afar and Somali regions. The study found statistically significant HIV risk differences in certain population segments by education, age, residence, occupation, wealth index and gender. In fact, further work needs to be devoted to understand the mechanisms by which HIV/AIDS is concentrated among merchants, educated groups, females, wealthier individuals and urban residents, particularly focusing on regional and zonal geographic borders within the hotspot areas of this study. This study recommends the need to have spatial based prevention strategies for specific population groups. Voluntary male circumcision might be considerable intervention in Gambella administrative regional where male circumcision is not widely practiced.

Conflict of interest

We declare that have no conflict of interest

Author's contributions

YL and DH conceptualized the study, performed the data analysis, made interpretations and drafted the manuscript. SB edited, interpreted the data and critically reviewed the manuscript. All authors read the manuscript and approved the final version.

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Social determinants of HIV infection, hotspot areas and sub-population groups in Ethiopia: Evidence from national Demographic and Health Survey in 2011

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Abstract

Objective: This study identifies social determinants of HIV infection, hotspot areas and sub-population groups in Ethiopia.

Design: The study used data from the 2011 Ethiopian Demographic and Health Survey (EDHS). Sample blood tests from the finger pricks collected on filter paper cards were labeled with a barcode unique to each respondent. Spatial scan statistics and geographic information system tools were used to map hotspot areas of HIV prevalence. Bivariate and multivariable logistic regression models were used to identify social determinants of HIV infection.

Population: A total of 30,625 adults (16,515 women and 14,110 men) were included from 11 administrative states of Ethiopia.

Main outcome measures: Laboratory-confirmed HIV sero-status is the main outcome variable.

Results: HIV prevalence reached 10-21% in the central, eastern and western geographic clusters of Ethiopia. Multivariable analysis showed that individuals who were in the middle, richer and richest wealth quintiles had increased odds of having HIV over those in the poorest quintile. Adults who had primary, secondary and higher educational levels had higher odds of being HIV positive than non-educated individuals. The odds of having HIV was higher among adults who had multiple lifetime sexual partners than those with a single partner. An increasing odds of HIV was observed among adults in the age group 25-29, 30-34, 35-39 and 40-45 years compared to age group45-49 years. Merchants had higher odds of being HIV positive than those who were not employed. The odds of having HIV was higher among urban residents and females than among rural residents and males, respectively.

Conclusion: This study found statistically significant HIV concentrations in administrative zones of central, eastern and western Ethiopia. Geo-spatial monitoring and targeting of prevention strategies for specific population groups is recommended.

Key words: Hotspot, social determinants, HIV, Ethiopia

Strength and limitations of the study

- One of the strengths of this study is the use of a nationwide laboratory-confirmed HIV sero-status data. Therefore, the study findings can be used to inform policy and program actors at sub-national and regional levels.
- However, the study has certain limitations. Some regions and EDHS clusters had small sample sizes, which raises the question about the accuracy of prevalence estimates per region, so that those should be interpreted with caution. Because the study was a secondary data analysis, it lacks other important social determinant variables which could be associated with risk of HIV infection.
- This study also shares the limitation of the cross-sectional study design which prohibits confirmation of cause and effect relationships.

Introduction

HIV/AIDS has been documented as one of the major public health challenges in the world[1]. Globally, there were approximately 35.0 million people living with HIV at the end of 2013 with 2.1 million people newly infected. The sub-Saharan region of Africa is the most affected in the world with 24.7 million people living with HIV in 2013[2]. This region accounts for almost 70% of the global total of new HIV infections despite of having only a 13% share of the world's population[2]. Ethiopia is one of the sub-Sahara African countries shared the burden of HIV epidemics[3]. There were totally 759,268 people living with HIV and 80,000 HIV-infected children in Ethiopia in the year 2012[4]. The national HIV prevalence among adults in Ethiopia has declined from 4.5% between 1998-1999[1] to 1.5% in 2011[5], which is an encouraging achievement for the country.

Although estimates suggest that the rate of new HIV infection is declining in many African settings[2], the HIV incidence remains unacceptably high with striking sub-population and geographic differences[6]. The HIV epidemic has been showing remarkable variations across population subgroups[7], regions and countries[6 8], at the sub-national level between provinces [9] and within sub-districts[10]. The geographical structure of HIV epidemic is the consequence of drivers of the epidemic and the availability of susceptible population to the infection[11]. Strongest clustering has been observed in countries with a low national prevalence of HIV infection[11]. The "know your epidemic" concept recognizes this geographical feature as a key strategy in identifying populations at higher risk of HIV infection and in which prevention interventions should be targeted[12].

The HIV/AIDS epidemic in Ethiopia is often classified as "generalized" among the adult population with significant heterogeneity among regions and population groups[13]. The rural epidemic appears to be relatively widespread but heterogeneous with most rural areas having a relatively low prevalence of HIV infection [13]. In many African countries including Ethiopia, the concept of concentrated sub-epidemics within a generalized epidemic context has been relatively neglected topic to date[14]. Mapping hotspot areas, identifying social determinants and affected population groups, especially in resource limited settings, would assist in targeting and prioritizing interventions[15]. The hotspot areas would be further examined for unobserved or

unknown risk factors which are driving the HIV epidemic. Monitoring a localized epidemic is, therefore, essential for more effective prevention strategies[16] in Ethiopia even though adult HIV prevalence has declined at the national level. Little information is available about the sub-geographic areas and certain sub-population groups in the country. We hypothesize that low national prevalence of HIV infection hides the localized epidemics in Ethiopia. Therefore, this study aimed to identify social determinants of HIV infection, hotspot areas, and sub-population groups to effectively target interventions in the country which has limited resources available.

Methods and materials

Data type and study design:

This analysis used data from the 2011 Ethiopian Demographic and Health Survey (EDHS). The survey followed an international DHS methodology and is conducted at five years interval. The EDHS was designed to provide population and health indicators at the national (urban and rural) and regional levels. The 2011 EDHS samples were selected using a stratified and two-stage cluster sampling design. The survey included 624 samples of enumeration areas (clusters), of which 187 were in urban areas and 437 were in rural areas. A representative sample of 16,702 households were interviewed in all 11 administrative regions and 85 zones. Of these, 11,590 households interviewed were from rural areas. A total of 30,625 adults between 15-59 years of age were included, among which 16,515 respondents were women. Overall, 86% of respondents who were eligible for testing were interviewed and consented to HIV testing. Four percent of respondents were refused to be tested for HIV and did not provide blood sample. The response rates for HIV testing were 89% for women and 82% for men. The detailed methodology is found elsewhere[17].

Data extraction:

The 2011 EDHS datasets were downloaded in SPSS format with permission from the Measure DHS website (http://www.dhs program.com). After understanding the detailed datasets and coding, further data recoding was done. Social determinants and HIV prevalence indicator variables were extracted from male and female datasets. Datasets of HIV test results, socio-demographic characteristics of respondents and Global Positioning System (GPS) coordinates of EDHS clusters were merged accordingly for this analysis.

Measurement of variables:

Sample blood tests with voluntary HIV counseling were done to provide HIV data for the 2011 EDHS. Five blood spots from the finger pricks were collected on a filter paper card labeled with a barcode unique to each respondent. The detailed procedures can be accessed elsewhere [17]. The barcodes identifying the HIV test results were linked with individual respondent datasets.

Based on the literature review [16 18-20] and data in the 2011 EDHS, social determinant variables were identified. For this study, the term "social determinants" encompass the socio-economic, cultural, residence and lifestyle conditions of people that may predispose to HIV infection. The chosen variables to potentially associate with HIV were wealth index, age, occupation, comprehensive knowledge of HIV, use of alcohol or khat, migration, religion, location of residence including administrative region, education, mass media exposure including reading newspaper, listening to radio and television, gender, total number of lifetime sexual partners and marital status. These variables were selected that guided by literature review[19 21-24].

Statistical analysis:

The spatial scan statistics (SaTScan) software (version 9.1, www.satscan.org) was used to detect the potential clustering of HIV cases[25]. The basic idea of SaTScan is to allow circular windows of various sizes to range across the study areas. At each location, the rate of disease inside the window is compared with that outside of it. For a given cluster (circular window), the software calculates the probability of a data point being a case inside or outside the circle under consideration. For each circle, a likelihood ratio is computed for the alternative hypothesis that there is an increased risk of disease inside the circle, against the null hypothesis that the risk inside the circle is the same as that outside. In this context, a hotspot cluster is detected within a defined geographical area during a specific timeframe if the area has a disproportionate excess of HIV cases when compared with neighboring areas under study. While satisfying assumptions of the statistical model, an unusual high or low number of cases in specific spatial areas can be characterized by statistical significance. The sets of potential clusters are then rank ordered according to the magnitude of their likelihood ratio test statistics. The user-defined maximum radius used by SaTScan was set to its default value of 50%, as recommended by Kulldorf[25]. In order to investigate the sensitivity of SaTScan results to the default setting, we ran the SaTScan

spatial scan statistics 10 times, starting with a maximum size of 5% and increasing the parameter by an interval of 5% with each run until reaching the default maximum size value of 50%. Results were not affected by the choice of radius selected; we therefore used the default value of 50% in our analysis.

We also used "svy" command in STATA version 11 to weight the survey data and do all types of analyses. Sample weights were applied in order to compensate for the unequal probability of selection between the strata that have been geographically defined as well as for non-responses. A detailed explanation of the weighting procedure can be found in the EDHS methodology report [17]. Descriptive statistics were used to determine the weighted prevalence of HIV across social determinant variables. Bivariate and multivariable logistic regressions were carried out to determine the factors associated with HIV prevalence. As recommended by Hosmer and Lemeshow, variables found to be statistically significant at p-value <0.25 during bivariate analysis could be candidates for multivariable logistic regression model[26]. This p-value cutoff point is important to retain variables that will have potential effects during multivariable analysis. A multi-collinearity test was done and variables with variance inflation factors (VIF) of greater than 10 were excluded from the multivariable analysis [27]. No variables were found to exceed the VIF value of 10 in the multicollinearity test. All tests were two-sided and a p-value <0.05 was considered statistically significant in the multivariable statistical model. Both crude and adjusted odds ratios were calculated with 95% confidence interval.

Ethical consideration:

The original DHS data were collected in conformity with international and national ethical guidelines. Ethical clearance for the original survey was provided by the Ethiopian Public Health Institute (EPHI) Review Board, the National Research Ethics Review Committee (NRERC) at the Ministry of Science and Technology, the Institutional Review Board of ICF International and the Centers for Disease Control and Prevention (CDC). The data for this study were downloaded and used after the purpose of the analysis was communicated and approved by the Measure DHS.

Results

Characteristics of the study population:

The 2011 EDHS included a total of 30,625 adults in the age range of 15–59 years for men and 15-49 years for women. Among the respondents, 53.9% (16,515) were females. About 68.8% (21,080) respondents were from rural areas. Approximately 42% of the respondents had not attended formal education while 41% had primary level education. The proportion of Christians (Orthodox, Protestant and Catholic) was 60.7% followed by Muslims which accounted for 37.5%. The mean age of respondents was 29.0 years with a standard deviation of 10.5 years.

HIV prevalence by socio-demographic characteristics:

The overall prevalence of HIV was 1.5% with a 1.9% [95% CI: (1.70-2.12)] prevalence rate in females and a 1.0% [95% CI: 0.84-1.18] prevalence rate in males. The prevalence of HIV in urban settings was 4.3% [95% CI: (3.81-4.81)] while in rural areas it was 0.7% [95% CI: (0.60-0.81)]. The prevalence of HIV infection was 1.8% [95% CI: (1.62-1.99)] among Christian religion followers. The prevalence of HIV infection in Gambella administrative region was 6.7% [95% CI: (3.51-12.60)] followed by administrative cities of Addis Ababa with 5.2% [95% CI: (4.14-6.45)] and Dire Dawa with 4.0% [95% CI: (1.64-9.53)]. The lowest prevalence, 1.0% [95% CI: (0.83-1.20)], was found in Oromiya region. Among the wealth quintiles, the highest prevalence of HIV infection at 4.1% [95% CI: (3.65-4.58)] was found in the richest wealth quintile. The prevalence of HIV infection among individuals who had attended secondary and higher education level was 2.4% [95% CI: (1.95-2.94)]. The prevalence of HIV infection in the age group 35-39 years was 3.0% [95% CI: (2.47-3.62)] followed by 30-34 age groups with 2.7% [95% CI: (2.18-3.28)]. About 7% [5.87-8.07] of HIV infection was observed in formerly married adults. Among the different occupational groups, the highest prevalence of HIV was found among mobile workers at 5.7% [95% CI: (2.94-9.40)] followed by merchants with 5.4% [95% CI: (4.41-6.48)]. HIV prevalence was 4.1% [95% CI: (2.73-5.81)] among frontline service workers, 2.9% [95% CI: (0.10-9.29)] among construction and engineering workers and 2.7% [95% CI: (2.22-3.24)] in sales workers (**Table 1).**

Geographic clusters of HIV prevalence in Ethiopia:

As shown on F**igure 1,** the prevalence of HIV reaches up to 10-21% in certain geographic clusters particularly in the central, eastern and western parts of the country. There are also some clusters with a prevalence of HIV from 4-9% in northern and southwestern Ethiopia. Most geographic coverages of the country have had an HIV prevalence rate of less than 4.5%. There were no EDHS clusters (enumeration areas) included in the peripheral areas of the country, particularly in eastern parts of Somali administrative region and as a result the HIV prevalence could not be estimated in this analysis.

As indicated in **Table 2 and Fig 2**, six clusters were identified during SaTScan analysis; however, only cluster 1 and 2 were statistically significant hotspots with p-value at <0.001 and 0.003, respectively. In the first cluster, a total of 164 EDHS enumeration locations were circled within a 258 km radius. This hotspot covered a total of 24 administrative zones from Oromiya, Amhara, Tigray, Afar and Somali administrative regions including Addis Ababa. A total of 252 HIV cases were observed in this hotspot with 2.6 relative risk and 48 log likelihood ratio (LLR) that would be about 153 HIV cases expected. In the second hotspot, only one EDHS enumeration location that found in Oromiya administrative region, West Arsi zone, was circled with 8.7 relative risk and 11.9 LLR.

Factors associated with HIV infection:

During bivariate analysis, ever use of khat and migration status had no statistically significant association with HIV based on the cutoff point p-value <0.25. Variables including exposure to mass media, ever use of alcohol, mobile workers and comprehensive knowledge of HIV were associated with HIV in the bivariate analysis; however; they were not found to be statistically significant in the multivariable logistic regression model.

As shown in the multivariable analysis of **Table 3 and Fig 3**, those individuals who were in the middle, richer and richest wealth quintiles had higher odds of having HIV compared to the poorest wealth quintile[AOR=1.7; 95% CI: (1.00-2.99)], [AOR=2.3; 95% CI: (1.37-3.90)] and [AOR=4.1; 95% CI: (2.28-7.39)], respectively. The odds of having HIV were higher among urban residents compared to their rural counterparts [AOR=1.8; 95% CI: (1.24-2.66)]. Compared

to Tigray regional state, the odds of having HIV were higher in Gambella administrative region [AOR=4.1; 95% CI: (1.70-9.88)]. Those individuals who were formerly married had higher odds compared to never married individuals [AOR=4.2; 95% CI: (2.48-7.16)]. Similarly, those individuals who had attended primary education had [AOR=1.7; 95% CI: (1.32-2.26)] and secondary and higher education had [AOR=1.6; 95% CI: (1.11-2.36)] times higher odds to have HIV infection compared to those who had no formal education.

Those Islamic religion followers had less likely to have HIV infection compared to Christian religions followers [AOR=0.58; 95% CI: (0.41-0.83)]. The odds of having HIV infection were higher among adults who had multiple lifetime sexual partners than individuals with only one lifetime partner [AOR=3.4; 95% CI (2.64-4.28)]. Compared to adults in the age group 45-49 years, those adults in the age group 15-19 years had less odds of having HIV infection[AOR=0.12; 95% CI:(0.02-0.66)]. However, adults in the age group 25-29 years, 30-34 years and 35-39 years were more likely to have HIV infection compared to adults in the age group 45-49 years [AOR=1.7; 95% CI: (1.15-2.52)], [AOR=2.0;95% CI: (1.32-2.91)] and [AOR=2.1; 95% CI: (1.42-3.07)], respectively.

Among the occupational categories, daily laborers had statistically significant lower odds of having HIV infection compared to non-working individuals [AOR=0.55; 95% CI: (0.35-0.87)]. However, merchants had higher odds of having HIV infection compared to those adults who were not-working [AOR=1.8; 95% CI: (1.30-2.43)]. The odds of having HIV infection among females were higher compared to male counterparts [AOR=1.9; 95% CI: (1.44-2.63)]. The vertical line in **Figure 3** represents odds ratio of 1. Variables with odds ratio on this reference line have no association with HIV. Variables with odds ratio above the reference line have a higher odds of acquiring HIV whereas variables with odds ratio below the reference line have lower odds of having HIV infection.

Discussion

This study found remarkable variations of HIV prevalence in geographic and subpopulation groups in Ethiopia. The result is similar with findings in other countries that indicated micro-level epidemics hidden by low national HIV prevalence[11 14 16]. This suggests that the HIV

epidemic in certain localities could cause an emergence or reemergence of the epidemic if not well addressed the sub-geographic and population groups.

The highest prevalence of HIV found in Gambella administrative region which could be attributed by higher prevalence of traditional practices such as polygamy and levirate marriage[28]. The other explanation could be that Gambella is one of the regions in Ethiopia where male circumcision is least practiced thought it has proved protective effect on HIV infection[29 30]. The next highest prevalence of HIV was found in Addis Ababa. This might be due to the fact that the city contains a relatively large segment of commercial sexual workers with various type[31]. Furthermore, Addis Ababa is a rapidly growing city that attracts various types of tourists which, in turn, may contribute to the HIV epidemic. Evidence showed that tourism has effect on addictive substance and drug use[32] and it is associated with higher odds of HIV infection[33]. Similarly, commercial sex workers target tourists for economic gain and this could transport diseases back into other communities[34]. Furthermore, a trans-generational and transactional sexual practices are very common in places of Dukem and Bushoftu towns which are found nearby Addis Ababa [35]. Dire Dawa administrative city also has a high prevalence of HIV which could be attributed by the fact that the town has been serving as a rest center for truck drivers from Djibouti port to Addis Ababa and who, along the way, frequent sex workers. This study also revealed that there are certain occupational groups which had a high prevalence of HIV. A population group that have higher than average HIV prevalence when compared to the general population is labeled as most-at-risk populations (MARPs)[36]. Accordingly in this study, those occupational groups including merchants, mobile workers, service workers, construction and engineering workers might be additional MARPs in addition to the previously described populations in Ethiopia.

The multivariable analysis found that HIV prevalence was associated with wealthier groups. There are different arguments either poverty or wealth is driving HIV transmission[37]. The relationship between HIV infection and wealth quintile did not show consistent trends in many other countries[21]. In this study, those individuals who were in the wealthier category had higher odds of having HIV infection compared to the poorest category. Similar findings were reported from the decomposition analysis from sub-Sahara African countries[18]. Other studies from developing countries also showed that HIV is more prevalent in wealthier groups [19 21 38-40]. A

recent meta-analysis study revealed that risky sexual behaviour is associated with high economic status[41]. A study in Addis Ababa among taxi drivers and assistants also found income as one of the factors associated with HIV risk behaviours [42].

The present study found higher odds of HIV infection among educated adults. Similarly, a systemic review studies showed that high HIV prevalence was found among more highly educated groups than less educated groups [39 43 44]. Highly educated groups had more sexual partners, non-marital sexual partners and a greater likelihood of premarital sex than less educated groups [40 41 45 46]. A study conducted in Ethiopia among women showed that HIV prevalence declined overtime among no formal and secondary education groups, but not among the primary educated group [45]. The study also come up with little evidence to show significant difference in the prevalence change overtime by educational attainment[44].

In this analysis, the odds of having HIV infection was 80% higher among urban residents compared to their rural counterparts. This could be explained by the presence of large numbers of MARPS in urban than rural areas. Urban residency was also associated with risky sexual behaviours in other developing countries[41]. As expected, this study found that those individuals who had multiple sexual partners had higher odds of HIV infection as compared to individuals who had single lifetime sexual partners. This finding is consistent with several studies elsewhere[47-49]. The present study showed that formerly married adults had higher odds of having HIV infection compared to non-married individuals. A similar finding was reported from many studies elsewhere[22-24 50]. Those formerly married adults found to engage in risky sexual behaviours[51 52]. This is explained by divorced and widowed women usually suffer from economic challenges that could lead some to have risky sexual behaviours such as prostitution or sexual for goods and favors. An evidence revealed that divorced adults had higher risks of heavy alcohol consumption[53] and such drinking behaviour could result in HIV infection.

In our analysis, females had higher odds of having HIV infection compared to males. There are a lot of biological, socio-economic and cultural risk factors that increase women's vulnerability to HIV acquisition[20]. The first explanation could be the biological disadvantage of female's reproductive anatomy. Women are at a greater physiological risk of contracting HIV than men because of fluid receptors. This is in part because women have a greater mucosal surface area exposed to pathogens and infectious fluid for longer periods during sexual intercourse and are likely to experience tissue injury[20]. Another possible explanation could be sex for money. Many

women also engaged in sex work in exchange for money, goods, or other benefits[54]. Gender inequality and gender-based violence placed women also at higher risk for HIV infection[47 55]. Gender norms in some African countries promote multiple concurrent sexual partners for men while women are expected to be monogamous and unquestioning of their partner's behaviour[47-49].

Public health implications

This study supports the hypothesis that risk factors for HIV are associated with certain specific socio-economic and demographic characteristics which could be targeted to improve existing public health prevention measures in the general population. In the absence of studies that attempted to quantify HIV infection by sub-population group and spatial variations, the present study provides useful information for policy and program actions. Among the occupational categories, merchants, construction and engineering workers, frontline service and mobile workers had high prevalence rates of HIV infection and need to be considered as a key population for HIV. In certain geographic clusters particularly in central and western parts of Ethiopia a statistically significant high HIV concentration was observed. This is evidence that the micro-epidemics started as localized in certain geographical locations and subpopulation groups in Ethiopia. Furthermore, this study showed that educated and wealthier groups had higher odds of having HIV infection than the less educated and poorer population categories. The most productive age group of 25-39 years is also found at risk for HIV infection which has its own development implications. Therefore, HIV is not only an issue of the health sector alone, it is a wide spectrum of development agenda. Monitoring the epidemics of HIV in accordance with population segmentation and localized intervention programs would have a paramount importance rather than using the national prevalence as the key monitoring variable.

Conclusion

The prevalence of HIV was neither randomly nor uniformly distributed in Ethiopia. The HIV epidemic has concentrated in geographic areas of 25 administrative zones in Oromiya, Amhara, Tigray, Afar and Somali regions. The epidemic is also concentrated among merchants, educated groups, females, wealthier individuals and urban residents. This study recommends the need to have spatial-based prevention strategies for specific population groups particularly focusing on regional and zonal geographic borders within the hotspot areas.

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Conflict of interest

We declare that we have no conflict of interest

Author's contributions

YL and DH conceptualized the study, performed the data analysis, made interpretations and drafted the manuscript. SB edited, interpreted the data and critically reviewed the manuscript. All authors read the manuscript and approved the final version.

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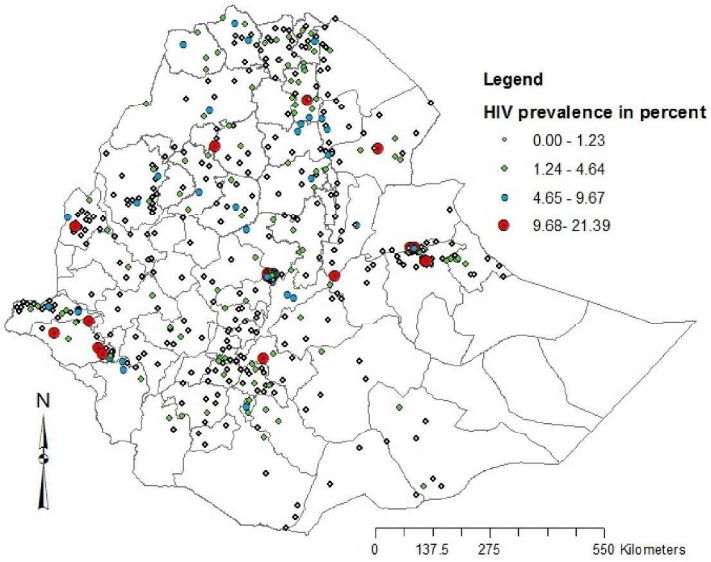

Fig1: Map to show the prevalence of HIV infection in EDHS cluster areas of Ethiopian Zones, 2011

Fig1
215x279mm (300 x 300 DPI)

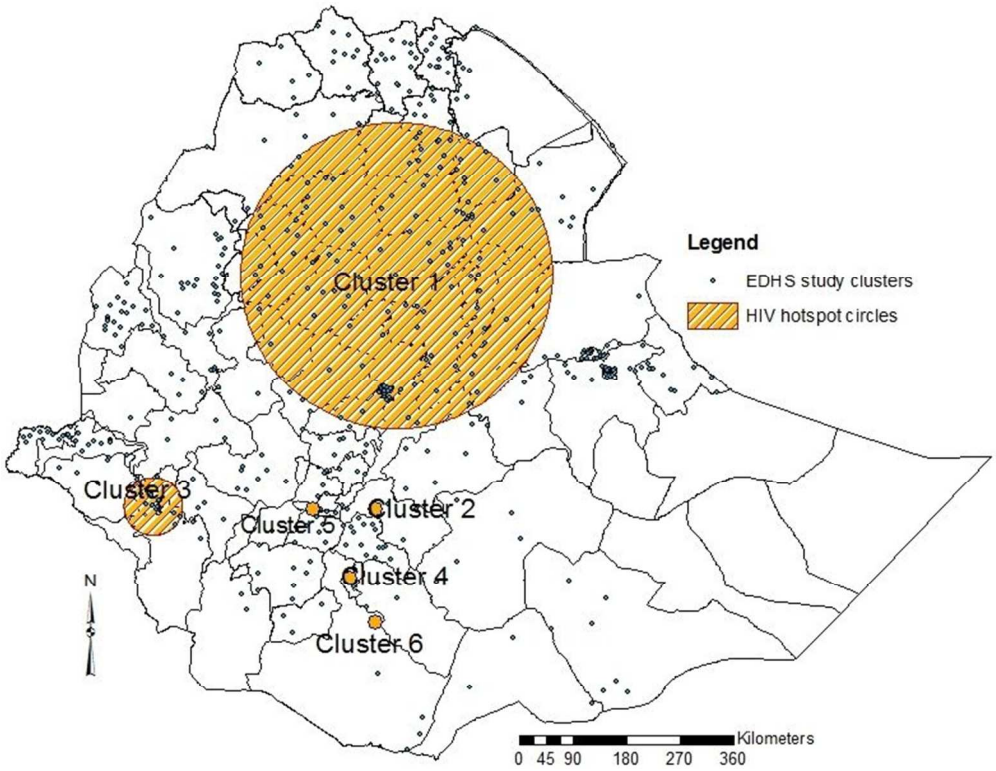

Fig 2: HIV hotspot clusters identified at zonal level using SaTScan spatial analysis tool, in Ethiopia 2011

277x254mm (72 x 72 DPI)

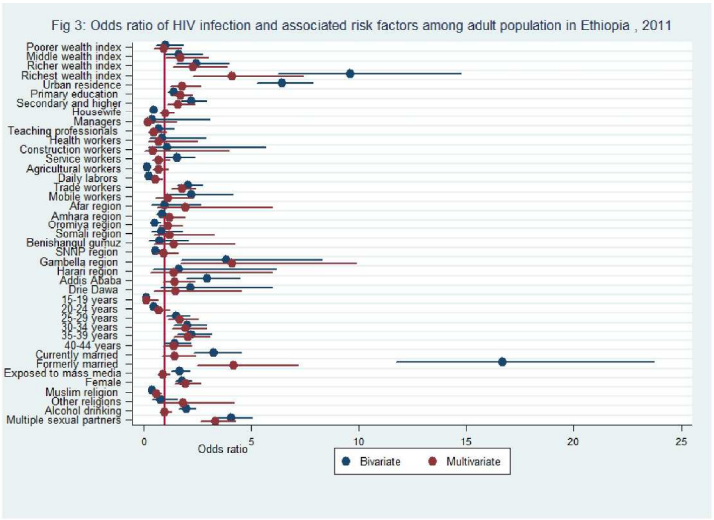

Fig3
215x279mm (300 x 300 DPI)

Table1: HIV prevalence by different socio-demographic characteristics of respondents in Ethiopia, 2011

Characteristics of respondents	HIV prevalence with 95%CI	Total weighted respondents	Weighted number of HIV Cases
Sex			
Male	1.0[0.84-1.18]	13,234	132
Female	1.9[1.70-2.12]	15,730	299
Residence			
Urban	4.3[3.81-4.81]	6,337	272
Rural	0.7[0.60-0.81]	22,628	158
Religion			
Christian	1.8[1.62-1.99]	20,147	363
Muslim	0.7[0.54-0.90]	8,231	58
Traditional and others	1.5[0.75-2.79]	587	9
Administrative regions			
Tigray	1.8[1.26-2.46]	1,901	34
Afar	1.8[0.52-3.90]	244	4
Amhara	1.6[1.34-1.89]	7,821	125
Oromiya	1.0[0.83-1.20]	10,983	110
Somali	1.5[0.73-2.95]	511	8
Benishangul-gumuz	1.4[0.42-3.12]	306	4
SNNPR	1.1[0.85-1.40]	5,457	60
Gambella	6.7[3.51-12.60]	127	9
Harari	3.0[0.42-8.01]	80	2
Addis Ababa	5.2[4.14-6.45]	1,422	74
Dire Dawa	4.0[1.64-9.53]	113	5
Wealth Index			
Poorest	0.4[0.25-0.59]	5,117	20
Poorer	0.5[0.33-0.71]	5,451	27
Middle	0.7[0.50-0.95]	5,572	39

Richer	1.1[0.86-1.39]	5,913	65
Richest	4.1[3.65-4.58]	6,912	283
Education			
Not formal education	1.1[0.93-1.29]	12,391	136
Primary	1.6[1.39-1.83]	12,837	205
Secondary and higher	2.4[1.95-2.94]	3,738	90
Marital status			
Never married	0.4[0.29-0.55]	9,376	38
Currently married	1.4[1.24-1.58]	17,548	246
Formerly married	6.9[5.87-8.07]	2,041	141
Age groups			
15-19	0.2[0.11-0.33]	6,637	13
20-24	0.7[0.50-0.97]	4,975	35
25-29	2.1[1.73-2.52]	5,148	108
30-34	2.7[2.18-3.28]	3,346	90
35-39	3.0[2.47-3.62]	3,399	102
40-44	2.0[1.49-2.66]	2,238	45
45-49	1.8[1.27-2.43]	2,019	36
50+	0.7[0.31-1.26]	1,203	8
Number of life time sexual partners			
Single	0.9[0.75-1.08]	13,063	118
Multiple	3.7[3.30-4.15]	7,612	282
Ever alcohol drinking			
No	1.0[0.85-1.17]	14,727	147
Yes	2.0[1.78-2.24]	14,229	285
Comprehensive knowledge on HIV			
No	1.5[1.36-1.65]	27,505	413
Yes	0.3[0.05-0.97]	676	2
Exposure to mass media			
No	1.0[0.79-1.24]	7,341	73

Yes	1.7[1.53-1.88]	21,495	365
Occupational status			
Not working including house wives	1.3[1.06-1.58]	7,240	94
Corporate and general managers	1.2[0.06-5.54]	87	1
Teaching and associate professions	2.0[1.06-3.66]	483	10
Health and life science workers	2.4[0.64-6.60]	121	3
Construction and engineering workers	2.9[0.10-9.29]	51	1
Front line service workers	4.1[2.73-5.81]	640	26
Sales workers	2.7[2.22-3.24]	3,932	106
Agricultural workers	0.5[0.37-0.65]	9,692	48
Daily laborers	0.7[0.49-0.99]	4,258	30
Merchants	5.4[4.41-6.48]	1,842	99
Mobile workers including drivers, operators and assemblers	5.7[2.94-9.40]	199	11
Other occupations*	0.1[0.03-2.48]	197	1
Total	**1.5[1.35-1.63]**	**28,964**	**431**

*Students, armed, legal, higher officials and ill people. Since we did a pooled data of both men 15-59 and women 15-49, a slight difference in figures have been shown from the original EDHS report.

Table 2: Statistical summaries from SaTScan clustering analysis in Ethiopian administrative regions and zones, 2011.

Clusters	Regions/Zones in the cluster	Radius	LLR	P-value	RR	Observed	Expected
Cluster1	Addis Ababa, Oromiya*, Amhara^, Tigray[$], Afar[@] and Somali[#]	258	48.0	<0.001	2.6	252	153
Cluster 2	Oromiya–West Arsi zone	0	11.9	0.003	8.7	9	1
Cluster 3	Gambella–Agnuak and Majanger zones SNNPR–Sheka, Bench maji and Keffa zones	49	6.0	0.413	3.1	13	4
Cluster 4	SNNPR – Gedio zone	0	4.9	0.719	4.3	7	2
Cluster 5	SNNPR – KT zone	0	3.7	0.975	3.1	8	3
Cluster 6	Oromiya – Borena zone	0	3.1	0.996	3.0	7	2

*East Shewa, West Shewa, South West Shewa, North Shewa, Oromiya Special Zone, Horo-Guduru, Parts of East Wolega, parts of West Hararge zones

^North Shewa Special zone, South Wollo, East Gojam, West Gojam, South Gondar, Eastern parts of North Gondar, Wag Himira and AwiAgew zones

[$] South Tigray zone

[@] Zone 1, Zone 2 and Zone 3

[#]Site Zone

LLR=Log Likelihood ratio, OR=Odds ratio, RR=relative risk, Radius is in kilometer

Table 3: Bivariate and multivariable logistic regression analysis to identify factors associated with HIV infection among adult population in Ethiopia, 2011

Independent risk factors	Crude OR with 95%CI	AOR with 95%CI
Wealth Index		
Poorest	1.00	1.00
Poorer	1.0[0.58-1.83]	0.9[0.50-1.75]
Middle	1.6[0.97-2.72]	1.7[1.00-2.99]*
Richer	2.4[1.51-3.96]**	2.3[1.37-3.90]*
Richest	9.6[6.23-14.70]**	4.1[2.28-7.39]**
Residence		
Rural	1.00	1.00
Urban	6.4[5.28-7.83]**	1.8[1.24-2.66]*
Administrative regions		
Tigray	1.00	1.00
Afar	1.0[0.36-2.66]	2.0[0.63-5.99]
Amhara	0.9[0.60-1.27]	1.2[0.80-1.91]
Oromiya	0.5[0.37-0.79]*	1.1[0.73-1.78]
Somali	0.8[0.38-1.82]	1.2[0.47-3.27]
Benishangul-gumuz	0.7[0.27-2.06]	1.4[0.47-4.24]
SNNPR	0.57[0.37-0.87]*	1.0[0.57-1.59]
Gambella	3.8[1.78-8.33]*	4.1[1.70-9.88]*
Harari	1.6[0.43-6.19]	1.4[0.33-5.97]
Addis Ababa	2.9[1.96-4.43]**	1.5[0.90-2.36]
Dire Dawa	2.2[0.82-6.04]	1.5[0.50-4.55]
Marital status		
Never married	1.00	1.00
Currently married	3.3[2.37-4.58]**	1.5[0.88-2.40]
Formerly married	16.9[11.94-24.07]**	4.2[2.48-7.16]**
Education		
No formal education	1.00	1.00

Primary education	1.4[1.12-1.73]*	1.7[1.32-2.26]**
Secondary and higher	2.2[1.68-2.85]**	1.6[1.11-2.36]*
Religion		
Christian	1.00	1.00
Muslim	0.4[0.29-0.51]**	0.6[0.41-0.83]*
Others including traditional religions	0.8[0.40-1.58]	1.9[0.82-4.19]
Life time sexual partners		
One	1.00	1.00
Multiple	4.1[3.30-5.06]**	3.4[2.64-4.28]**
Age group		
15-19	0.1[0.07-0.24]**	0.1[0.02-0.66]*
20-24	0.5[0.31-0.77]*	0.7[0.42-1.20]
25-29	1.5[1.06-2.15]*	1.7[1.15-2.52]*
30-34	2.0[1.41-2.90]**	2.0[1.32-2.91]*
35-39	2.2[1.55-3.17]**	2.1[1.40-3.07]**
40-44	1.4[0.94-2.19]	1.4[0.89-2.21]
45-49	1.00	1.00
Occupation		
Not working	1.00	1.00
Corporate and general managers	0.9[0.12-6.42]	1.0[0.76-1.43]
Teaching and associate professions	1.5[0.78-2.99]	0.2[0.03-1.53]
Health and life science workers	1.9[0.57-6.04]	0.5[0.22-1.06]
Construction and engineering workers	2.3[0.44-11.81]	0.7[0.21-2.49]
Front line service workers	3.2[2.08-5.02]**	0.4[0.05-3.95]
Sales workers	2.1[1.58-2.76]**	0.7[0.41-1.20]
Agricultural workers	0.4[0.26-0.52]**	0.7[0.45-1.13]
Daily laborers	0.5[0.36-0.82])**	0.6[0.35-0.87]*
Merchants	4.3[3.22-5.71]**	1.8[1.30-2.43]**
Mobile workers including drivers and operators	4.6[2.46-8.69]**	1.1[0.56-2.27]
Sex		

Male	1.00	1.00
Female	1.8[1.49-2.24]**	1.9[1.44-2.63]**

*p<0.0001, *p<0.00001