Socioeconomic disparities and the distribution of HIV in Cameroon: a multilevel logistic regression analysis

Zhongshang Yuan (✉ yuanzhongshang@sdu.edu.cn)

Shandong Universtiy

Weiqiang Lin

Shandong University

Marlvin Anemey Tewara

Shandong University

Liu Yunxia

Shandong University

Helen Binang Barong

Shandong University

Che Pantalius Nji

Tuberculosis Reference Laboratory Bamenda

Nguedia Meguimfouet Linda

Laboratoire d'Analyses Medicale du Centre

Omam Francine Ariane

Universite de Ngaoundere

Tchio Tchoumba Michele Audre

Xi'an Jiaotong University

Prisca N. Mbah-Fongkimeh

The University of New Castle

Abstract

Background: There have been controversial debates on the relationship between socioeconomic status and the distribution of HIV in Cameroon. We aim to illustrate the vulnerability of socioeconomic disparities and the risk of getting HIV for public health interventions.

Methods: Descriptive statistics was conducted to quantify the socioeconomic gradients of HIV. A Multilevel logistic regression model was used to study the relationship between socioeconomic factors and HIV. The effect of the factors was presented as odds ratios (OR), with 95% confidence intervals (CIs). *P*-value less than 0.05 was considered to be statistically significant. We further mapped HIV prevalence in ArcGIS to visualize the regional distribution of HIV.

Results: HIV was significantly associated with age (p<0.001), sex (p<0.001) and varies significantly by geographic region (p<0.001), level of education (p=0.001), wealth status (p<0.001), religion (p=0.042), ethnicity (p<0.001) and residence (p=0.001). HIV positive participants were more likely to be women, people with higher educational level, live in urban areas, practice the protestant religious belief, belong to the ethnicity of Kako/Meka/Pygmy and distributed in the East, South, and Yaoundé regions. Age, sex, region, education level, and ethnicity were significantly associated with the odds of having HIV from the multilevel regression model.

Conclusion: Our finding recommends for novel intervention programs that will target the various socioeconomic factors associated with the odds of having HIV for proper public health management of the disease in Cameroon.

1. Introduction

HIV continues to be a major public health burden in Cameroon(1). In 2016, a report on HIV burden in Cameroon highlighted that there were 32 000 (22 000–41 000) new HIV infections and 29 000 (25 000–33 000) AIDS-related deaths (2). About 560 000 people were living with HIV, among whom 37% (31% – 43%) had access to antiretroviral therapy. For those living with HIV, approximately 19% (16% – 22%) had suppressed viral loads and 74% (56% – 90%) of pregnant women with the disease were under treatment or taking prophylaxis to prevent mother to child transmission. An estimated 4000 (1600–6500) children were newly infected with HIV due to mother-to-child transmission(2–4). The prevalence of HIV in Cameroon mostly includes gay men and other men who have sex with men (37.2%), sex workers (24.3%), and prisoners (3.96%)(2).

There have been controversial debates on the relationship between the socioeconomic status and the distribution of HIV in Cameroon and other Sub-Sarah Africa (SSA) countries. Most studies argued that an increase in socioeconomic statuses such as wealth and education will increase the risk of getting HIV due to affluent lifestyles and many sexual partners(5,6) while others reported poverty and no education as potentially vulnerable factors (5–11). In Cameroon, HIV prevalence among women was higher among those from wealthier households. Moreover, HIV prevalence was lowest among women and men who

have had no education. The Demographic and Health Survey (DHS) report demonstrated that, among women, HIV prevalence was higher among those with higher education at the national level, though other studies have reported lower prevalence at the City level (6,12).

Socioeconomic disparities in population and global health outcomes are emphasized because social conditions, such as knowledge, wealth, education, power, prestige, and beneficial social associations, allow individuals to avoid health-related risks and to adopt protective strategies, and access to quality health care services(9). Understanding these differences in socioeconomic status with respect to HIV prevalence and distribution is very vital for strategic HIV prevention programs in Cameroon and SSA.

Although the DHS program in Cameroon has highlighted some general trends of the relationship between socioeconomic disparities and the risk of getting HIV and their distribution(12), detailed assessment of these differences and other related factors are limited or underemphasized in reported studies(6) as there are substantial variations in these relationships across, regions, tribes, religions, ethnicity, residence, wealth, educational level and employment status. In order to elucidate these variations in Cameroon, we aim to illustrate the vulnerability of socioeconomic disparities and the risk of getting HIV for public health interventions.

2. Materials And Methods

2.1. Data Source

Data for this study was obtained from the DHS website(https://dhsprogram.com)(13). The Cameroon DHS and Multiple Indicators Cluster Survey (DHS-MICS 2011) datasets were used and this survey was conducted from January to August 2011 by the National Institute of Statistics in collaboration with the Ministry of Public Health. The DHS has been asking questions about HIV/AIDS knowledge, attitudes and behaviors since 1988. Indicators include knowledge of HIV prevention methods, attitudes towards those living with AIDS, beliefs about AIDS transmission, and experiences with higher-risk sex, including paid sex. The DHS-MICS was implemented with financial support from the Government of Cameroon, the U.S. Agency for International Development (USAID), the United Nations Children's Fund (UNICEF), the United Nations Population Fund (UNFPA), and the World Bank. Usually, some institutions provide their expertise in the implementation of the survey, in particular, the Centre Pasteur of Cameroon (CPC) for the HIV testing component. ICF International provided assistance through the MEASURE DHS program funded by USAID. Details on the DHS program, household cluster points sampling (Figure 1) and survey design are described elsewhere(13,14).

Analyses in this paper were restricted to participants with non-missing information on key variables of interest (i.e. sex, age, education level, ethnicity, place of residence, employment status, wealth quintile, region, and religion). Participants were excluded if they missed the self-report of HIV.

2.2. Ethical approval

Data access for downloads was obtained through a written request from the DHS data discharge team of the USAID. The linkage of DHS HIV test results (HIV Biomarker) to the full DHS survey record allows for an in-depth analysis of the sociodemographic and behavioral factors associated with HIV infection(13). Datasets, which include test results that can be linked to other variables in the DHS are available for research and study. All DHS studies in Cameroon and data release have been approved by the Cameroon government.

2.3. HIV Prevalence Testing.

HIV prevalence estimates are usually obtained from sentinel surveillance systems that monitored HIV rates among pregnant women and high-risk populations. By collecting blood for HIV testing from representative samples of the population of women and men in a country, the DHS Program can provide nationally representative estimates of HIV prevalence rates for over 60 countries. Both sentinel surveillance and population-based sources of prevalence data are used to track HIV epidemics. Population-based testing is usually carried out every 3 to 5 years in most countries, because of the size and cost of the surveys(13). Sentinel surveillance testing is often reported annually and provides a good benchmark for measuring progress over short time periods. Furthermore, population-based testing is dependent on the population's willingness to be voluntarily tested for HIV.

2.4. HIV testing protocol and measurement

The DHS HIV testing protocol provides for informed, anonymous, and voluntary testing of women and men, usually age 15-49. The testing protocol undergoes a host country ethical review. Biomarker agents test participants on the field using full blood samples. Alere Determine is used as the first-line test and unigold is used as the second line. Results are handed to the participants after post-test counseling and positive cases are referred to treatment sites. Indeterminate cases are referred for confirmations by ELISA in designated facilities within their clusters. Dried blood spot samples are also collected from participants and transferred to the reference laboratory (CPC) for quality control of HIV results via Western blot and ELISA techniques.

2.5. Statistical analysis.

Categorical variables were described using frequencies and proportions accounting for the survey design. Sample weights, mean, and standard deviations were conducted to quantify the socioeconomic gradients of HIV. The χ^2 test was performed to assess the proportional difference of categorical variables and t-test was used for continuous variables to contrast the Cameroon DHS participants by HIV status. A multilevel logistic regression model was used to investigate the association between socioeconomic factors and HIV, adjusting the influence of survey clusters in Cameroon. Firstly, we constructed an empty model without any covariates to determine whether it was necessary to account for the multilevel structure of the data. Secondly, we constructed the multilevel logistic regression to study the relationship between socioeconomic factors and HIV disease while considering the effect of the clusters. The effect of factors was presented as odds ratios (OR) with 95% confidence intervals (CIs), derived using Markov Chain

Monte Carlo methods, accounting for the survey design and sampling weights. Prevalence estimates for the whole study population, population subgroups, and regression analysis were also accounted for by the complex survey design and sampling weights.

Descriptive statistics and prevalence rate analyses were derived using SAS 9.2. A multilevel logistic regression model was constructed using Stata version 14 (Stata-Corp., College Station, TX, USA). *P*-value of less than 0.05 was considered to be statistically significant. To further visualize the distribution of HIV prevalence in the different DHS geographic regions, we mapped HIV prevalence in ArcGIS 10.3 (ESRI, Redlands, California, USA) software.

3. Results

3.1. General characteristics according to HIV status.

A summary of the socioeconomic and demographic characteristics according to HIV status is presented in Table 1. Among the 10,478 subjects, 49.4 % were male, 50.6% were female and 493(4.7%) participants had HIV. The mean age of the whole study population was 31.4. HIV was significantly associated with age (p<0.001) and sex (p<0.001). Moreover, HIV significantly varied by geographic region (p<0.001), level of education (p=0.001), wealth status (p<0.001), religion (p=0.042), ethnicity (p<0.001) and residence (p=0.001). Compared to the Non-HIV participants, the HIV participants were more likely to be women, within the higher education level, within protestant religion, lived in urban areas, within poorer to richest wealth index, distributed in the East, South, and Yaoundé DHS regions, and belong to the ethnicity for Kako/Meka/Pygmy. The incidence of HIV increases with the improvement of socioeconomic level.

3.2. Multilevel logistic regression analysis of factors associated with HIV

Under the empty model, there was a significant variation in the odds of having HIV (τ = 0.456, 95% CIs: 0.301−0.691) across clusters in Cameroon. The interclass correlation coefficient indicated that 12.2% of the variance in the odds of having HIV could be attributed to the difference between clusters. Table 2 shows the result of the multilevel logistic regression analysis of factors associated with HIV. Age, sex, region, education level, and ethnicity were significantly associated with the odds of having HIV while considering the effect of the clusters. The odds of HIV increased by 1.03-fold (95% CIs: 1.02-1.04) for every 1-year increase in a participant's age. Male participants had lower odds of having HIV than female participants (OR=0.39, 95% CIs: 0.33−0.46). Participants who lived in the Far North had 76% (p<0.001) less likely to have HIV than in the Adamawa region. Participants with educational level of primary and secondary were 105% (p<0.001) and 117% (p<0.001) more likely to have HIV respectively, than those with no education. Participants belonging to the ethnicity of Bamilike/Bamoun had lower odds of having HIV than those of Arab-Choa/Peulh/Houssa/Kanuri (OR=0.53, 95% CIs: 0.29-1.00).

Figure 2 presents the Geographic Information Systems (GIS) spatial distribution analysis and it indicates that the South region had the highest HIV prevalence followed by Yaoundé, Center, East, Southwest, and Northwest. HIV prevalence was higher in women from all the regions than men except for the West region.

Discussion

In this study, we investigated how socioeconomic differences could be associated with the risk of having HIV in Cameroon. Our study used HIV biomarkers and household sociodemographic data that were collected from eligible participants. These findings have contributed to the vast majority of studies in SSA that have investigated the association of socioeconomic status and the prevalence of HIV(5,10,15,16).

Overall, HIV prevalence was 4.7 % which is a decrease from 5.5% during the Cameroon 2004 DHS. The South region had a higher prevalence of HIV as compared to the East that saw higher HIV prevalence during the 2004 surveys(12), while the Far North region still maintains a low HIV prevalence in all the cross-sectional studies. The change in the HIV prevalence pattern by region may be due to rapid urbanization that has seen a subsequent increase in HIV prevalence in the urban areas as compared to the rural areas. Our descriptive findings confirm with that of Hajizadel (15) who had similar results with increase HIV prevalence in urban areas though common among the poorest group of people in Uganda, Kenya, Zimbabwe, and Swaziland. Comparing with those without HIV, HIV was common in those who have attained a high educational level, rich, and residing in urban areas.

HIV prevalence was significantly associated with age, sex, region, education level, and ethnicity. The odds of having HIV increases with age. This is true for the DHS participants as most of those enrolled in the survey is usually 15 years and above.

HIV prevalence by gender in Cameroon was higher in women than men. Women seen as a high-risk group calls for targeted prevention programs. For example, in 2013 Kisesa and Chamla (17) reported that two-thirds of the 250,000 new HIV infections were common among adolescent girls between 15- 19 years. In this report, Cameroon, India, Malawi, Haiti, Namibia, and Zimbabwe contributed to 50% of adolescent's HIV transmission; high prevalence of intimate partner violence, age-desperate sex, and gender-based inequality were regarded as the three common factors responsible for higher HIV prevalence among girls(17–19). With support from our spatial HIV distribution map (Figure 2) that has been used to manage HIV prevention programs elsewhere(20–25), HIV prevalence by gender in Cameroon base on the risk factors of intimate partner violence, age-desperate sex, and gender-based inequality in women and girls can be further investigated in regions of alarming female HIV prevalence such as the South, East, Southwest, Northwest, and Yaoundé to inform for intervention and outreach programs.

Although the male participants had lower odds (OR=0.39, 95% CIs: 0.33–0.46) of having HIV than females in our study, prevention measures such as those including HIV knowledge, attitude, and self-testing should be encouraged among men. In a study on "Perceived cost advantages and disadvantages of purchasing HIV self-testing kits among urban Tanzanian men: an inductive content analysis", men were not willing to go for counseling or visit clinics for HIV testing because they never wanted to stay away from work as they were the only provider of income for their families(26). This is not different from Cameroon as most male participants would be away at work during the time of the DHS survey and thus a lower number of male participants. Further studies are needed to compare the socioeconomic gradients between male and female and their association with HIV in Cameroon.

Educational level had a significant association with having HIV in Cameroon. Participants with primary or secondary education have higher odds of contracting HIV than those with no education. This is not the first time more educated people have been proven to be more likely to contract HIV in Cameroon. A multilevel logistic analysis of the 2004 DHS data set for Cameroon by Jane (6), demonstrated that highly educated participants especially women, were more likely to have had premarital sex making them vulnerable to the disease. These findings were also true for Burkina Faso, Kenya, and Ghana, whereas years of schooling were positively associated with first intercourse for men in Kenya and Cameroon and thus increase sexual behaviors, practices, and risks of getting HIV. Having a high level of educational attainment has been known to be a protective factor against HIV infections and having a general knowledge of the disease(10,27). However, it is a reverse paradigm in Cameroon and many SSA counties. This may be due to the fact that high level of education increases the socioeconomic status such as wealth, better jobs, and overall social status which have been associated with premarital sex, unprotective sexual behaviors, and multiple partners which are risk factors of contracting HIV. Contrary to our study, findings on the socioeconomic status and the vulnerability to HIV infection in Uganda demonstrated that those with higher educational attainment were less likely to be HIV positive than those with no education(10). Furthermore, higher educational attainment was positively associated with HIV testing among pregnant women in Zambia 2014 DHS study (28). Despite the disparities between Cameroon and other Africa countries, the current evidence from our study and that for the Cameroon 2004 DHS affirms that HIV prevention campaigns in Cameroon should pay more attention to those with higher level of education. HIV prevention programs should implement self-testing, rapid diagnostics technique, counseling, treatment and linkage to care policies that will encourage those with higher education level to participate without fear of stigmatization(29–31).

Our analysis found ethnicity to be associated with HIV. For instance, participants from the Bamilike/Bamoun ethnic groups were less likely to get HIV than those from the Arab-Choa/Peulh/Houssa/Kanuri. There was no clear statistically significant difference between HIV association with other ethnic groups in Cameroon. However, Odimegwu (32) showed that determinants of HIV stigma and discrimination vary by ethnicity in Nigeria and that significant ethnic differentials in HIV/AIDS stigma and discrimination by Secondary School education exist among the Hausa and Igbo ethnic groups. Further studies to understand the distribution of HIV among ethnic groups in Cameroon to ease the establishment of intervention programs at the level of ethnicity, customs, tradition, and beliefs are required as the descriptive analysis demonstrated disparities among the ethnic groups though this study could not account for the differences within ethnicity.

HIV was positively associated with region. Participants living in the Far North were 76% less likely to have HIV than those living in Adamawa. Living in a particular region could not be demonstrated to be associated with the odds of having HIV in our study. Other socioeconomic characteristics and their distribution among other factors like the rapid growth of urban cities could be the reason while HIV prevalence varies across the different regions and not necessarily because of one staying there. Moreover, our multilevel model did not find residences in these regions to be significantly associated with the odds of having HIV. Residing in an urban or rural residence has been however strongly associated

with the odds of having HIV(9,10,33). Some studies argue that the positive association of urban residences with HIV prevalence was not due to increasing incidence, but improved access to HIV treatments, provision of services, and volunteering counseling in urban areas compared to rural areas(15).

Wealth index did not have any significant association with HIV prevalence in our model. The association of household wealth with HIV prevalence has observed mix debates(5,7). Fox (5), highlighted a body of evidence at the national and individual level of the association of the rich with high risk of HIV in SSA. This study also demonstrated some disparities of wealth within the different regions, urban and rural areas in Cameroon and other SSA. The differences were accounted for base on the distribution of other socioeconomic factors such as more employment opportunities in urban than in rural areas. Our descriptive study clearly supports this claim as HIV prevalence was highest among the rich, and those currently working and leaving in the urban areas. Jane(6) again demonstrated that wealth and HIV were related in Cameroon (DHS 2004) and Tanzania (DHS 2003). Preventive measures should also target the wealth gradient disparities in Cameroon for effective HIV/AIDs control.

We did not find any statistically significant association of belonging to a particular religion and having HIV. Faust (7), found that affiliating to a particular religion had significantly higher odds of low HIV-related knowledge among respondents with traditional religious beliefs in Nigeria and that it was necessary to consider awareness programs targeting these groups, an important characteristic that should be investigated in Cameroon.

This study had the following limitations: First, the findings are based on the Cameroon 2011 cross-sectional study and may not present the current situation of some of the socioeconomic variables used although our findings presented similar trends with previous studies in Cameroon. A recent data set or study is required to confirm the socioeconomic differences observed in our study. Second, our study did not consider participants with missing values for the socioeconomic variables used. HIV biomarkers data was only used for participants presented as HIV positive or negative. Those with intermediate test results or having HIV I and II were not included in the analysis because of missing values for some participants. This may have altered the findings from studies that used the same datasets such as the DHS general report of the socioeconomic differences and HIV distribution in Cameroon. Despite these limitations, our findings have made a modest contribution to the gap of knowledge of the association between HIV prevalence and the socioeconomic status and investigated on additional factors that were limited in previous studies in Cameroon for public health intervention programs.

Conclusions

HIV was prevalent in women than men and comparing with HIV negative individuals, HIV positive individuals attained higher level of education, were richer and residing in urban areas. Age, sex, region, education level, and ethnicity were significantly associated with the odds of having HIV. Our finding recommends for novel intervention programs such as counseling and self-testing that will target the

various socioeconomic factors associated with the odds of having HIV for proper public health management of the disease.

Declarations

Acknowledgments:

Availability of Data and Materials:

 Data supporting this study are available at the DHS website: https://dhsprogram.com upon registration.

Authors' contributions:

Conceptualization, W.L and M.A.T; Formal analysis, W.L and M.A.T; Funding acquisition, Z.Y; Methodology, W.L and M.AT; Resources, W.L and M.A.T; Supervision, L.Y and Z.Y; Writing – original draft, W.L, M.A.T and C.P.N; Writing – review & editing, L.Y, H.B.B, N.M.L, O.F.A, TTMA, P.N.M.F and Z.Y

Ethics approval and consent to participate

DHS studies in Cameroon are approved by the Cameroon government. Written informed consent was obtained from all participants.

Consent for publication

Not applicable

Competing interests

The authors declare that they have no competing interests.

Abbreviations

SSA: Sub-Saharan Africa; DHS: Demographic and Health Survey; USAID: United States Agency for International Development; UNICEF: United Nations Children's Fund, UNFPA: United Nations Population Fund; CPC: Centre Pasteur of Cameroon

References

1. CDC Global Health - Cameroon [Internet]. [accessed 2019 Sep 12]. Available from: https://www.cdc.gov/globalhealth/countries/cameroon/default.htm

2. UNAIDS Cameroon [Internet]. [accessed 2019 Aug 18]. Available from: https://www.unaids.org/en/regionscountries/countries/cameroon

3. Mbanya D, Sama M, Tchounwou P. Current Status of HIV/AIDS in Cameroon: How Effective are Control Strategies? Int J Environ Res Public Health. 2008;6.

4. Sama C-B, Feteh VF, Tindong M, Tanyi JT, Bihle NM, Angwafo FF. Prevalence of maternal HIV infection and knowledge on mother–to–child transmission of HIV and its prevention among antenatal care attendees in a rural area in northwest Cameroon. Jhaveri R, editor. PLOS ONE. 2017 Feb 15;12(2): e0172102.

5. Fox AM. The Social Determinants of HIV Serostatus in Sub-Saharan Africa: An Inverse Relationship between Poverty and HIV? Public Health Reports. 2010 Jul;125(4_suppl):16–24.

6. Jane G. Fortson. The Gradient in Sub-Saharan Africa: Socioeconomic Status and HIV/AIDS. Demography. 2008;45(2):303–22.

7. Faust L, Yaya S, Ekholuenetale M. Wealth inequality as a predictor of HIV-related knowledge in Nigeria. BMJ Global Health. 2017 Dec;2(4): e000461.

8. Amoo EO, Igbinoba A, Imhonopi D, Ajaero CK, Akinyemi JO, Igbokwe D, et al. Trends, Determinants, and Health Risks of Adolescent Fatherhood in Sub-Saharan Africa. 2018;28(4):10.

9. Kabudula CW, Houle B, Collinson MA, Kahn K, Gómez-Olivé FX, Tollman S, et al. Socioeconomic differences in mortality in the antiretroviral therapy era in Agincourt, rural South Africa, 2001–13: a population surveillance analysis. The Lancet Global Health. 2017 Sep;5(9): e924–35.

10. Igulot P, Magadi MA. Socioeconomic Status and Vulnerability to HIV Infection in Uganda: Evidence from Multilevel Modelling of AIDS Indicator Survey Data. AIDS Research and Treatment. 2018 Jun 7; 2018:1–15.

11. Chirwa GC. Socioeconomic Inequality in Comprehensive Knowledge about HIV in Malawi. Malawi Medical Journal. 2019 Jun 20;31(2):104.

12. Cameroon DHS 2011 report [accessed 2019 Aug 18] Available from: https://dhsprogram.com/pubs/pdf/HF42/HF42.pdf.

13. The DHS Program - Quality information to plan, monitor and improve population, health, and nutrition programs [Internet]. [cited 2018 Feb 15]. Available from: https://dhsprogram.com/

14. Tewara MA, Mbah-Fongkimeh PN, Dayimu A, Kang F, Xue F. Small-area spatial statistical analysis of malaria clusters and hotspots in Cameroon;2000–2015. BMC Infectious Diseases [Internet]. 2018 Dec [cited 2018 Dec 14];18(1). Available from: https://bmcinfectdis.biomedcentral.com/articles/10.1186/s12879-018-3534-6

15. Hajizadeh M, Sia D, Heymann S, Nandi A. Socioeconomic inequalities in HIV/AIDS prevalence in sub-Saharan African countries: evidence from the Demographic Health Surveys. International Journal for Equity in Health. 2014;13(1):18.

16. Helleringer S, Kohler H-P, Frimpong JA, Mkandawire J. Increasing Uptake of HIV Testing and Counseling Among the Poorest in Sub-Saharan Countries Through Home-Based Service Provision: JAIDS Journal of Acquired Immune Deficiency Syndromes. 2009 Jun;51(2):185–93.

17. Kisesa A, Chamla D. Getting to 90–90–90 targets for children and adolescents HIV in low and concentrated epidemics: bottlenecks, opportunities, and solutions. Current Opinion in HIV and AIDS. 2016 Mar;11: S1–5.

18. UNAIDS, UNICEF and WHO urge countries in western and central Africa to step up the pace in the response to HIV for children and adolescents [Internet]. WHO | Regional Office for Africa. [accessed 2019 Jan 19]. Available from: http://afro.who.int/news/unaids-unicef-and-who-urge-countries-western-and-central-africa-step-pace-response-hiv

19. Boesten J. Gender and HIV/AIDS: Critical Perspectives from the Developing World [Internet]. 1st ed. Routledge; 2016 [cited 2018 Dec 4]. Available from: https://www.taylorfrancis.com/books/9781315583907

20. Cuadros D, Abu-Raddad L. Geographical Patterns of HIV Sero-Discordancy in High HIV Prevalence Countries in Sub-Saharan Africa. International Journal of Environmental Research and Public Health. 2016 Aug 31;13(9):865.

21. Chamla DD, Olu O, Wanyana J, Natseri N, Mukooyo E, Okware S, et al. Geographical information system and access to HIV testing, treatment, and prevention of mother-to-child transmission in conflict-affected Northern Uganda. Conflict and Health. 2007;1(1):12.

22. Cuadros DF, Sartorius B, Hall C, Akullian A, Bärnighausen T, Tanser F. Capturing the spatial variability of HIV epidemics in South Africa and Tanzania using routine healthcare facility data. International Journal of Health Geographics [Internet]. 2018 Dec [cited 2018 Dec 4];17(1). Available from: https://ij-healthgeographics.biomedcentral.com/articles/10.1186/s12942-018-0146-8

23. Cuadros DF, Awad SF, Abu-Raddad LJ. Mapping HIV clustering: a strategy for identifying populations at high risk of HIV infection in sub-Saharan Africa. International Journal of Health Geographics. 2013;12(1):28.

24. Vanmeulebrouk B, Rivett U, Ricketts A, Loudon M. Open source GIS for HIV/AIDS management. International Journal of Health Geographics. 2008;7(1):53.

25. Kandwal R, Garg PK, Garg RD. Health GIS and HIV/AIDS studies: Perspective and retrospective. Journal of Biomedical Informatics. 2009 Aug;42(4):748–55.

26. Jennings L, Conserve DF, Merrill J, Kajula L, Iwelunmor J, Linnemayr S, et al. Perceived Cost Advantages and Disadvantages of Purchasing HIV Self- Testing Kits among Urban Tanzanian Men: An Inductive Content Analysis. Journal of AIDS & Clinical Research [Internet]. 2017 [cited 2018 Dec 4];08(08). Available from: https://www.omicsonline.org/open-access/perceived-cost-advantages-and-disadvantages-of-purchasing-hiv-selftesting-kits-among-urban-tanzanian-men-an-inductive-content-anal-2155-6113-1000725.php?aid=93281

27. Mee P, Fearon E, Hassan S, Hensen B, Acharya X, Rice BD, et al. The association between being currently in school and HIV prevalence among young women in nine eastern and southern African

countries. Carael M, editor. PLOS ONE. 2018 Jun 20;13(6):e0198898.

28. Muyunda B, Musonda P, Mee P, Todd J, Michelo C. Educational Attainment as a Predictor of HIV Testing Uptake Among Women of Child-Bearing Age: Analysis of 2014 Demographic and Health Survey in Zambia. Frontiers in Public Health [Internet]. 2018 Aug 14 [cited 2019 Aug 18];6. Available from: https://www.frontiersin.org/article/10.3389/fpubh.2018.00192/full

29. Todd CS, Mills SJ, Innes AL. Electronic health, telemedicine, and new paradigms for training and care: Current Opinion in HIV and AIDS. 2017 Sep;12(5):475–87.

30. Suthar AB, Ford N, Bachanas PJ, Wong VJ, Rajan JS, Saltzman AK, et al. Towards Universal Voluntary HIV Testing and Counselling: A Systematic Review and Meta-Analysis of Community-Based Approaches. Sansom SL, editor. PLoS Medicine. 2013 Aug 13;10(8): e1001496.

31. Stekler J, Wood B, Ballenger C. Arguments for and against HIV self-testing. HIV/AIDS - Research and Palliative Care. 2014 Aug;117.

32. Odimegwu CO, Alabi O, De Wet N, Akinyemi JO. Ethnic heterogeneity in the determinants of HIV/AIDS stigma and discrimination among Nigeria women. BMC Public Health [Internet]. 2018 Dec [cited 2019 Aug 18];18(1). Available from: https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-018-5668-2

33. Magadi MA. The Disproportionate High Risk of HIV Infection Among the Urban Poor in Sub-Saharan Africa. AIDS and Behavior. 2013 Jun;17(5):1645–54.

Tables

Table 1. Characteristics of the study population according to HIV status.

	All (N=10478)	No HIV (n=9985)	HIV (n=493)	HIV Prevalence	P
All Cameroon	10478	9985	493	4.7%	
Age	31.4(10.3)	31.3(10.3)	33.2(8.4)		<0.001
Sex					<0.001
Female	5305(50.6%)	4984(49.9%)	321 (65.2%)	6.1%	
Male	5173(49.4%)	5001(50.1%)	172(34.9%)	3.3%	
Region					<0.001
Adamawa	465 (4.4%)	437 (4.4%)	28 (5.7%)	6.0%	
Center	905(8.6%)	852(8.5%)	53(10.7%)	5.9%	
Douala	1172(11.2%)	1113(11.1%)	59 (12.0%)	5.1%	
East	472 (4.5%)	440(4.4%)	33(6.6%)	6.9%	
Far North	1580(15.1%)	1562(15.6%)	18 (3.7%)	1.1%	
Littoral	464(4.4%)	442(4.4%)	22(4.4%)	4.7%	
North	1058(10.1%)	1026(10.3%)	32(6.5%)	3.0%	
Northwest	867(8.3%)	811 (8.1%)	56(11.3%)	6.4%	
West	1095(10.5%)	1061(10.6%)	34 (7.0%)	3.1%	
South	344(3.3%)	318 (3.2%)	26 (5.3%)	7.6%	
Southwest	831(7.9%)	782(7.8%)	49 (9.9%)	5.9%	
Yaoundé	1225(11.7%)	1141(11.4%)	83 (16.9%)	6.8%	
Residence					0.001
Urban	5552(53.0%)	5263(52.7%)	290(58.7%)	5.2%	
Rural	4926(47.0%)	4722(47.3%)	204(41.3%)	4.1%	
Educational Level					0.001
No education	1709(16.3%)	1669(16.7%)	40(8.1)	2.3%	
Primary	3552(33.9%)	3368(33.7%)	185(37.4%)	5.2%	
Secondary	4432(42.3%)	4204(42.1%)	228(46.2%)	5.1%	
Higher	784 (7.5%)	744(7.4%)	41(8.3%)	5.2%	
Religion					0.042
Catholic	4027(38.4%)	3833(38.4%)	193 (39.2%)	4.8%	
Protestant	3277(31.3%)	3096(31.0%)	181(36.7%)	5.5%	
Muslim	2132(20.3%)	2052(20.6%)	80 (16.2%)	3.8%	

Animist	284(2.7%)	278(2. 8%)	6 (1.2%)	2.2%
Other Christians	250(2.4%)	233(2.3%)	17 (3.5%)	6.8%
None	404(3.9%)	393 (3.9%)	11(2.2%)	2.7%
Other	105(1.0%)	100(1.0%)	5(1.0%)	4.5%
Ethnicity				<0.001
Arab-choa/Peulh/Houssa/Kanuri	913 (8.7%)	882 (8.8%)	31 (6.3%)	3.4%
Biu-Mandara	1408(13.4%)	1383(13.9%)	25 (5.1%)	1.8%
Adamawa-Oubangui	975 (9.3%)	930 (9.3%)	45(9.1%)	4.6%
Bantoide South-West	145(1.4%)	135(1.3%)	10 (2.0%)	6.9%
Grassfields	1347(12.9%)	1251(12.5%)	95 (19. 4%)	7.1%
Bamilike/Bamoun	2561(24.4%)	2468(24.7%)	93 (18.9%)	3.6%
Coitier/Ngoe/Oroko	485(4.6%)	464 (4.7%)	21(4.2%)	4.3%
Beti/Bassa/Mbam	2111(20.1%)	1976(19.8%)	134 (27.3%)	6.4%
Kako/Meka/Pygmy	303 (2.9%)	279 (2.8%)	24.3(4.9%)	8.0%
Stranger/Other	230 (2. 2%)	216 (2.2%)	14(2.8%)	5.9%
Wealth index				<0.001
Poorest	1661(15.9%)	1624(16.3%)	37 (7.6%)	2.3%
Poorer	1862(17.8%)	1776(17.8%)	86 (17.5%)	4.6%
Middle	1940(18.5%)	1854(18.6%)	86(17.4%)	4.4%
Richer	2354(22.5%)	2231(22.3%)	124(25.1%)	5.3%
Richest	2660(25. 4%)	2501(25.0%)	160(32.4%)	6.0%
Currently working				0.059
No	2470(23.6%)	2373(23.8%)	97 (19.7%)	3.9%
Yes	8008(76.4%)	7612(76.2%)	396(80. 3%)	4.9%

Table 2. Factors associated with HIV identified by the multilevel logistic regression model

Variables	Odds Ratio	95% Conf. Interval	P>z
Age	1.03	1.02-1.04	<0.001
Sex			
Female	1 (Reference)		
Male	0.39	0.33-0.46	<0.001
Region			
Adamawa	1 (Reference)		
Center	1.19	0.63-2.26	0.596
Douala	1.24	0.67-2.29	0.495
East	1.29	0.68-2.43	0.434
Far North	0.24	0.12-0.46	<0.001
Littoral	1.15	0.58-2.26	0.694
North	0.63	0.33-1.19	0.153
Northwest	0.88	0.44-1.73	0.701
West	0.91	0.47-1.79	0.790
South	1.58	0.83-3.01	0.166
Southwest	1.03	0.51-2.07	0.943
Yaoundé			
	1.59	0.86-2.96	0.140
Residence			
Urban	1 (Reference)		
Rural	1.00	0.73-1.38	0.995
Educational Level			
No education	1 (Reference)		
Primary	2.05	1.39-3.02	<0.001
Secondary	2.17	1.43-3.31	<0.001
Higher	1.80	1.00-3.25	0.052
Religion			
Catholic	1 (Reference)		
Protestant	1.11	0.89-1.37	0.362
Muslim	1.41	0.97-2.06	0.072
Animist	1.17	0.51-2.70	0.712
Other Christians	0.99	0.57-1.71	0.965
None	0.97	0.46-2.03	0.931

Other	1.10	0.46-2.63	0.832
Ethnicity			
Arab-choa/Peulh/Houssa/Kanuri	1(Reference)		
Biu-Mandara	1.05	0.52-2.10	0.895
Adamawa-Oubangui	1.31	0.73-2.35	0.359
Bantoide South-West	1.24	0.48-3.21	0.654
Grassfields	1.29	0.63-2.65	0.485
Bamilike/Bamoun	0.53	0.28-1.02	0.058
Coitier/Ngoe/Oroko	0.78	0.36-1.68	0.521
Beti/Bassa/Mbam	0.83	0.42-1.63	0.589
Kako/Meka/Pygmy	1.19	0.53-2.68	0.668
Stranger/Other	0.87	0.37-2.03	0.739
Wealth index			
Poorest	1(Reference)		
Poorer	1.15	0.72-1.85	0.560
Middle	1.04	0.63-1.71	0.875
Richer	1.15	0.67-1.99	0.607
Richest	1.21	0.68-2.15	0.510
Currently working			
No	1(Reference)		
Yes	1.25	0.98-1.59	0.077

Figures

Figure 1
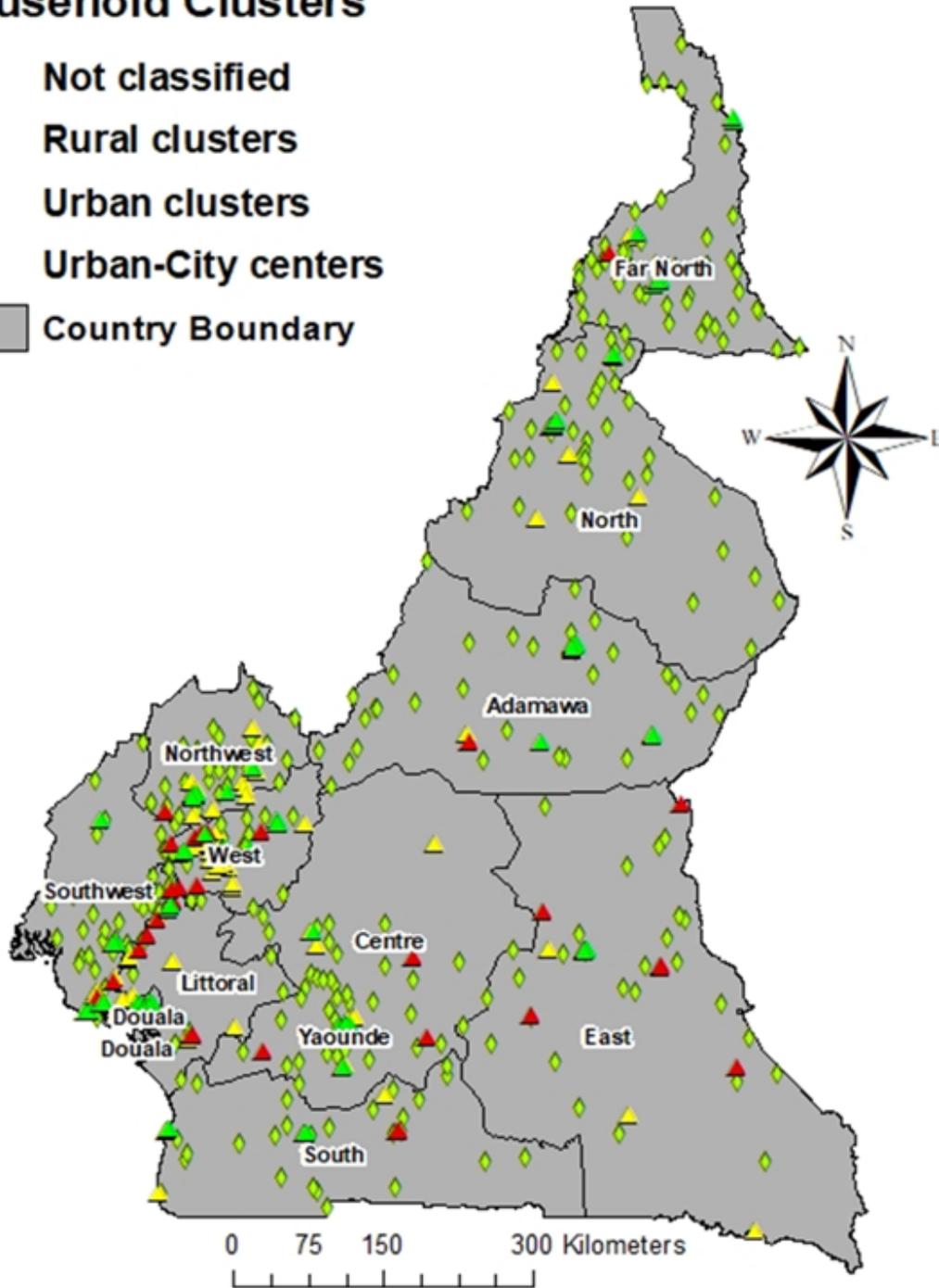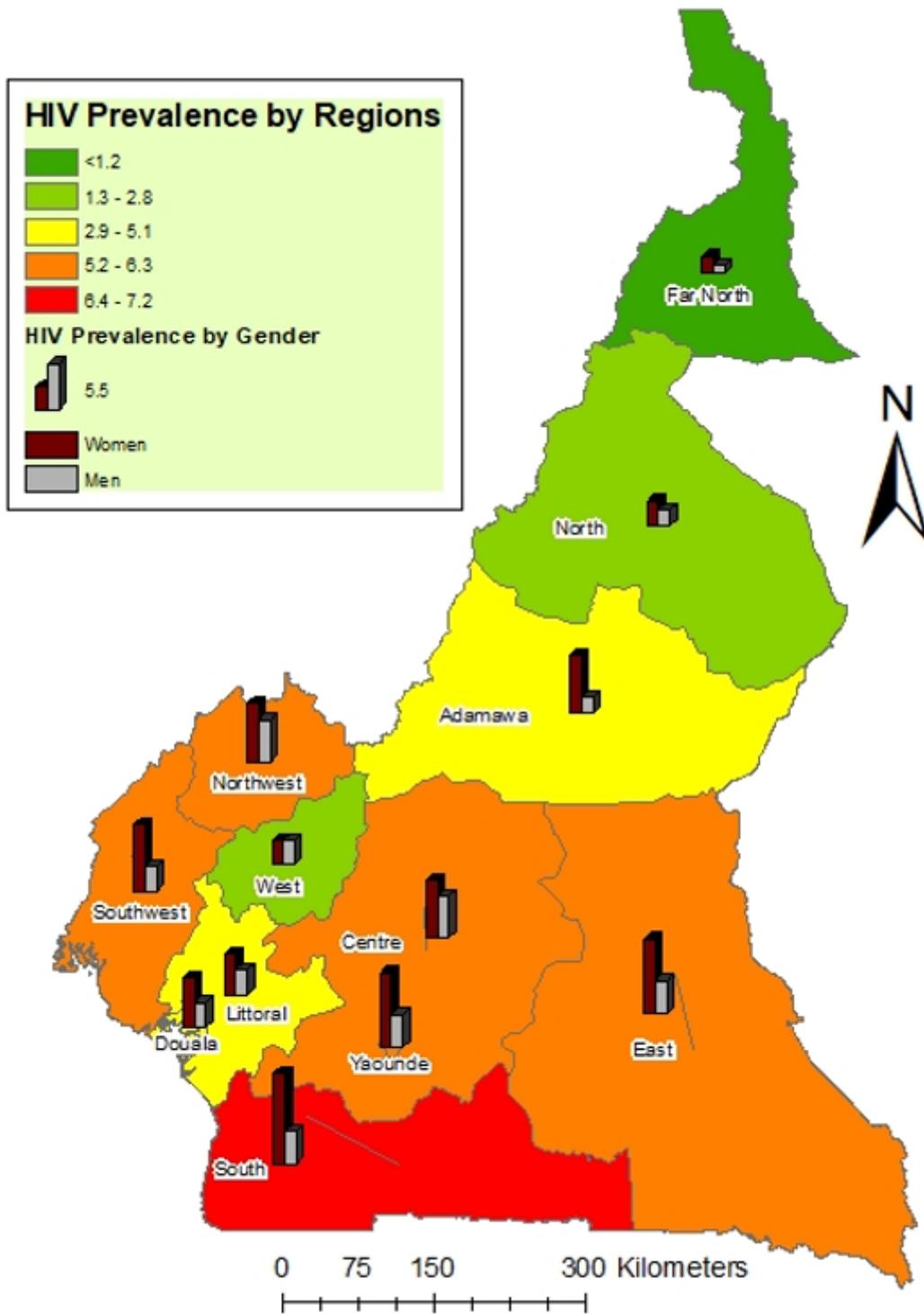
DHS household survey cluster points.

Figure 2

Spatial distribution of HIV prevalence by regions and gender