Developing regional estimates of adult HIV prevalence in

Côte d'Ivoire in 2012 from DHS VI data

Introduction

The HIV prevalence in Côte d'Ivoire among adults aged 15-49 was 3.2% in 2012 according to UNAIDS, the second highest in West Africa [1]. Without knowledge of subnational variation in HIV prevalence, policy makers at the government and aid agencies would have difficulty identifying priority areas and allocate funding efficiently. Therefore, this paper aims to demonstrate regional HIV prevalence in Côte d'Ivoire in 2012 estimated directly from the Demographic and Health Survey (DHS) VI data as well as the spatially smoothed regional estimates.

Methods

Design and Data

The DHS is a nationally-representative household survey that collects data on population demographics, health, and nutrition [2]. The 2011-2012 Côte d'Ivoire DHS was the latest that collected data on HIV dried blood spot test results [3]. The survey used a stratified two-stage cluster design to select a national sample of 9,686 households among 10,413 eligible ones (93.0%) from 352 clusters (161 urban and 191 rural) in 11 regions (Figure 1) [4]. Each of the ten regions outside Abidjan had one urban stratum and one rural stratum, and Abidjan was one single urban stratum, which summed up to 21 strata in total. In the first stage, the clusters were

randomly selected in each stratum "with a probability proportional to their number of ordinary

households in the census" [5]. In the second stage, a fixed number of households were selected

in each cluster using a simple random sampling [5].

A sub-sample of 11,348 adults (5,671 women aged 15-49 and 5,677 men aged 15-59)

were eligible for HIV testing [4]. A total of 9,518 adults (85.4%) from 4,087 households were

included in the HIV test result dataset [6]. A weighting variable proportional to the inverse

sampling probability of each household is available in the dataset. Information on the

urban/rural status and regional location of each cluster was available in a separate dataset

which was merged onto the HIV test dataset by cluster to create a strata variable.[6] A dataset of

DHS regional boundaries was used to construct adjacency matrix and map the regional

estimates of HIV prevalence [7].

<u>Statistical Analysis</u>

Since the HIV test data were obtained through a complex survey design, I accounted for

the sampling weights and strata to obtain the weighted mean of positive HIV test results per

region as the estimated regional HIV prevalence. I used a spatial smoothing Fay-Herriot model

to estimate the smoothed weighted posterior mean by region by accounting for both the survey

design and spatial random effects. I excluded four individuals with undetermined test results,

which resulted in a final sample of 9,514 adults from 4,086 households. All analyses were

completed using R version 3.6.3 [8], the *survey* package (*v3.35-1*) [9], and the *SUMMER* package

(*v0.3.0*) [10].

Results

Compared to those who were HIV negative, HIV positive people were more likely to live in urban areas such as Abidjan and Bouaké in the North Central region (Table 1). Accounting for the survey design, the estimated adult HIV prevalence in Côte d'Ivoire in 2012 was 4.0% (95% CI 3.4%, 4.5%). Abidjan, North Central, and Southwest had the highest weighted HIV prevalence (Table 2), all above the national average. After accounting for spatial random effects, West substituted Southwest as the region with the third highest smoothed weighted posterior mean (Table 2).

The regional variation in smoothed posterior means is not as obvious as that in the weighted direct estimates (Figure 2). The difference between the highest and lowest regional HIV prevalence estimates shrank from 3.3 to 1.8 percentage points after spatial smoothing. The largest shrinkage towards the overall mean happens to regions with the highest or lowest weighted estimates (Figure 3). Moreover, the 95% intervals of the smoothed posterior means are narrower than those of the weighted estimates (Figure 2), and the standard deviations (SDs) for most regions were reduced by the smoothing, with the highest SDs reduced the most (Figure 3).

Discussion

This subnational analysis reveals that the regions with the largest cities, i.e., urban populations, had the highest HIV prevalence estimates. Spatial smoothing of weighted estimates that account for the survey design pulls the highest and lowest estimates toward the overall mean, potentially reducing the variability due to the survey design to some extent.

Smoothing also leads to lower SDs, i.e., variability, since the smoothing model accounts for not only the survey design but also spatial pattern.

In terms of limitations, administrative boundaries group observations in the same region arbitrarily, which may have obscured phenomena along regional borders. Although spatial smoothing dampens the regional variations by accounting for neighboring regions, it still does not break the confinement of administrative boundaries. Furthermore, analyses that stop at regional level estimates may have missed variations within urban areas that are densely populated and thus extensively sampled. Last but not least, spatial smoothing may not have accounted for all confounding. Therefore, future exercises should try to construct an HIV prevalence surface, provide estimates at the district level and more nuanced analysis for densely populated areas, and account for all confounders.

References

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Table 1. Characteristics and HIV test results of the study sample

Characteristics	Number of subjects (%)		
	HIV negative	HIV positive	Total
No. of subjects	9156	358	9514
Urban	4008 (43.8)	198 (55.3)	4206 (44.2)
Regions			
Central	672 (7.3)	22 (6.1)	694 (7.3)
East Central	863 (9.4)	35 (9.8)	898 (9.4)
North Central	903 (9.9)	47 (13.1)	950 (10.0)
West Central	783 (8.6)	22 (6.1)	805 (8.5)
North	731 (8.0)	19 (5.3)	750 (7.9)
Northeast	718 (7.8)	27 (7.5)	745 (7.8)
Northwest	998 (10.9)	23 (6.4)	1021 (10.7)
West	896 (9.8)	39 (10.9)	935 (9.8)
South without Abidjan	645 (7.0)	28 (7.8)	673 (7.1)
Southwest	796 (8.7)	27 (7.5)	823 (8.7)
Abidjan	1151 (12.6)	69 (19.3)	1220 (12.8)

Table 2. Weighted direct estimates and spatially smoothed estimates of regional HIV prevalence in Côte d'Ivoire in 2012

	Weighted Direct Mean (95% Confidence Interval)	**Smoothed** Posterior Mean (95% Interval)
National	3.96 (3.43, 4.50)	-*
Regions**		
Abidjan	5.42 (4.00, 6.85)	4.82 (3.58, 6.50)
North Central	4.57 (3.14, 6.00)	4.11 (3.27, 5.21)
Southwest	4.46 (2.31, 6.62)	3.95 (2.77, 5.63)
West	4.38 (2.69, 6.06)	4.06 (3.18, 5.20)
East Central	4.12 (2.41, 5.82)	3.76 (2.58, 5.32)
South without Abidjan	3.43 (2.09, 4.77)	3.67 (2.58, 4.92)
Central	2.88 (1.59, 4.16)	3.36 (2.32, 4.46)
West Central	2.80 (1.47, 4.13)	3.32 (2.32, 4.35)
North	2.64 (1.37, 3.91)	3.19 (2.12, 4.29)
Northeast	2.54 (1.44, 3.63)	3.17 (2.13, 4.24)
Northwest	2.14 (1.21, 3.06)	3.03 (1.94, 4.11)

All numbers are in percentages.

* Not available

** Regions are displayed in descending order of weighted direct estimates.

Figure 1. The 11 regions of Côte d'Ivoire for DHS-VI in 2012

Figure 2. Regional variations in HIV prevalence in Côte d'Ivoire in 2012 comparing the weighted direct versus spatially smoothed estimates and 95% intervals
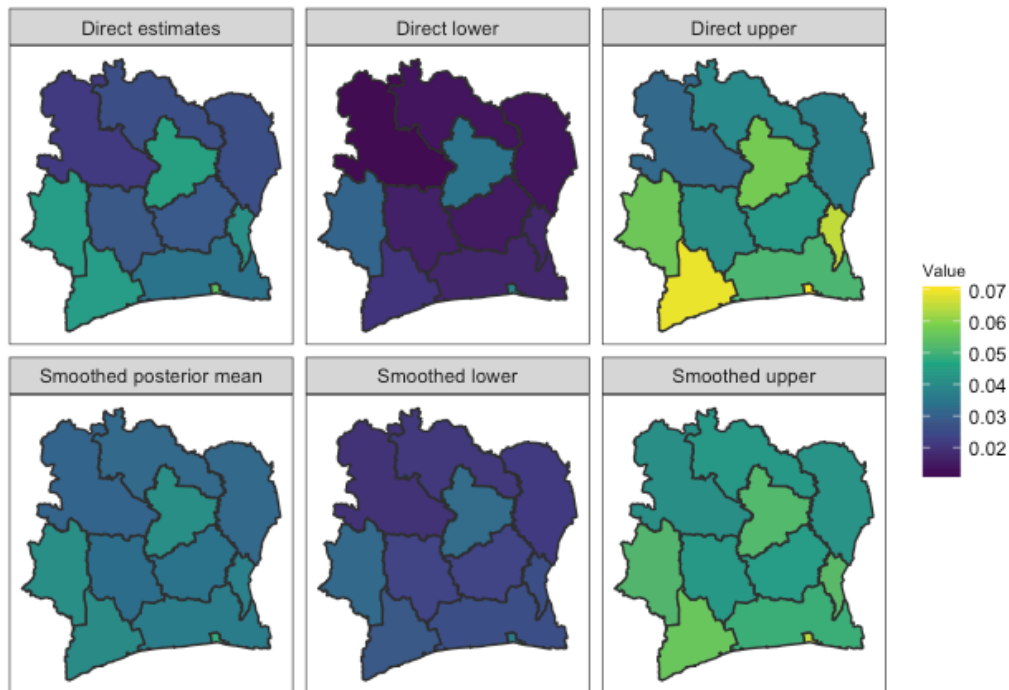
Figure 3. Comparison of the weighted direct versus spatially smoothed estimates and standard deviations (SDs) of regional HIV prevalence in Côte d'Ivoire