Using GPS data to construct a spatial map of the HIV epidemic in Malawi

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RATIONALE

In order to develop effective control strategies for HIV epidemics, it is essential to know how many individuals are infected with HIV and where they live.

OBJECTIVES

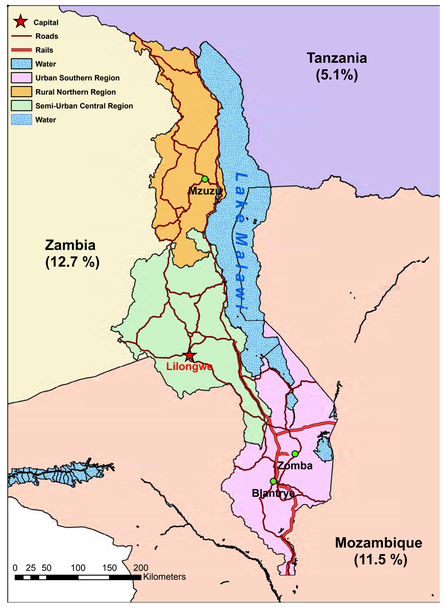
I. **To characterize and map the demography of Malawi.**
II. **To construct HIV surface prevalence maps for Malawi.**
III. **To construct an HIV density of infection map for Malawi, where the density of infection is defined as the number of HIV-infected individuals per 100 km².**

INTRODUCTION

Malawi has a population size of ~16 million. It is divided into three regions (fig. 1): the rural northern region, the semi-urban central region, and the urban southern region. The second largest city Blantyre (1,068,681) is located in the urban southern region, while the capital city, Lilongwe (1,077,116), is the largest city in Malawi and located in the semi-urban region. Mzuzu (128,432), which is the largest city in the rural northern region, is the third largest city in Malawi.

Malawi has one of the world's most severe HIV epidemics. The average prevalence is ~11%. Neighboring countries, Mozambique and Zambia have a similar HIV prevalence to Malawi, ~13% and ~12% respectively. Tanzania's HIV prevalence is significantly lower at ~5%.

Figure 1: Map of Malawi

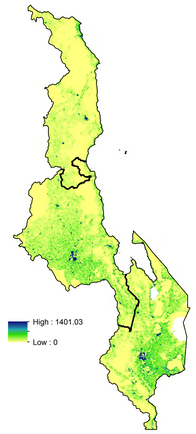


METHODS

- We used WorldPop data to construct a population density map for Malawi.
- We used geo-referenced HIV testing data from the 2010 Malawi Demographic and Health survey (DHS), a national representative survey. We calculated prevalence based on a sample of 7,091 women and 6,497 men aged 15-49.
- We constructed HIV surface prevalence maps by using ordinary kriging to spatially interpolate the prevalence data.
- We constructed the density of infection map for Malawi using raster multiplication of the demographic map and the HIV surface prevalence map for the entire population.

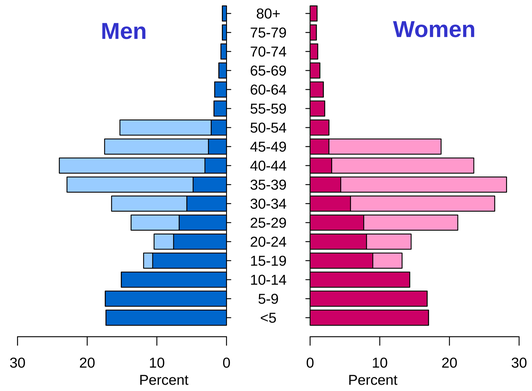
RESULTS: DEMOGRAPHY

Figure 2a: Demographic Map



- There is significant geographical variation in population density, ranging from 1 to 1,401 individuals per 100 km².
- 45% of the population live in the southern region, 42% live in the central region, and 13% live in the northern region.
- There is extremely high density in the cities in all three regions.

Figure 2b: Population distribution & HIV prevalence by age

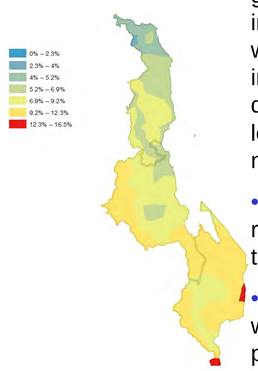


- The age distribution is shown in dark blue for men, and dark red for women. Malawi has a very young and growing population.
- HIV prevalence for men is shown by the light blue data and for women is shown by the light pink data. Prevalence is higher in women (~13%) than in men (~9%).
- HIV prevalence peaks earlier in women than in men: 35-39 year olds versus 40-44 year olds.
- HIV prevalence in women 25-29 and 30-34 years old is almost double than in men of the same age: ~14% vs. ~7% and ~21% versus ~11%, respectively.

RESULTS: HIV SURFACE PREVALENCE MAPS

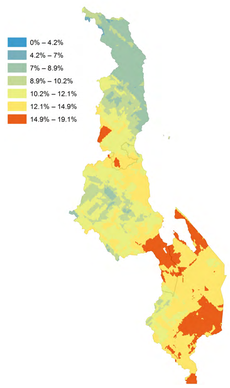
Figure 3: HIV Prevalence

Figure 3a: Men



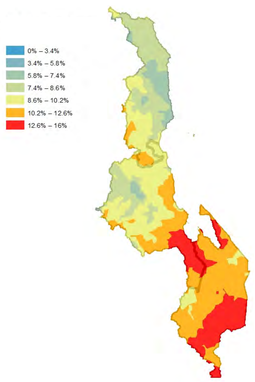
- There is a geographic trend in prevalence, with the highest in the south decreasing to the lowest in the north.
- Prevalence ranges from ~2% to ~17%.
- The two areas with the highest prevalence border Mozambique: the Lake Chilwa area, and the Nasanje district.

Figure 3b: Women



- HIV prevalence is higher in all regions for women compared to men.
- The north to south trend in prevalence is less pronounced than in men.
- There are high prevalence areas in all three regions. In the south the regions border Mozambique. In the north the region borders Zambia.

Figure 3c: The entire population

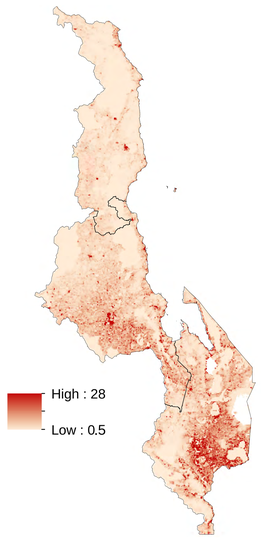


- The overall geographic pattern in prevalence reflects the geographic pattern in prevalence for women. The north to south trend in prevalence is pronounced.
- The southern part of the semi-urban central region and the urban southern region have the highest HIV prevalence.

	Women	Men	Both
Northern	8%	5%	6%
Central	9%	6%	7%
Southern	18%	11%	16%

RESULTS: HIV DENSITY OF INFECTION MAP

Figure 4: Map showing the number of HIV-infected individuals per 100 km²



- We estimate from the map that ~1.2 million adults, 15-49 years old, are infected with HIV in Malawi.
- Throughout Malawi the density of infection varies from 0.5 to 28 HIV-infected individuals per 100 km².
- The density of infection is greatest in urban centers in all three regions.
- The density of infection is highest in the southeastern region of the country bordering Mozambique.
- In areas where prevalence is high (fig. 3c), the density of infection may be only moderate.

DISCUSSION/IMPLICATIONS

✓ The HIV epidemic in Malawi is likely to continue to increase as a significant proportion of the population is below 20 years old.
✓ The epidemic in Malawi shows significant geographic variation, there is a distinct trend in increasing prevalence from north to south.
✓ There are distinct gender-specific geographic patterns in epidemic severity.
✓ The HIV surface prevalence maps show the areas where men and women are at the greatest risk of infection.
✓ The density of infection map identifies the areas where there is the greatest need for treatment and prevention programs.
✓ The density of infection map can be used to estimate the number of individuals who need treatment and the number who need prevention programs in specific areas of the country.
✓ To implement a "treatment as prevention" intervention in Malawi, over 1.2 million adults would need to be treated.

ACKNOWLEDGEMENTS

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