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Poster · July 2016

DOI: 10.13140/RG.2.2.10301.46560

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Cross-sectionally estimated age-specific HIV incidence among young women in a rural district of Kwazulu-Natal, South Africa

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Background

- Population-level HIV incidence is the most sensitive indicator of epidemiological trends, including for monitoring high-level interventions in support of global HIV elimination goals.
- We demonstrate the use of a method for estimating HIV incidence from age structure of prevalence, by application to a cross-sectional household survey data from Eshowe and Mbongolwane.

Methods

Survey Design: People aged 15-59 from sampled households were interviewed and offered HCT, with anonymous blood specimens collected for laboratory analysis. One hundred and twenty-five clusters of 25 households each were randomly drawn from 14 electoral wards, with the number of clusters per ward proportional to its population size [1].

Theory: Adapting the method of Mahiane et al [2] to a 'stable' epidemic, the age-specific incidence for any non-remissable condition, $\lambda(a)$, can be written as:

$$\lambda(a) = \frac{1}{1-p(a)} \cdot \frac{dp}{da} + \Delta(a) \cdot p(a) \qquad (1)$$

where $p(a)$ is the age-specific prevalence and $\Delta(a)$ is the age-specific excess mortality of the condition (note that 'baseline' mortality does not affect the estimate, and excess mortality enters only in conjunction with prevalence - both of which will be small in a young population).

Analysis: Several parameterisations of prevalence as a function of age were explored, considering tradeoffs of precision against sensitivity to age-trends. A cubic polynomial in a was found to be sufficiently flexible. The model was fit to data for females aged 15-23, but slope estimates at the edges do not appear to be sufficiently robust for use in age-specific incidence estimation.

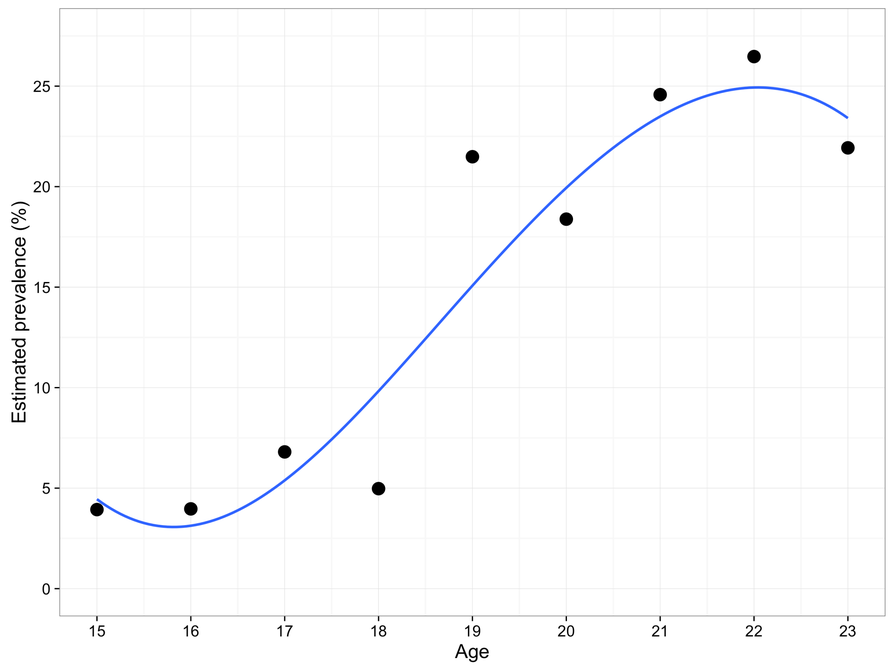

Figure 1: Fitted HIV prevalence among females aged 15-23

Results

- Incidence as a continuous function of age, using the most age-flexible model, is shown in Figure 2 and point estimates and confidence intervals at each age are given in Table 1.
- The analysis suggests a rapid escalation in incidence among females from age 15 to 18 years, with a peak at 19 years of **6.2% p.a.** (**95% CI: 4.1%-8.2%**).
- An age-insensitive model produced an averaged incidence estimate of **3.3% p.a.** (**2.6%-4.1%**) for females aged 15-23.
- Similar models of piecewise age-constant incidence, for various age ranges, are given in Table 2.
- A sensitivity analysis was conducted for excess mortality rates ranging from 0%-5% p.a., with the most extreme case shown in Figure 3. At age 19, a 5% mortality rate increases the incidence point estimate from 6.2% to 6.9%.

Age (yrs)	Incidence	95% CI
16	0.7%	0.0%-2.7%
17	3.8%	2.4%-5.2%
18	5.6%	3.6%-7.6%
19	6.2%	4.1%-8.2%
20	5.4%	3.8%-7.1%
21	3.4%	1.2%-5.7%
22	0.2%	0.0%-4.9%

Table 1: Estimated age-specific HIV incidence among females aged 16-22

Age (yrs)	Incidence	95% CI
15-17	1.4%	0.0%-3.9%
18-20	10.1%	5.7%-14.6%
21-23	0.0%	0.0%-5.5%
15-23	3.3%	2.6%-4.1%

Table 2: Estimated 'age-constant' HIV incidence among females aged 15-23

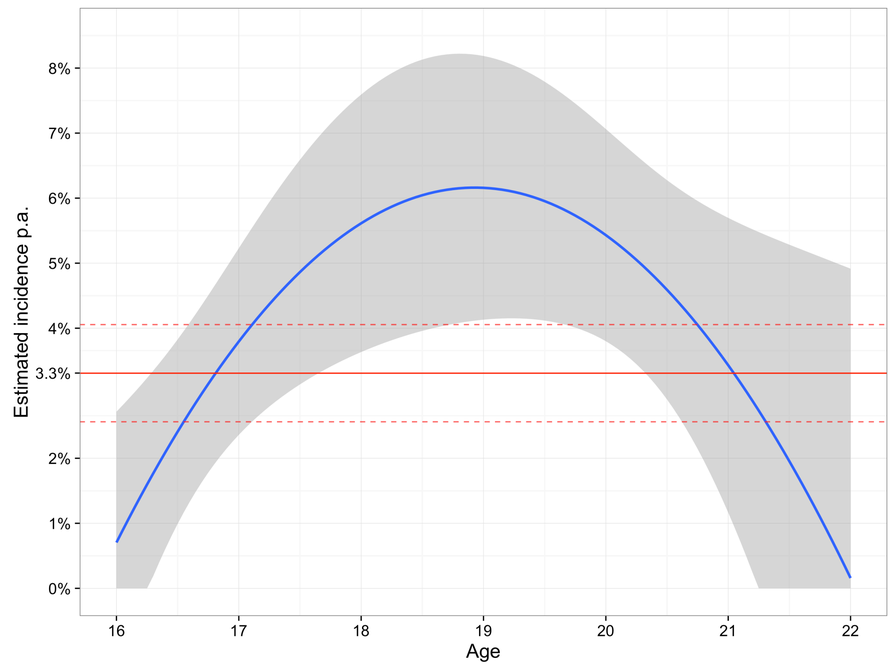

Figure 2: Estimated age-specific HIV incidence among females aged 16-22 (with 'age-constant' incidence shown in red)

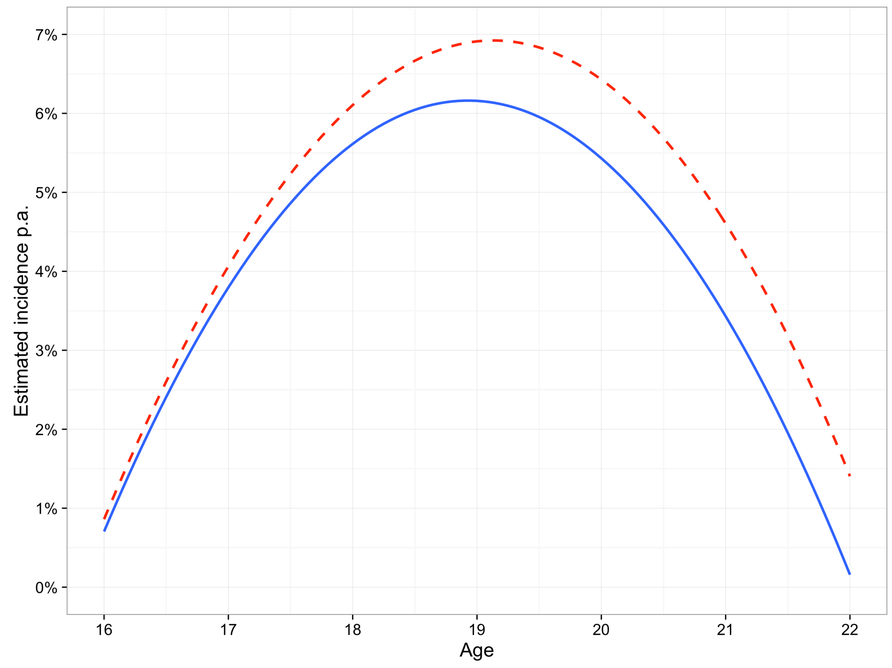

Figure 3: Incidence estimates without excess mortality (shown in blue), and with excess mortality of 5% p.a. (shown in red)

Conclusions

- The very high incidence at critical ages seen in this analysis would be invisible to routine 5-year age bin analyses, and may be important for targeting prevention interventions.
- Ongoing substantial secular changes in prevalence would lead to significant biases in an analysis of this kind. This could be addressed if data from multiple time points were available.
- The larger impact of prevalence and mortality in higher age groups probably limits informative estimation to younger populations.
- Nevertheless, these estimates demonstrate the potentially important use of underutilised data in support of incidence trend estimation, particularly among young women, who experience the highest incidence and can be regarded as a sentinel population.
- Generalisation of these methods to datasets with multiple time points would be more illuminating, for example for detection of secular incidence changes, which are currently highly elusive to all established methods.

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Acknowledgements

The survey on which this study is based was conducted by *Médecins Sans Frontières* and *Epicentre*. The analysis was made possible by the financial support of the *Department of Science and Technology* and the *National Research Foundation* of South Africa.