Decreasing Community Infectiousness Is a Marker for Decreases in New HIV Infections among Dutch Homosexual Men

Ard van Sighem[1], Daniela Bezemer[1], Frank de Wolf[1,2], Christophe Fraser[2]

[1]Stichting HIV Monitoring, Amsterdam, the Netherlands; [2]Imperial College London, London, United Kingdom

Stichting HIV Monitoring
Meibergdreef 9
1105 AZ Amsterdam, the Netherlands
phone/fax: +31-20-5666781/5669189
email: A.I.vansighem@amc.uva.nl

Background

- Decreasing community viral load is associated with a decreasing number of HIV diagnoses (Das et al., PLoS One 2010; Montaner et al., Lancet 2010).
- However, changes in *diagnoses* do not necessarily represent changes in *infections*.
- Also, changes in *observed* community viral load do not necessarily reflect changes in *true* community viral load, i.e., including those who are yet undiagnosed.
- For the HIV epidemic amongst men who have sex with men (MSM) in the Netherlands, we sought to investigate under which conditions changes in observed community viral load represent changes in the annual number of infections.

Methods

Mathematical model

- A transmission model based on Bezemer *et al.* (Epidemics 2010) was used to estimate transmission rates, diagnosis rates, and annual number of infections needed to explain observed national data on annual HIV and AIDS diagnoses amongst MSM in the ATHENA national observational cohort.
- This model describes progression of patients through different stages of the HIV infection including treatment.

Figure 1: Flow diagram of the MSM transmission model.
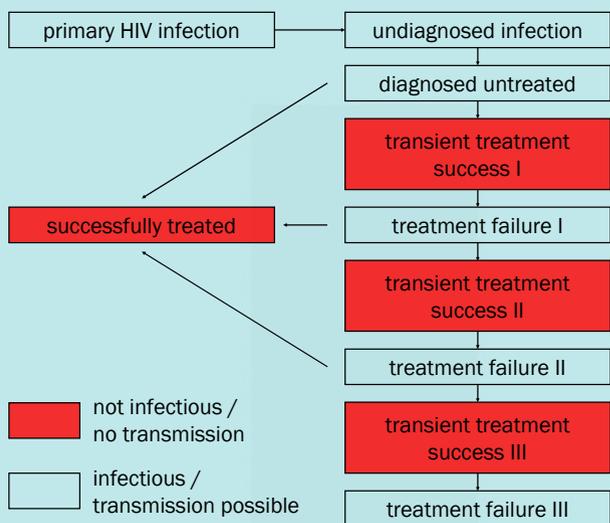

Methods

Viral load and infectiousness

- Patients in untreated stages or during treatment failure were assumed to have a viral load of 10^5 copies/ml corresponding with the median viral load in MSM in ATHENA.
- Viral load was transformed into infectiousness – transmission rate per year – using a relation derived from serodiscordant heterosexual couples (Fraser *et al.*, PNAS 2007):
  - 0.001 for successfully treated patients (Figure 1, red boxes).
  - 0.28 for untreated stages or treatment failure (open boxes).

Intervention studies

- 3 interventions effective from 2010 and there effect on observed community infectiousness, true community infectiousness, and annual number of new infections were explored:
  - reducing overall risk behaviour between 0% and 40%.
  - reducing time from infection to diagnosis between 2.4 years (current estimate) and 1 year in combination with a 50% decrease in risk behaviour after diagnosis.
 - antiretroviral treatment started immediately at diagnosis.

Figure 2: Observed and true (i.e., including the estimated 20% of the infected population who have not yet been diagnosed) community infectiousness (CI) without any intervention (black lines), with risk behaviour reduced by 40% (red), with time to diagnosis of 1 year (green), or with immediate treatment (blue).
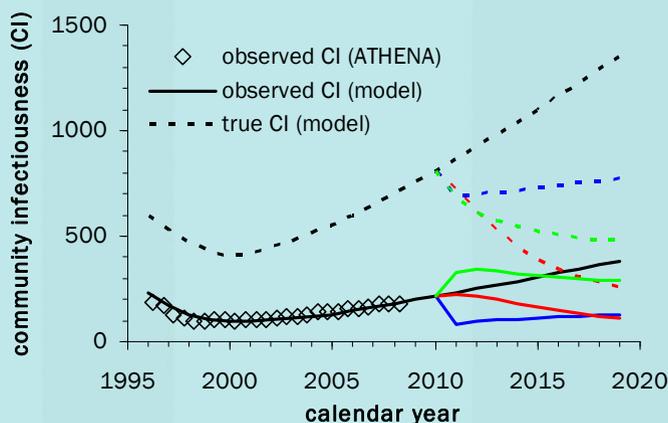
Results

- True community infectiousness substantially decreased when reducing risk behaviour by 40% or time to diagnosis to 1 year (Figure 2).
- At the same time, observed community infectiousness initially increased and only decreased after one or two years.
- Immediate treatment only gave a temporary decrease in both true and observed community infectiousness.
- Decreases in observed community infectiousness between 2012 and 2019 were always associated with decreases in the number of infections when simultaneously implementing different combination of intervention strategies (Figure 3).

Figure 3: Relation between changes in number of infections and changes in observed community infectiousness between 2012 and 2019 if treatment is started as at present (blue) or immediately at diagnosis (pink). Each point corresponds with a reduction in risk behaviour and time to diagnosis within the given ranges.
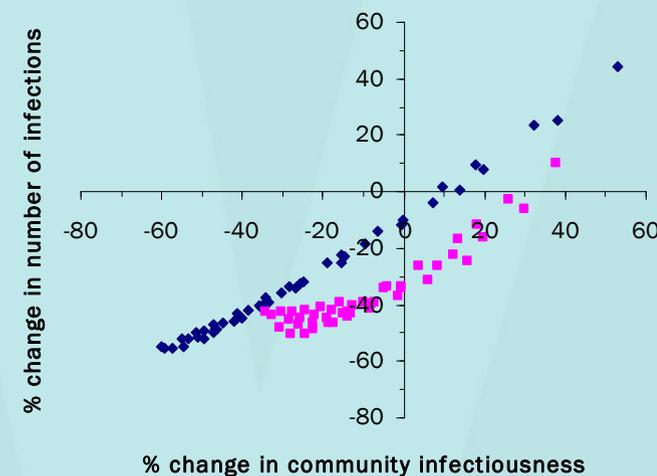
Conclusions & discussion

- Only after one or two years after implementing interventions do changes in observed community infectiousness reflect changes in both true community infectiousness and number of infections.
- Wide-scale treatment by itself is not enough to halt the increase in annual number of infections.