Population-based modeling as the first step in optimization of HIV interventions in Ukraine

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BACKGROUND. Recent advances in HIV prevention and treatment have decreased number of new HIV infections in regions of the world that have traditionally been the source of highest concern, such as countries in sub-Saharan Africa. Despite these encouraging results, in other parts of the world the HIV epidemic continues to grow. In particular, the HIV epidemics in Eastern Europe and Central Asia have been rapidly growing over the past decade. Among the countries in the region, Ukraine's situation has raised serious concerns, since it has one of the fastest growing HIV epidemics in the world, which makes it an important case study for HIV interventions.

METHODS. It has been used open source statistical data of HIV/AIDS monthly incidence and prevalence in Ukraine (http://aph.org.ua/uk/resursy/statystyka) also as statistical data of Ukrainian population (http://www.ukrstat.gov.ua/operativ/operativ2007/ds/nas_rik/nas_u/nas_rik_u.html).

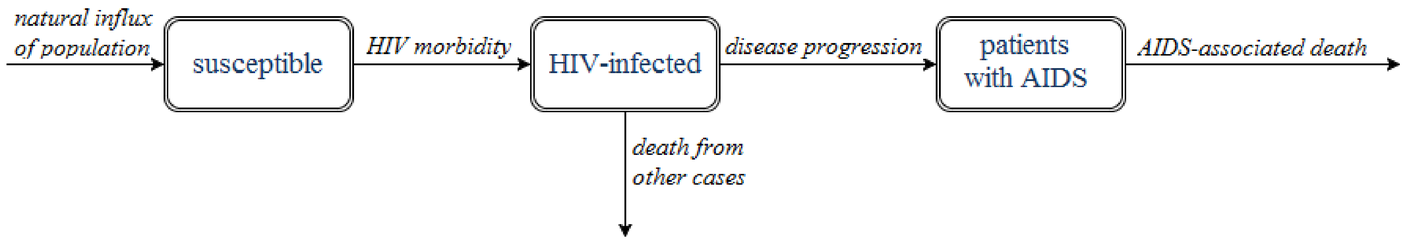

Fig. 1. System dynamic model of HIV/AIDS epidemic in Ukraine

As modeling approach we chose flow-chart compartment (system dynamic) model, widely used in formal description of infectious disease epidemic process. The proposed model has three compartments, describing three subgroups of Ukrainian population in dynamics: susceptible persons, HIV-infected persons, patients with AIDS (fig. 1).

RESULTS. With the use of statistical data and mathematical approaches, we have estimated the transition rates between different population subgroups and found that these rates are time-dependent.

It was estimated transmission parameter of HIV-infection in Ukrainian population has been decreasing during decade of years from 0,02 to 0,004, showing the effectiveness growth of different HIV prevention strategies (condome use, voluntary counceling and testing etc) (fig. 2).

We found that HIV-infection progression to AIDS rate has oscillatory nature and varies from 0.002 to 0.006 during the studied years (fig. 3). It can be explained by possible difference of antiretroviral treatment coverage of HIV-infected persons and its overall effectiveness.

The same oscillatory nature has death rate of AIDS-patients decreasing to minimum value – 0,005 (fig.4).

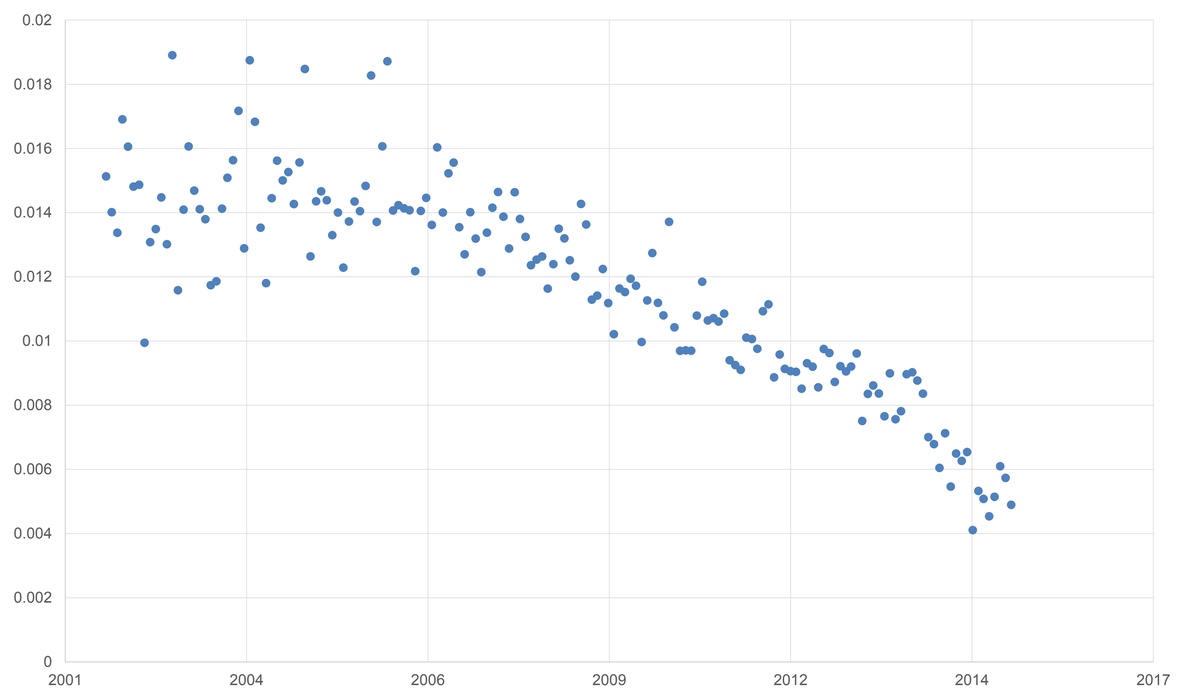

Fig. 2. Transmission parameter of HIV-infection in Ukrainian population

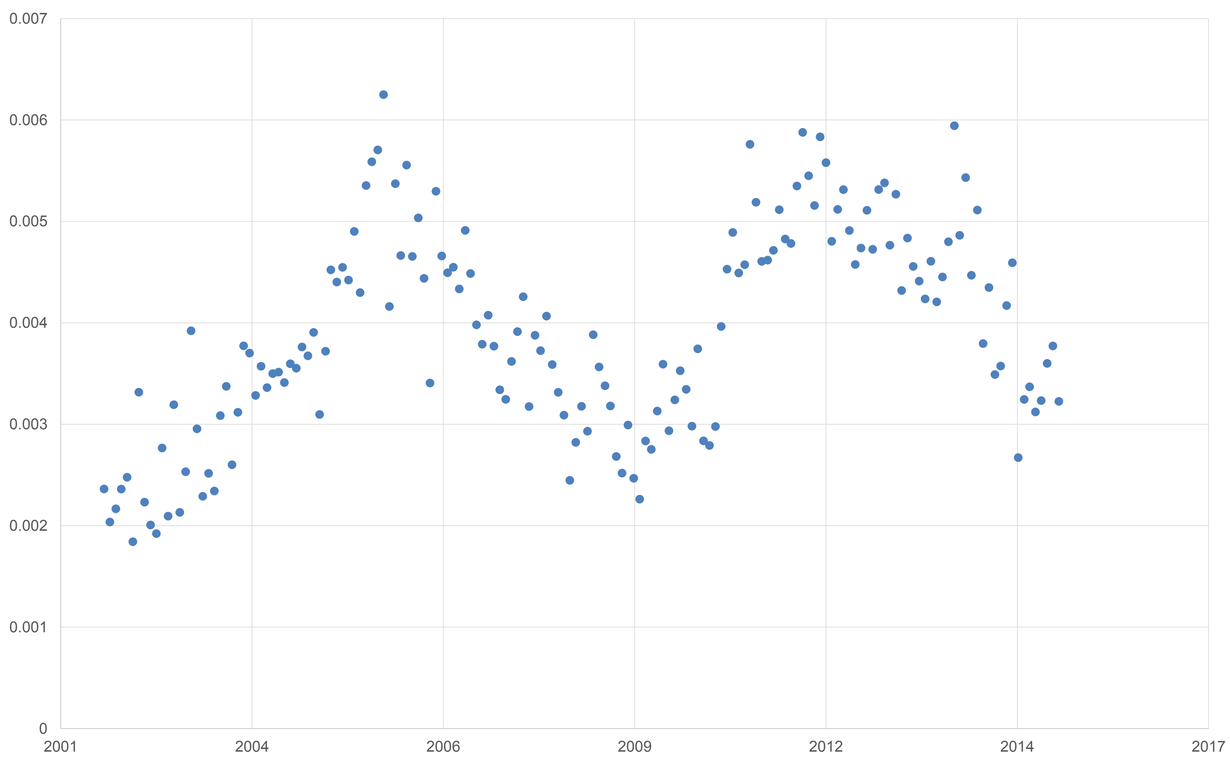

Fig. 3. Rate of HIV-infection progression to AIDS

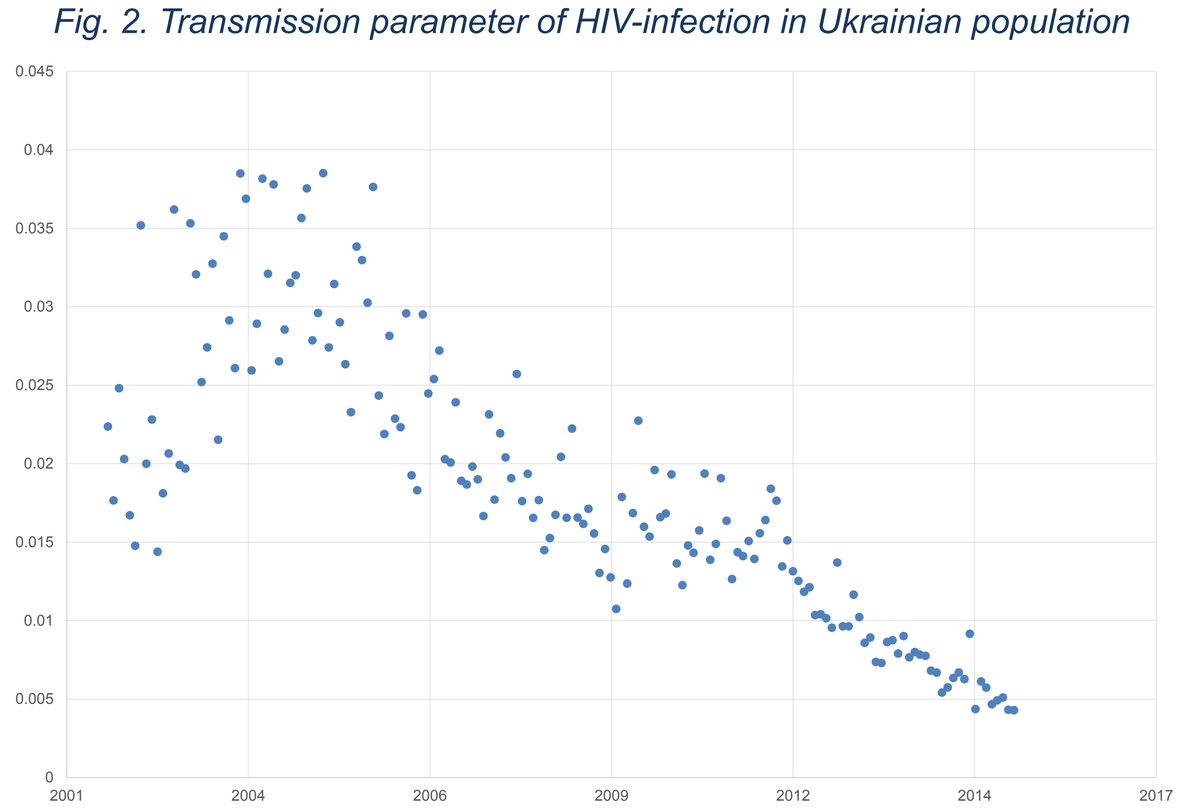

Fig. 4. Rate of AIDS progression to death

We have used approaches of mathematical analysis for estimation of equilibrium of the studied dynamic system of HIV/AIDS epidemics. We found that such possible equilibrium would be unstable and possible equilibrium fractions of Ukrainian population would change in time (fig. 5). Even a small perturbation of dynamic system (change in population, introduction of prevention strategies etc) could lead to a displacement of its equilibrium and commitment to a new equilibrium point.

CONCLUSIONS. In the field of HIV prevention, analytic models become necessary for analysis of recent epidemiological data and simulation of impact of different intervention strategies on HIV prevalence among Ukrainian population. The health officials can use the developed model within identification of key socio-economic parameters associated with these strategies.

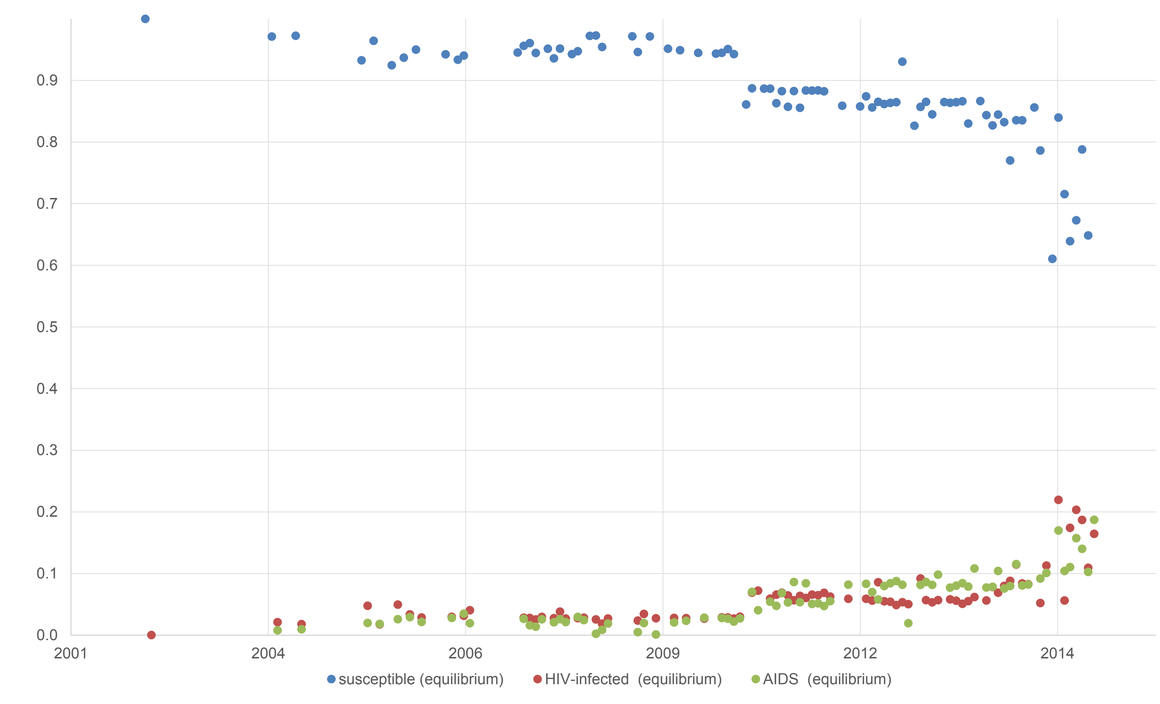

Fig. 5. Theoretical equilibrium fractions of Ukrainian population