Development of a simulator to evaluate public health control strategies of tuberculosis in big cities

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Abstract: Tuberculosis (TB) is still one of the most important infectious diseases worldwide, killing over 1.5 million people each year. It is estimated that one third of world population has already been infected by Mycobacterium tuberculosis. In particular, the Ciutat Vella neighbourhood in Barcelona has a tuberculosis incidence which is comparable with the incidence in countries like Sudan. In this work, we improved a previous agent-based model (ABM), to develop a simulator of the tuberculosis dynamics in Ciutat Vella, as a first step towards the simulation of tuberculosis dynamics in big cities. This simulator has allowed us to perform virtual experiments to assess the efficacy of public health strategies. The model was implemented in NetLogo, a free and open-source simulation tool that incorporates an user-friendly interface. NetLogo is time-consuming for large populations (our model has around 100,000 individuals), some optimization work was required in order to make experimentation.

Model and implementation

➢ Five infection TB states:
Each state has a certain behavior and there are many transitions between the states. These transitions may be affected by population heterogeneities (diabetes, HIV infection...).

➢ NetLogo user-friendly interface:
The simple interface allows to easily overview the progress of the simulation and change its initial parameters.

Results

➢ Two experiments:
Different initial distributions of infection times (i.e. time elapsed since infection) and different types of screenings (i.e. procedures designed to detect diseases before the person affected shows any symptoms).

➢ Results obtained

Conclusions: The presented work is a first step towards a user-friendly integrated platform for the simulation of tuberculosis spreading in a certain community. It allows the study of TB dynamics in heterogeneous populations. All the parameters have been calibrated to the tuberculosis situation in the Barcelona district of Ciutat Vella, but the model is robust enough to be calibrated to any other region. Its implementation in NetLogo makes evident the computing limitations of this platform, although it has proven to be useful for its use by non-experts. Therefore, we proposed and proved the success of a solution that overcomes these limitations. With the optimized, calibrated model, we performed some experiments to prove its utility. We designed two sets of experiments, one related to the distribution of infected times and one related with the screenings. The result of the first experiment points out how careful one has to be with the assumptions taken at the moment of modelling a system. The second experiment allowed us to see the effect of three different types of screening. We saw contact tracing and random screening of 100% as the most effective. These experiments prove the utility of the simulator as an assistance tool for public health decision-making.

Literature cited


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