Cost-Benefit Analysis of Vaccine-Based Interventions to Control Pandemic Influenza

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OBJECTIVE
The objective of this study is to evaluate the direct and indirect impact of vaccine-based interventions for prevention and control of an influenza pandemic, for the city of Chicago, using a dynamic agent based model.

BACKGROUND
Vaccination is a recommended strategy to control seasonal and pandemic influenza for individuals aged >6 months. However, the direct and indirect epidemiological impact of vaccination for all age and risk groups from the societal standpoint are less known. Direct benefits of vaccine include the number of averted cases and influenza associated outcomes among vaccinated individuals [1]. Indirect impacts of vaccination arises because effectively vaccinated individuals reduce pathways of transmission to secondary and subsequent cases. Figure 1 illustrates the direct and indirect impacts of vaccination. This study applies a dynamic agent-based model to estimate the direct and indirect epidemiological impact, and conduct cost-benefit analysis of vaccine-based interventions.

METHODS
Chicago was selected to study the impact of vaccination intervention on different severity of pandemic influenza. We use a collocation based synthetic social contact network, generated for the city of Chicago, using the methodology explained in [2–4]. The transmission dynamics of the influenza-like illness in the population is simulated using the susceptible-exposed-infectious-recovered (SEIR) epidemiological model. We use an agent-based model to compare the costs and benefits of vaccine-based interventions under different transmission scenarios during an influenza pandemic.

For the base case, three different forms of pandemic influenza were designed:
- Moderate influenza: 28.9% cumulative infection rate
- Strong influenza: 38.6% cumulative infection rate
- Catastrophic influenza: 58.1% cumulative infection rate

Influenza associated outcomes include: death, hospitalization, outpatient visit, and illness (without medical care).

Vaccine intervention: 40% of population is vaccinated, and vaccine efficacy is 40%.

RESULTS
Figures 2 and 3 illustrate the direct and indirect impacts of vaccination. Vaccination of 40% of the population results in 19.84% (range: 17.41%-23.84%) reduction in the attack rate of influenza in the dynamic model, compared to 6.77% (range: 4.7%, 9.4%) reduction in the attack rate in the static model [1]. In summary, vaccination results in 46.8% (range: 26.0%, 69.2%) higher net return per capita in the dynamic model in comparison to the static model.

DISCUSSION
Based on comparison of vaccine-based intervention scenarios and health outcomes from the static Monte Carlo model [1] and the dynamic agent-based model, more cases of influenza are averted, and more cost effective for all age and risk groups. Relatively better estimates of epidemiological impact and cost-benefit outcomes can be estimated using dynamic models, such as the agent-based model used in this study, in comparison to static models.

Public health implications: Measurement of direct and indirect effects of vaccine interventions facilitate efficient allocation of public health resources to minimize deaths, hospitalizations, and outpatient visits during an influenza pandemic.

REFERENCES

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