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Individually based stochastic model of influenza: an analysis of school closure

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In this research, we proposed an infectious disease spread model of influenza which was individually based and stochastic. We first described the method to build a realistic model, or to estimate realistic parameter values, based on observed data. An appropriate model has to be individually based and stochastic if we take advantage of small unit data (in this case, every day class unit data). We also analysed the effect of different strategies of school closure, e.g., the criteria for implementing school closure and the duration of continuous school closure.

The data we used were the daily reported data of the numbers of cases of swine flu and the dates of school/class closure in each class of schools collected from September 2009 to March 2010 in a city in Japan. Because the data were collected in each class, transmission rates could be estimated separately for within class, within-school and inter-school rates. Totally 21,253 cases were reported out of 51,871 students in 134 schools (elementary schools, junior high schools, high schools and kindergartens). To construct accurate model, infected numbers must be estimated from case report data taking latent period into account, which is deterministically impossible. To resolve this difficulty, we stochastically estimated and obtained data of infected numbers by 'Monte Carlo back calculation' and used in the analysis. The analysis was mainly carried out using data during September up to December to avoid the influence of vacations. The influence of humidity was also analysed using daily meteorological data of the area where data were collected. The analysis of total population using deterministic model was also carried out to obtain the overview of the flu spread.

The transmission rates of different levels were estimated by maximum likelihood method using detailed data reconstructed by Monte Carlo back calculation method. The rate within class was much larger (approximately 15 times larger) than within school rate. The transition rate between schools was much smaller than between classes of the same school. Stochastic variations of estimated parameters were also analysed. Optimal strategy of school closure was analysed in relation to the characteristics of flu.

By the analysis based on stochastic infectious disease spread model, we could have presented possible variations of total number of cases and the size and timing of the epidemic peak. 'Monte Carlo back calculation' approach was concluded to be useful in the analysis of effective preventive strategy against influenza based on individually based stochastic model.

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