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Resume: 2つの方法を利用した風疹のワクチン接種の優先的接種のモデル化

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Resume of forthcoming article

As an original study is expected to be printed elsewhere, herewith a Resume of the study is provided for this proceedings.

Background

Rubella is a contagious viral disease, caused by rubella virus and directly transmitted from human to human. The infection is often mild and symptoms last on average for 1 to 3 days. However, if pregnant women are infected during their early gestational age of pregnancy, the infection could also influence fetus, leading to a cause of congenital rubella syndrome (CRS). Once CRS occurs, it induces serious incurable illness and about 20% of CRS is considered to result in miscarriage. For this reason, adolescent female has been a target of routine immunization as soon as the vaccine was developed. Later, industrialized nations have aimed to elevate herd immunity so that the epidemic itself can be controlled.

Nevertheless, an epidemic of rubella was seen from 2013-15, involving mostly adults, especially adult males. It is a tragedy that as many as 45 CRS cases have been confirmed and notified to the government. The epidemic was considered to have been caused by a policy failure of previous vaccination program that has led the present day 30s-50s male susceptible to rubella. Now an effective supplementary vaccination program has to be considered, and such program has to be supported by objective scientific evidence as assisted by mathematical models. When considering the supplementary vaccination and revaccination among susceptible pockets in adults, it is vital to identify the most cost-effective strategy of vaccination. This is particularly the case when an epidemic sporadically occurs, because the country would not have sufficient stock of vaccines to be put into place.

The purposes of the present study were two-fold. One was to identify the most economical vaccination strategy, anticipating similar future rubella epidemics. The other was to estimate the required minimum vaccination doses to ensure that the major epidemic would not happen.

Method

Modeling strategy

Using a mathematical model, we reconstruct the transmission dynamics of rubella in 2012-13 and use it for planning future control. There were two tasks. One was to characterize the age and gender specific transmission dynamics. We employed the so-called multivariate renewal process, i.e.,

$$c_{ai}(t) = s_{ai}(t)\sum_{j}\sum_{b} R_{abij}\int_{0}^{t} c_{bj}(t-s)g(s)ds$$

to describe the temporal evolution of rubella epidemic.

The other was to implement multiple scenarios varying target host of supplementary vaccination and revaccination.

Model parameterization

The way to identify susceptible individuals by age and gender has posed a problem in defining the baseline, because susceptibles can be manually identified in two different ways. One is to trust seroprevalence data, as indicating the fraction protected. The other is to explicitly quantify the next generation matrix using the age and gender stratified data. For both methods, we have used the age- and gender-specific contact rates.

Results/Discussion

Analyzing both cases, we showed that vaccinating 30s male is optimal. To achieve optimal vaccination, the supplementary vaccination and revaccination should not involve female and should not involve 40s male. It was also shown that securing 7.4 million vaccines would help reduce the reproduction number to be below 1.0.

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