Using an individual based model to compare pertussis maternal immunisation strategies

Nicholas Geard1,2, Patricia Campbell1, James M. McCaw1, Kevin Korb2, Jodie McVernon3

1 Vaccine and Immunisation Research Group, Melbourne School of Population and Global Health, The University of Melbourne, Victoria, Australia
2 Faculty of Information Technology, Monash University, Victoria, Australia

Background

Despite high levels of childhood immunisation, incidence of pertussis has increased over the last decade in several countries. Rising levels of disease in adolescents and adults whose immunity has waned, and in infants too young to be vaccinated, has prompted a search for new vaccine approaches (Libster 2012).

Maternal vaccination against pertussis has the potential to provide protection for both mother and infant. The transfer of maternal pertussis antibodies has been demonstrated, and may protect a newborn infant in the critical period before direct vaccination. In addition, the immunisation of the mother may provide a partial cocooning effect, decreasing the likelihood of household exposure.

Ethical and technical issues make efficacy trials of maternal vaccination difficult, therefore modelling offers an approach to exploring potential effectiveness and population level implications.

Methods

Population Model: An individual based model was used that explicitly represents the age and household structure of the population (Geard et al. 2013). Calibrated using demographic data (% from the Australian Bureau of Statistics, the model captures the household context of mothers and newborns, as well as household and community patterns of contact.

Disease Model: A modified version of a previously published model for pertussis was used that includes waning of immunity, and boosting of immunity upon re-exposure (Lavine 2010).

Results

In the simulations, introducing maternal immunisation reduced total incidence by (A) 6% and (B) 7%. However, incidence in 0-1 year olds was reduced by (A) 23% and (B) 26%, and in 20-40 year olds (the primary recipients of the vaccination) by (A) 19% and (B) 21%.

Individual based models can include high levels of population heterogeneity, enabling exploration of realistic scenarios that are more challenging using traditional modelling approaches. Subject to the validity of the underlying assumptions about disease dynamics and contact structure, the model results suggest that pertussis maternal immunisation could provide increased protection to newborns, but that household-level effects should be carefully evaluated.

In particular, the model currently assumes an average duration of immunity of 10 years, meaning that a mother vaccinated prior to the birth of her first child is likely to remain protected through the birth of subsequent children, even without revaccination. Additionally, we have assumed no interference of maternally derived antibodies with the child’s immune response to their subsequent primary vaccination. We are exploring the implications of varying these assumptions in current work.