Bayesian Tests and Fuzzy Hypotheses: estimating the optimal age to vaccinate against measles in São Paulo

Neli R. S. Ortega and Eduardo Massad
School of Medicine, the University of São Paulo and LIM01/HC-FMUSP
Av. DR. Arnaldo 455, 01246-903, São Paulo Brazil
E-mail: neli@dim.fm.usp.br, edmassad@usp.br

Claudio J. Struchiner
FIOCRUZ, Rio de Janeiro, Brazil
E-mail: stru@procc.fiocruz.br

The introduction of measles vaccines more than 25 years ago has dramatically reduced the number of cases in many countries. However, measles still accounts for 10% of global mortality from all causes among children aged less than 5 years, which represents approximately 1 million deaths annually, and it is the first cause of deaths preventable by vaccines in children. The presence of maternally derived transplacental antibody has been correlated with the vaccine primary failure to immunise infants less than 1 year of age. Because vaccination results in lower antibody titters than does natural infection, vaccinated women are likely to pass lower levels of the measles antibody to their infants. Previous works suggest that infants of mothers in the vaccine era may lose passively acquired antibodies earlier than 12 months, creating a state of susceptibility at a younger age [3]. Therefore, it is important to investigate how the levels of measles antibody in women, resulting from extensive vaccination programs, may influence the susceptibility to measles of children born to those women. Recently, we carried out a seroprevalence survey in South-eastern Brazil in an attempt to answering some of those questions. We then proposed a mathematical model to estimate the optimal age for vaccination considering the mother's serostatus, children seroconversion to vaccine and an ad hoc function of undesirability associated with the disease at age \( a \). The output of the model is the recommendation of vaccination in the age \( a \). Both inputs and outputs of the model are fuzzy variables and an adequate defuzzification method was proposed to decide what age is more recommended to vaccination.

The model’s performance was very similar to that obtained by classical dynamical systems approach but, by taking into account subjective information in the form of fuzzy hypothesis, it is more intuitively acceptable by the decision maker. In addition, the Bayesian test of fuzzy hypothesis is an interesting approach from the theoretical point of view, in the sense that it combines two complementary areas of investigation, normally seem as competitive.