Understanding bronchiolitis dynamics and assessing immunization strategies using a multivariate age-structured stochastic model

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Abstract

Bronchiolitis is a highly morbid disease in children under the age of 2, with respiratory syncytial virus (RSV) being the most common pathogen responsible for the disease. The development of various immunization strategies for bronchiolitis necessitates the evaluation and comparison of their efficacy to inform policymakers.

In this study, we propose a novel multivariate age-structured stochastic model to understand bronchiolitis dynamics in children under 2 years of age, utilizing high-quality data from the Valencia health system integrated database. Our modeling approach combines ideas from compartmental models and Bayesian hierarchical Poisson models, where the population is divided into four age groups, and new infections are described by considering the interaction among these groups. We use a Poisson model (or negative binomial model if the data exhibit overdispersion) to formulate our model, with the mean of the distribution at each time point being observation-driven, where the autoregressive parameter varies stochastically over time.

Our model also includes a parameter that allows for the representation of heterogeneous mixing of individuals in the population. Our approach does not require information on susceptibles, and it provides a simplified framework to describe disease counts, avoiding the modeling of complex transitions between the different compartments. Additionally, we extend our model to simulate the effect of potential newborn immunization scenarios on the burden of disease.