

A Model for Studying the herd immunity effect of the Varicella

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Introduction

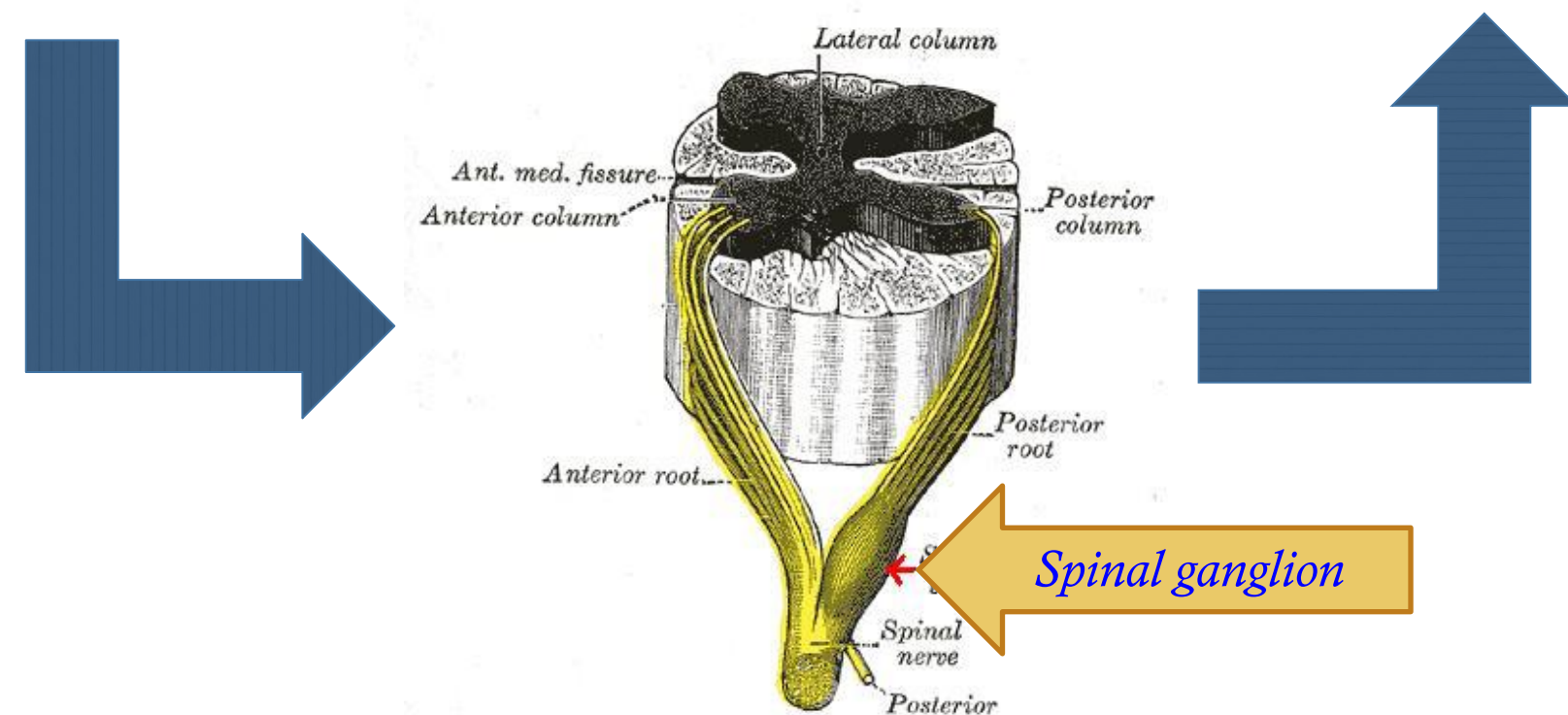
Chickenpox or Varicella is a highly contagious disease caused by the Varicella Zoster Virus (VZV). This virus is the responsible for both Varicella and Herpes Zoster and it has a very high prevalence. Varicella affects mostly children. In the case of adults, it is more severe.



Varicella



Herpes
Zoster



Once the individual recovers from varicella, VZV hides inside the spinal ganglion. For unknown reasons, from the age of 50, the virus may get reactivated and produces the Herpes Zoster.

Some doctors conjecture that a partial coverage of the Varicella vaccine could induce an increase of cases in adults:

- if the herd immunity stopped the virus circulation, non vaccinated children reach adulthood without having had contact with the virus
- in the long-run the vaccine may lose effectivity
- cases of Herpes zoster in adults may increase.

As a consequence, in 2013, the Spanish Agency of Medicines blocked the Varicella vaccine distribution.

However, the benefits (health and economic) of the children vaccination programs are reported in several publications.

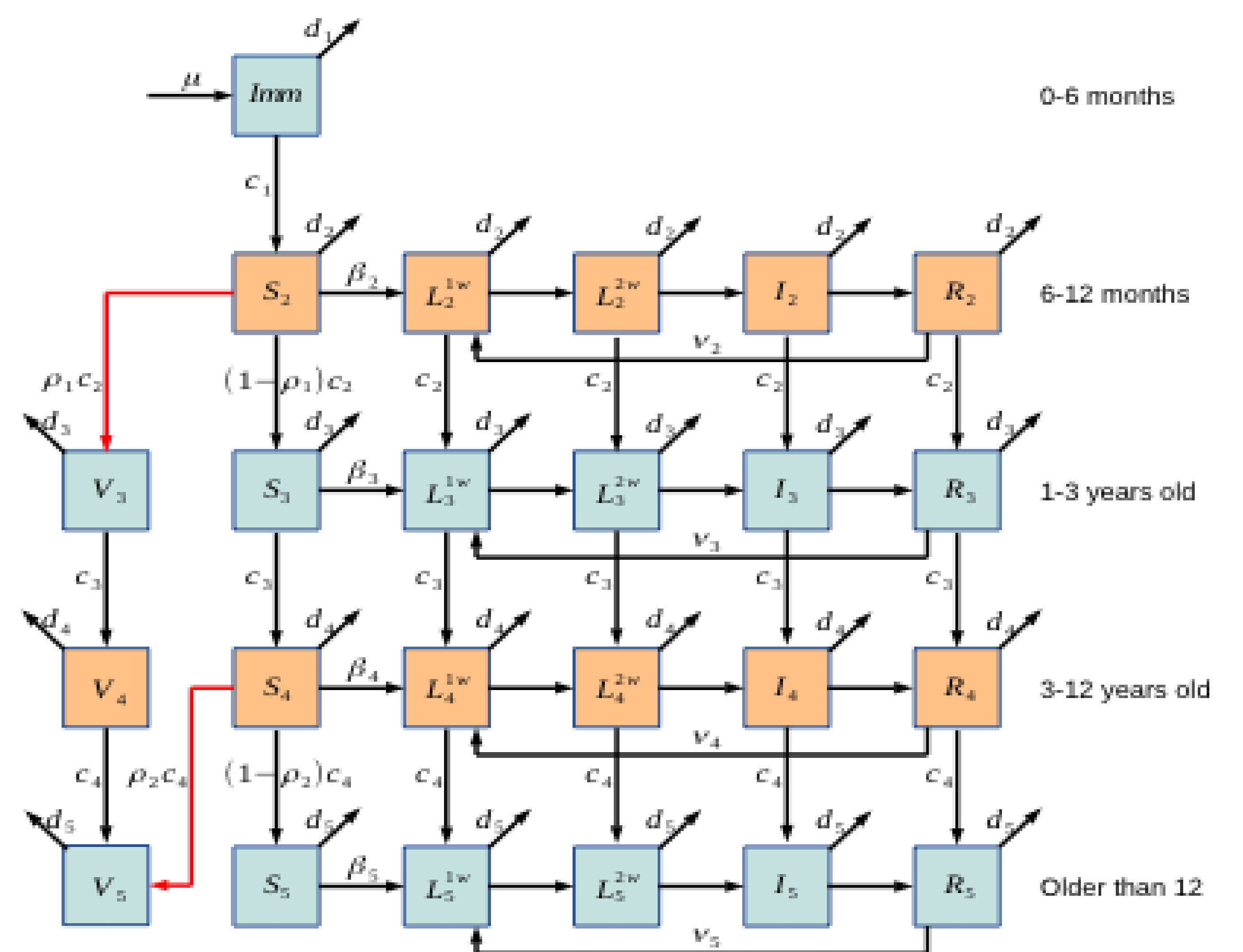
Until 2013, the parents payed the vaccine (free vaccination) and a coverage around 50% was reached. Also, the Public Health vaccinates 12 years old susceptible individuals.

We develop a mathematical model to study the transmission dynamics of Varicella that allow to assess the impact of this partial coverage of the vaccination program. Note that, from the Public Health point of view, the herd immunity may be an undesirable effect of the partial vaccination because Varicella and/or Herpes Zoster in adults use to be severe.

Mathematical modelling

We divide the population into de age groups 0-6 months, 6-12 months, 1-3 years, 3-12 years and older than 12 years.

The varicella disease states are: Immune (Imm), Susceptible (S), Latent 1st week (L^{1w}), Latent 2nd week (L^{2w}), Infected/Infectious (I), Recovered (R) and Vaccinated (V).

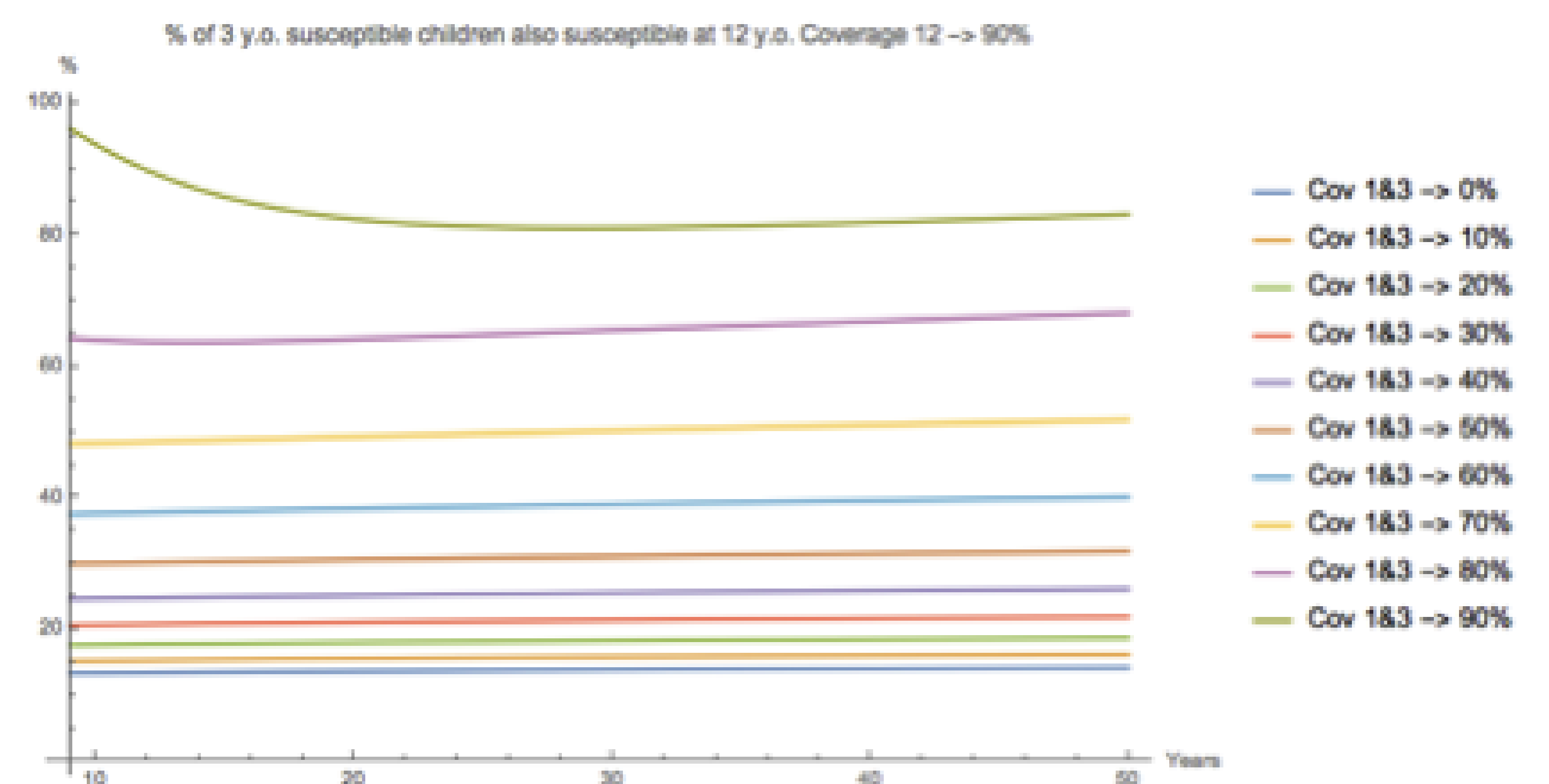


Unknown model parameters are determined to get the best weekly reported cases data fitting.

Vaccination simulations

We are going to consider the following vaccine programs: two doses at 12 months and 3 years of age, with coverage 50%, 60%, 70%, 80%, 90% (simulating the current free vaccination), and catch up of susceptible at 12-years-old with coverage 90% (the existing vaccination program).

Then, we are going to assess the number of susceptible at 12-years-old individuals per year in the following 50 years.



The above Figure shows the % of 3-years-old susceptible that are also susceptible at 12-years-old. Note that the differences are increasing as the partial coverage increases and the jumps are remarkable when the coverage is greater than 70%. The % of susceptible decreases as the coverage increases, however these non-vaccinated susceptible are better protected against infection because the herd immunity.

Conclusion

The free vaccination program, where parents pay for the vaccine, does not show a shift in the disease incidence always that the vaccination at 12 years of age is maintained and the coverage of the free vaccination is 70% or less.

Lack of herd immunity implies that the virus is freely circulating, therefore it is expected that the contact of adults with the virus persists and the potential for a Herpes Zoster and Varicella cases increase in the adults will be minimal.