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Onward Virus Transmission after Measles Secondary Vaccination Failure

Appendix 1

PubMed

("previous immunity"[tiab] OR "prior immunity"[tiab] OR "vaccination failure"[tiab] OR "vaccine failure"[tiab] OR "breakthrough infection*"[tiab] OR immunized[tiab] OR immunised[tiab]) AND (Measles[Mesh] OR Measles[tiab] OR "Measles Vaccine"[Mesh] OR "Measles-Mumps-Rubella Vaccine"[Mesh])

Web of Science

("previous immunity" OR "prior immunity" OR "vaccination failure" OR "vaccine failure" OR "breakthrough infection*" OR immunized OR immunised) AND (Measles OR Measles OR "Measles Vaccine" OR "Measles-Mumps-Rubella Vaccine")

Embase

('previous immunity':ti,ab OR 'prior immunity':ti,ab OR 'vaccination failure':ti,ab OR 'vaccine failure':ti,ab OR 'breakthrough infection*':ti,ab OR immunized:ti,ab OR immunised:ti,ab) AND (Measles/exp OR Measles:ti,ab OR 'Measles Vaccine'/exp OR 'Measles-Mumps-Rubella Vaccine'/exp)

Relationship of Directly Calculated R_{eff} to Survivor function R_{eff} and Ordinary Differential Equations R_{eff}.

R_{eff} can also be estimated using the survivor function (*1*–*3*) and ordinary differential equations (ODEs). In both the survivor function (equation with integral) and the ODE (equation

with βIS) the $b(x)$ can be simplified to 1, meaning 100% chance the person will transmit throughout their infective period. For these models there can be 1 or more infected individuals transmitting (I).

Survivor Function and Ordinary Differential Equations

$$R_{eff} = I \int_0^a f(x)b(x)dx = \beta IS \cdot b(x) \cdot a$$

$f(x) =$ transmissions function to susceptible individuals per unit of time for period a (during one infective period, which is ≈8 days for measles; see Figure 3). $f(x)$ is similar to β in that it represents a rate, but the rate of $f(x)$ changes overtime. Integration (area under the curve) represents the total transmissions during the period a.

$b(x) =$ probability the person is infective during entire infective period a (8 days). $b(x)$ is a term that can be a simple proportion, or a time dependant function. This term modifies the likelihood of being infectious, similar to how an individual with SVF will have a modified transmission period. The function $b(x)$ may modify the transmission rate profile or make it an all or none phenomenon. $b(x)$ is a unique function, which is most thought of as 1 in ODEs (thus not included), as all infected persons always transmit in the common models. However, not all persons with SVF transmit the virus, which is why the term $b(x)$ should be included or modeled when estimating the R_{eff} for persons with SVF.

a = duration of infective period. Measles is generally infective from 4 days before the onset of the rash, and 4 days after the onset of the rash, giving an infective period of 8 days (a = 8 days).

βIS = the transmission rate per unit of time (β), which in this case will be 1 day. I is the proportion of persons that are infective. The proportion of persons that are susceptible is represented by S and is equal to $1 - I$. The following must hold true: $S + I = 1$, and if there are 100 persons in the model, then $S = 0.99$ and $I = 0.01$. The total transmissions per day is then multiplied by the infectious period a to provide an estimate of total transmissions per infective period R_{eff} β the transmission rate, assumed to be fixed for the entire infective period in ordinary differential equations (ODE) here.

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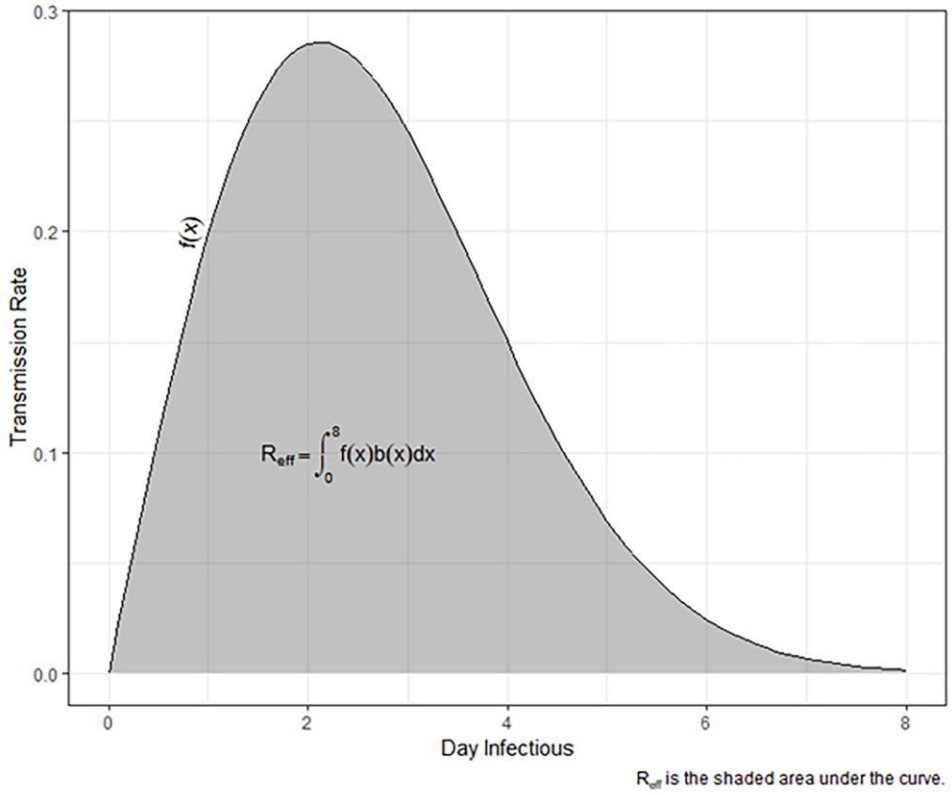

Appendix 1 Figure. Example curve of the function of the transmission rate during the infectious period. This curve represents the probability of transmission on a given day and assumes an average number of contacts per day, whereas the ODE parametrizes this separately. The transmission rate function $f(x)$ bears similarity to β used in ODEs, except that β would remain uniform throughout the infectious period and it assumes a fixed number of contacts per day (IS component of the βIS). In this example, the person is most infectious at the end of day 1 to about day 3. This curve would look similar (but not identical) to a curve representing excreted live viral load. The R_{eff} in its most basic form for one person that is infectious can be taken as the integral of the function shown in Figure 3. In other words, the R_{eff} is the area under the curve.