What does the "reproductive number" mean, how can it be used, and how does it contrast to "incidence"?

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Key Points:

- The reproductive number is a measure of transmissibility of a pathogen
- The incidence is a measure of pathogen frequency

The reproductive number is often mentioned in pathogen modelling papers to refer to the potential transmissibility of a particular pathogen. This number can range from very low to extremely high values. To give you an idea, the R0 for measles virus has been estimated to be in the range of 7-16 (Vynnycky and White, 2011). For PRRS, this number has been estimated to be approximately 2-3 (Jeong et al., 2014) at the within-farm level.

It is known that when the reproductive number is 1 the pathogen is stable; when it is > 1, the pathogen is spreading, and when <1, the pathogen is dying out.

The reproductive number comes in different varieties, according to the situation at which it is being estimated:

- **R_0 (reads "R nought")**: this refers to the **basic reproductive number**, and is the number of secondary cases caused by a primary case in a completely susceptible population.
- **R_e**: this refers to the **effective reproductive number** and is the same concept as above except that it does not assume a completely susceptible population. Therefore this number can be estimated later during an epidemic when underlying immunity is present.
- **TD-R: time-dependent reproductive number** is calculated over time for a period that can vary to a couple of months to years, so there is one number for each interval.

Using within-farm PRRS as an example, the R0 would be an appropriate calculation for cases in which we have a naïve population or even in the context of an emerging PRRSV strain for which there is no previous immunity in the herd. But, once the herd has been infected, the Re or TD-R should be used.

How do we use the estimate?

One of the main uses for this number is for disease control programs. For example, if we have an effective vaccine, we can actually calculate the minimum percentage of animals to be vaccinated in order to eradicate the pathogen. For example, for human influenza, that has an R0 estimated between 2-4, approximately 50-75% of the population needs to be vaccinated in order to lead to pathogen extinction (Vynnycky and White, 2011). As expected, the higher the R0, the higher the target vaccination rate needs to be.

Another important use of the reproductive number is that it is related to the type and intensity of interventions that aim to control an epidemic (e.g. increase or change in biosecurity measures or introduction of vaccination). Therefore we can verify whether interventions are being successful for a particular disease (Nishiura and Chowell, 2009).

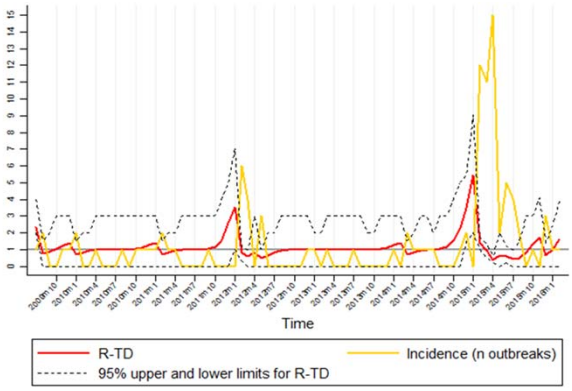
How does it contrast to incidence?

Most people are familiar with the concept of incidence, which is a measure of frequency of pathogen and can be calculated as a risk or a rate. It refers to the number of new events (e.g. PRRS or PED outbreaks) in a population. This measure is very important, but it does not tell us how transmissible a pathogen may be (Vynnycky and White, 2011). The reproductive number, on the other hand, is a measure of transmissibility.

On-going project

In one study, we are using data from SHMP outbreaks to estimate the TD-R at a higher level (transmissibility of PRRS within systems and regions) and contrasting the incidence with these reproductive numbers. We will check whether there are instances when we should be more attentive to one versus the other. We also want to compare the reproductive numbers across different geographic regions and production systems.

Preliminary results from that project show interesting findings. Figure 1 shows an example for one region within the USA with the curves for the TD-R and the incidence. We can see that (1) the TD-R estimation tends to stay around the value of 1 (which makes sense for an endemic pathogen that remains stable in the population of, in this case, farms), and (2) the TD-R tends to peak before the incidence does. We are testing this for other regions now, and will determine if this could be useful to predict the beginning of the PRRS season. Stay tuned for more detailed results!



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