6. Buy one, get some free: The indirect effect of infectious disease interventions

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Genetic selection of livestock for lower prevalence of infectious diseases has long been considered an important addition to other interventions, such as vaccination. But its potential is often seen as limited because of the low heritability of disease traits. The methods used to estimate this heritability, however, totally ignore the population (transmission) dynamics of infectious diseases. Instead, they treat an infectious disease as a trait that arises entirely from the individual itself. Here we show that the dynamics of transmission have a considerable effect on the results of genetic selection, using simulations of an SIS-model with heterogeneity in individual susceptibility. Even though individuals differed only in susceptibility, feedback effects in the transmission process rapidly led to a certain degree of herd immunity, even leading to eradication in some scenarios. This feedback occurs because individuals that have a low susceptibility are not only less likely to get infected themselves, but also contribute to a lower number of infectious individuals in the population as they are less often infected themselves. This leads to so-called indirect genetic effects, the effects of the genes of an individual on the infection status of its herd mates. Our theoretical work shows that these indirect effects result in a total effect that is a factor of the inverse of the prevalence larger than the direct genetic effect. For example, for a prevalence of 25%, the total effect is four times greater than the direct effect. The total effect thus increases strongly with decreasing prevalence. This implies that genetic selection will become more and more effective as prevalence goes down. Our results, however, are not only applicable to genetic selection, but in general to interventions targeted at infectious diseases, both in animals and humans. Since many diseases have a prevalence below 0.5, this implies that the indirect effect of an intervention is at least as large as the direct effect. Then vaccination of an individual not only protects the individual itself, but also at least one other individual.

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