

How can indirect contacts influence epidemics spread in farm systems? The case study of Parma province (Northern Italy)

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The spread of infectious diseases in livestock farms can cause serious negative impacts both from economic and social viewpoints. Epidemiological studies are thus key in supporting the design of more effective control measures. In this context, network models are commonly adopted tools to describe epidemic spread. Nodes represent farms while links describe the possible pathogen transmission routes, which can in turn be distinguished between direct contacts, i.e. animal movements, and indirect ones, like sharing of equipment and/or movement of workers and vehicles. While there is an already well-established branch of literature investigating the former, indirect contacts are still quite disregarded as potentially important transmission factors. One possible cause is that, while animal movements must be registered in EU-countries national databases, little information is available to date on workers' visits. Here we used data from a collection campaign on calves transportations in the Province of Parma (Northern Italy) occurred between September and November 2014. We built a network and studied its properties to detect which farms could act as super-spreaders or super-susceptibles in the unfortunate case of an epidemic. Our analyses were conducted both on static and on time-varying (weekly) networks and our results highlighted how the use of a static approach may bring to an overestimation of the epidemic final size. Interestingly, we found that indirect contacts can connect farms which are geographically far apart one from another, with non-trivial implications on disease control. Last, to quantitatively enucleate the specific contribution of indirect contacts, we contrasted our outcomes with those obtained by more complete networks accounting also for direct contacts. The comparison revealed that indirect contacts can play a very crucial role in the spatiotemporal pattern of disease spread.