

Network analysis of direct and indirect contacts between dairy farms in the Province of Parma (Emilia-Romagna, IT)

Gianluigi Rossi¹, Stefano Pongolini¹, Giulio A. De Leo², Mauro Cavalca³, Luca Zarenghi³, Silvano Natalini⁴, Luca Bolzoni¹, ¹Istituto Zooprofilattico della Lombardia e dell'Emilia Romagna, Parma, Italy; ²Stanford University, Monterey, CA, ³AUSL di Parma, Parma, Italy; ⁴Regione Emilia-Romagna, Bologna, Italy.
Contact: gianluigi.rossi@izsler.it

Although live animals exchange is considered the most effective route of disease transmission between farms, the spread through contaminated equipment, vehicles, or personnel proved to be crucial for many epidemics, included the 2001 foot-and-mouth disease in the UK or the worldwide spread of avian flu in 2000s decade. Among farm professional visitors, veterinarians are considered particularly dangerous for disease spread due to their close contact with animals. While between-farm direct contacts (i.e. animals exchange) have been studied in depth over the past 20 years, indirect contacts (e.g. through veterinarians or other operators) have been often overlooked, mainly because of the challenging task represented by data retrieval.

Our work aims to understand the role of indirect contacts due to veterinarians' visits in a potential epidemic spread. Starting from 1349 dairy farms of the Italian Province of Parma, we build two contact networks using data on cattle exchange (direct contacts), and government and private veterinarians (indirect contacts).

We employ network analysis techniques to evaluate network features associated to the two considered routes of transmission. Moreover, we identify farms acting as a super-spreader in the direct contact network and in the indirect one. In particular, we compute for each farm the infectious chain under different assumptions on farm infectious period. Finally, we evaluate the impact of indirect contacts on the overall contact network (which includes both direct and indirect) weighted for the difference in the infective potential with respect to direct contacts.

Direct and indirect networks show non-trivial differences, in particular with respect to the number of connections, the contacts' frequency, and the identity of farms acting as super-spreaders. Furthermore, our results show that, despite their expected low infection probability, the contribution of indirect contacts to a potential epidemic spread can be critical.

Therefore, our work highlights the significant role of indirect contacts, in particular their importance in designing effective surveillance and control strategies.