D3.4.1: Overview of models and parameters to assess transmission in animals

JIP COVRIN WP3

Responsible Partner: UoS (23) and WBVR (31)

Contributing partners: All partners

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OVERVIEW OF MODELS AND PARAMETERS TO ASSESS TRANSMISSION IN ANIMALS

1. Introduction

COVRIN aims to integrate research by One Health EJP partner institutes on the topics of SARS-CoV-2 emergence, risk assessment and preparedness. The project has two main operational objectives: (i) to identify drivers for the emergence and spread of SARS-CoV-2, and (ii) to generate data and build models for risk assessment of SARS-CoV-2. To achieve these objectives, integrative research activities are focused on four topics: (i) research on detection of SARS-CoV-2 in animal species and the environment; (ii) research on SARS-CoV2 molecular and biological characterization; (iii) SARS-CoV-2 surveillance and risk assessment, focussed on the animal human interface; and (iv) coronavirus preparedness. The overall aim of the COVRIN project is to generate and share data of these integrative research activities, in order to increase the preparedness for future coronavirus outbreaks.

The main goal of WP3, from which this deliverable is part of, is to integrate the currently fragmented data from sampling of animals and the environment (WP1) across partner countries, into an aligned One-Health surveillance system for SARS-CoV-2 that is based on data from the three components (i.e. humans, animals, and the environment), as well as the different sectors therein (e.g. pets, livestock, wildlife). This aligned surveillance will then be combined with the data on bioavailability in samples (WP1) to inform risk assessment and transmission models.

Task T3.4, from WP3, aims to develop models for transmission routes and risk assessment of SARS-CoV-2 in a One Health perspective. The first step is to conduct a landscape evaluation and overview of different dynamics models and required parameters to test hypotheses regarding the role of animals as potential reservoir hosts and parameters needs.

2. Succeptible animal species and parameters of relevance

To characterise susceptible animal species and assess their potential role as reservoirs of SARS-CoV-2, a list of relevant parameters was identified and used to develop a “Biological information matrix”. Information regarding these parameters for each identifed animal species (e.g. Cats, dogs, minks, laboratory animals, etc) will be collected following experimental studies and literature reviews.

The parameters found relevant can be summarized in the following categories: (1) Infection and disease (Clinical signs), (2)Virus replication (shedding), (3) Pathology, (4) Immunology, (5) Epidemiology. Table 1 below summarises all of the parameters being considered.

Table 1. Summary of Parameters of relevance to consider for transmission of SARS-CoV-2 in animals

Category	Parameter
Infected	Infected/number challenged
	Fever
	Cough
	Diarrhoea
	Dyspnea/breathing disorders
	Loss of apetite

Replication	Nasal
	Nasopharyngeal/throat
	Faecal
	Trachea
	Lungs
	Tonsils
	Intestines
	Duration of shedding (days)
Pathology	Lungs
	Trachea
Inmunology	Antibodies (neutralizing)
Epidemiology	Transmission Direct (R)
	Transmission Indirect (R)

A first systematic review and meta-analysis, to fill out these parameters, has been performed for Non-Human primates. As manuscript has been written (Counotte et al 2021) which has been uploaded to a preprint server and is under review.

3. Modelling efforts thus far

From a risk assessment perspective, transmission parameters are important to assess the risk that a susceptible animal species can become infected and sustain transmission within the same species (potential reservoir), as well as the risk of this animal specie to transmit infection back to humans. Relevant parameters to assess these risks are the reproduction number, the latent and infectious periods and the transmission rate parameter. Quantification of these parameters is being done by performing Systematic literature reviews (SR) for data collection on transmission (experimentally and at household levels) and then use of statistical and mathematical models to analyse these data and quantify parameters. For this purpose, a library of model code is being developed in R. Currently, the library includes a wide range of models, such as the Final size method to quantify the reproduction number, generalized linear regression models to quantify the transmission rate, survival models to quantify the latent and infectious periods and also Bayesian methods.

The first application of these models was to quantify the parameters relevant for cat-to-cat transmission. This work has been finalized and has been submitted for review; it is already uploaded in a preprint server (Gonzales et al 2021). Reviews for other species are also being conducted, and the ensemble of the results will be provided in the report for deliverable D3.4.2.

The code library will be made available with later deliverables, once finalised. It is currently being used and shared internally with collaborators within the COVRIN project to apply for the analysis of transmission from experiments done within COVRIN or data collected from the SR.

4. Other outputs

A number of manuscripts related to activities within Task 3.4 have been submitted to (preprint) or published in peer-reviewed journals. Below a list thus far:

[1] Decaro, N., Grassi, A., Lorusso, E., Patterson, E. I., **Lorusso, A.**, Desario, C., Anderson, E. R., Vasinioti, V., Wastika, C. E., Hughes, G. L., Valleriani, F., Colitti, B., Ricci, D., Buonavoglia, D., Rosati, S., Cavaliere, N., Paltrinieri, S., Lauzi, S., Elia, G., & Buonavoglia, C. (2021). Long-term persistence of neutralizing SARS-CoV-2 antibodies in pets. *Transboundary and emerging diseases*, 10.1111/tbed.14308. Advance online publication. https://doi.org/10.1111/tbed.14308

[2] Decaro, N., Vaccari, G., **Lorusso, A.**, Lorusso, E., De Sabato, L., Patterson, E. I., Di Bartolo, I., Hughes, G. L., Teodori, L., Desario, C., Colitti, B., Ricci, D., Buonavoglia, D., Rosati, S., Martella, V., Cammà, C., Agrimi, U., & Elia, G. (2021). Possible Human-to-Dog Transmission of SARS-CoV-2, Italy, 2020. *Emerging infectious diseases*, *27*(7), 1981–1984. https://doi.org/10.3201/eid2707.204959

[3] Counotte, M. J., de Souza Santos, M. A., Stittelaar, K. J., van der Poel, W. H. M., & Gonzales, J. L. (2021). Assessment of the efficacy of SARS-CoV-2 vaccines in non-human primate studies - a systematic review. https://doi.org/10.31219/osf.io/u3fwj

[4] Gonzales, J.L.; De Jong, M.C.M.; Gerhards, N.M.; Van der Poel, W.H.M.(2021) The SARS-CoV-2 reproduction number R0 in cats. BioRxiv, doi:10.1101/2021.07.20.453027.