RAPID QUALITATIVE RISK ASSESSMENT:
SARS Coronavirus 2 (SARS-CoV-2) in Companion Animals

Iteration #3: March 3, 2021

Summary

The primary route for exposure of humans to SARS-CoV-2 is via other humans. It is unlikely that companion animals play a major role in the spread of this human disease. However, there is currently a lot of uncertainty related to infection in animals other than humans.

Natural infection with SARS-CoV-2 has been reported in cats and dogs living in households with infected people in numerous countries. There has also now been a small number of naturally-infected ferrets reported (World Organisation for Animal Health, 2020). Infection in these species tends to be either sub-clinical or cause mild respiratory or gastrointestinal signs. Several observational studies have been conducted on dogs and cats with prevalence varying significantly based on infection status in humans in the same household or region (Barrs et al., 2020; Deng et al., 2020; Fritz et al., 2020; Hamer et al., 2020; Michael et al., 2021; Michelitsch et al., 2020; Patterson et al., 2020; Perisé-Barrios et al., 2020; Stevanovic et al., 2020; Temmam et al., 2020; Weese, 2020; Zhang et al., 2020). Other mammals sometimes kept as pets have been shown experimentally to be susceptible to infection, including some species of hamsters and rabbits (Bertzbach et al., 2020; Bosco-Lauth et al., 2021; Chan et al., 2020; Lee et al., 2020; Mok et al., 2020; Mykytyn et al., 2020; Osterrieder et al., 2020; Sia et al., 2020; Trimpert et al., 2020).

This iterative rapid qualitative risk assessment (RQRA) process was initiated at the beginning of the SARS-CoV-2 pandemic, as evidence related to infection in companion animals was rapidly evolving, as it is likely to continue to do for some time to come. The RQRA is intended to inform immediate decisions regarding guidance and handling of mammalian pets belonging to people with COVID-19, and the development of infection prevention, control and response policies. An Emergency Collective Expert Appraisal Group was formed, consisting of volunteers from federal, provincial and territorial departments of public health, animal health, wildlife and the environment, veterinary associations, and academia. The group meets regularly to discuss updated information and its effect on the risk.

The assessment makes a number of assumptions, including that the source of exposure of a mammalian pet would be an infected owner, and that the context for the assessment is the current pandemic situation. The assessment results could be updated as more information becomes available.

[This assessment was conducted by a multi-jurisdictional Emergency Collective Expert Appraisal Group. The methodology is intended to be used in situations where policy decisions need to be made in the face of high uncertainty. Given the minimal data available on surveillance, research, epidemiology and risk behaviours specifically related to SARS-CoV-2 in animals, the assessment was primarily informed by the group's collective professional knowledge on such topics as infectious diseases, virology, epidemiology, industry practices, and human-animal interactions. Assumptions, and sources of variability and uncertainty are detailed in the document. The findings and conclusions represent the consensual, but not necessarily unanimous, opinions of the group participants, and do not represent the views of the participants' respective organizations.]

Figure 1 describes the scenario pathway for this assessment:

- **Human - pet**
  In order to become infected, pets must first be exposed to an infectious dose of the virus through direct or indirect contact with their infected owner, and the pet must be susceptible to developing infection.
- **Human - pet - human**
  If a pet is exposed and infected, further transmission of the virus is dependent on the infected pet shedding a sufficient amount of the virus in respiratory secretions, vomit, feces, or other bodily fluids, and then having sufficient direct or indirect contact with a non-infected human.
- **Human - pet - wildlife**
  Transmission of infection to wildlife is dependent on sufficient shedding of the virus by the pet, as well as direct or indirect contact with wildlife that are susceptible to developing infection. One of the potential pathways includes feral cats as an intermediary for transmission from pet cats to wildlife. This also depends on sufficient viral shedding and contact.

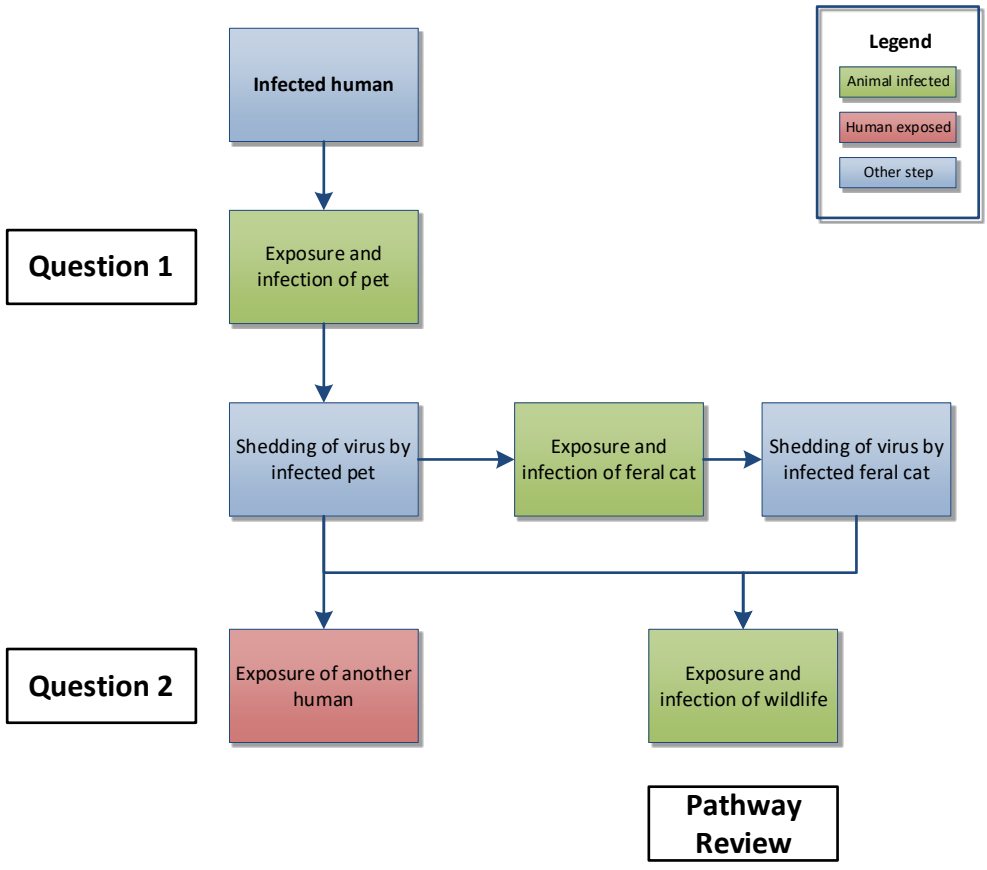

Figure 1: Scenario pathway illustrating the potential infection of a mammalian pet with SARS-CoV-2, and potential subsequent exposure of susceptible humans and animals.

This assessment addresses the following specific risk questions:

Question 1: What is the probability of exposure of companion animals to SARS-CoV-2 in Canada, and subsequent infection, through direct or indirect contact with infected humans (i.e., human-pet transmission), and what is the resulting impact on companion animal health?

The probability of the exposure and infection of Canadian companion animals to SARS-CoV-2 from infected humans is:

- **Most likely low for dogs**, but ranging from very low to moderate due to variability. Dogs generally have close contact with their owners, but experimental and observational studies show that not all exposed dogs develop infection and the susceptibility appears to be less than cats. The likelihood of infection is thought to depend on the exposure dose and host factors (e.g., age, immune status, co-morbidities, breed predilection for respiratory disease). The uncertainty is moderate.
- **Most likely moderate for cats**, but ranging from low to high due to variability. Cats generally have close contact with their owners, and extensive contact with many surfaces within the household. Experimental and observational studies confirm a higher susceptibility to infection in cats than dogs, and yet as with dogs, exposure does not guarantee infection and host-related factors appear to influence the outcome. The uncertainty is moderate. Although there is low uncertainty regarding their susceptibility as a species, the factors influencing individual infection are still unclear.
- **Most likely moderate for ferrets**, but ranging from low to high due to variability. Ferrets likely have close contact with their owner, though the extent that they wander and contact other surfaces is variable. Experimental results suggest a high level of susceptibility to infection, as does natural infection in the related species, mink. However, there have so far been only a small number of reports of natural infection in pet ferrets. The uncertainty is moderate.
- **Most likely very low to low for other small mammals**, but ranging from very low to moderate due to variability. These species tend to spend much of their time in cages, and therefore have more limited contact with their owner than other species. Susceptibility to infection appears to be quite species-dependent, with experimental results suggesting susceptibility of hamsters, deer mice, and some rabbit species. The uncertainty is high.

If a companion animal becomes infected, the most likely scenario is one or a small number of resulting companion animal cases within the household. However, spread could be higher in cats that go outdoors and have contact with feral cat colonies. Infection in pets has generally been either sub-clinical or mild, though more serious disease might be seen in animals that are immunocompromised or have underlying medical conditions. The magnitude of the effect on the Canadian veterinary industry of cases of SARS-CoV-2 in companion animals was also considered to be indiscernible to minor. **The overall national-scale impact on companion animal health of this scenario is therefore considered to be negligible to low.**

Variability in the estimate is dependent on risk factors, such as: extent of human-animal physical interaction, extent that the animal roams freely in the household and contacts various surfaces, and host factors (e.g., age, immune status, co-morbidities). Key uncertainties that will affect the probability

estimate include: infectious dose, susceptibility of various species under natural conditions, and the factors influencing individual infection.

Question 2: What is the probability of exposure of humans to SARS-CoV-2 in Canada through direct or indirect contact with mammalian pets owned by infected humans (i.e., human-pet-human transmission), and what is the resulting human health impact at the national level?

SARS-CoV-2 is primarily a human disease. The probability of human exposure to SARS-CoV-2 from infected companion animals in Canada is first dependent on the animal becoming infected from exposure to an infected human, as in question 1. The animal must then shed sufficient virus, and have sufficient exposure to a susceptible human, to transmit the infection. The probability of this overall pathway (i.e., human-pet-human transmission) is:

- **Most likely very low for dogs**, but ranging from negligible to low due to variability. Despite frequent contact between dogs and people other than their owners, preliminary experimental information suggests that infected dogs shed little, if any, viable virus, and do not transmit infection to in-contact animals. The uncertainty is moderate.
- **Most likely moderate for cats**, but ranging from very low to moderate due to variability. The evidence suggests that infected cats are capable of at least some level of shedding of viable virus for short periods, and transmission to in-contact cats in the laboratory; however, there is uncertainty regarding the extent of shedding under natural conditions, and host-related factors likely contribute to variability. In addition, the amount of contact they have with people other than their owners is highly variable. The uncertainty is moderate.
- **Most likely low for ferrets**, but ranging from very low to moderate. Experimental evidence suggests that ferrets are capable of shedding viable virus and transmitting to in-contact ferrets, but most ferrets have very little contact with humans other than their owner. The likelihood may be higher for veterinary staff. The uncertainty is moderate.
- **Most likely very low to low for other small mammals**, but ranging from very low to moderate. Experimental evidence suggests that hamsters are capable of shedding viable virus and transmitting to in-contact hamsters, and that New Zealand White rabbits shed viable virus, but possibly not at a high enough dose to transmit to other rabbits. These types of animals tend to spend most of their time in a cage and have limited contact with people other than their owner. The uncertainty is high.

Given the current context of a global pandemic, with a vast number of cases resulting from exposure to sources other than mammalian pets, **the overall national-scale impact on human health associated with this transmission pathway of current strains of SARS-CoV-2 is considered to be negligible to low.** The impact could be higher in particular cases involving highly susceptible individuals. Since the most likely spread scenario in question one was considered to be one or a small number of companion animal cases within the household, the impact associated with virus mutations was not included in this assessment.

In addition to the risk factors mentioned in question 1, other sources of variability in the probability estimates include: extent of contact with people other than the owner (including cats roaming outdoors), extent of infection control (e.g. hand hygiene) between the pet and humans, living conditions (e.g., house versus apartment), comorbidities in the pet or human, and the occupation or lifestyle of the

person (i.e., general public versus veterinarians). The probability of being infected by another person is notably higher than any probability of being infected via a pet. The greatest risk of infection for other humans in the household is the infected human in the household.

Key uncertainties that will affect the probability estimate include: infectious dose, the probability of shedding of an infectious dose of viable virus by the pet, and the influence of host factors on this shedding. Evidence is provided in a small number of experimental studies on dogs, cats, ferrets and other small mammals. Worldwide, natural infection of companion animal species has only been documented in dogs, cats and ferrets, and most cases so far are thought to be a result of spill-over from infected humans.

It is strongly recommended that risk assessments be conducted on a case-by-case basis, as required, particularly for those individuals that must have very close contact (veterinarians and veterinary technicians) with species that have been shown to become infected and shed virus (e.g., cats, ferrets and hamsters).

Review of companion animal to wildlife transmission pathway

Potential pathways of SARS-CoV-2 transmission to wildlife from free-roaming pet cats and dogs were reviewed. There is still a high level of uncertainty associated with the susceptibility of wildlife species to SARS-CoV-2 under natural conditions. Only one naturally-infected wild animal has been reported globally, and this wild mink was epidemiologically linked to an infected mink farm (World Organisation for Animal Health, 2020).

The likelihood of contact between pets and wildlife will vary by the species of pet, its habits, and the wildlife species present in that region and habitat. Transmission of SARS-CoV-2 is most likely to involve close direct contact, or contact with enclosed and/or heavily contaminated environments. Predation events that involve fighting have the potential to result in virus transmission from prey to predator, or from predator to prey if the prey survives the attack.

Birds and amphibians are unlikely to be susceptible to SARS-CoV-2, and so were not considered further. The mammalian wildlife species that were considered most likely to be susceptible to infection and have close contact with pets were: fishers (as predators of cats), cougars/mountain lions (as predators of cats), and deer mice (if they survive being preyed upon by cats). The susceptibility of opossums is unknown, but their habits may bring them in close contact with cats. Wildlife species that may be susceptible, but are less likely to have contact with pets that is sufficient to result in transmission are: wild mink, skunks, lynx/bobcat, deer, and possibly some bat species. Based on the preliminary data available to date (on various species or their close relatives), the wildlife species that are less likely to be susceptible include: raccoons, coyotes, house mice, chipmunks, gray squirrels, and big brown bats.

Feral (i.e., non-owned) cats are the most likely to have contact with wildlife, but they are also less likely to have close contact with infected humans. One of the potential pathways for wildlife exposure would be transmission from infected humans to pet cats, followed by transmission from roaming pet cats to feral cats and then transmission from these feral cats to wildlife. The role of feral cats was also assessed in the Rapid Qualitative Risk Assessment on farmed mink (Emergency Collective Expert Appraisal Group, 2020).

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Appendix: Definitions of qualitative estimates

Table 1 - Likelihood Definitions

Likelihood of event occurring	Descriptive Definition	Likelihood of event NOT occurring
Negligible	The likelihood of the event is virtually zero	High
Very low	The event is very unlikely	Moderate
Low	The event is unlikely	Low
Moderate	The event is fairly likely	Very low
High	The event is likely	Negligible

Table 2 – Uncertainty categories[1]

Uncertainty category	Interpretation
Low	There are solid and complete data available; strong evidence is provided in multiple references; authors report similar conclusions. Several experts have multiple experiences of the event, and there is a high level of agreement between experts.
Moderate	There are some but not complete data available; evidence is provided in a small number of references; authors report conclusions that vary from one another. Experts have limited experience of the event and/or there is a moderate level of agreement between experts.
High	There are scarce or no data available; evidence is not provided in references but rather in unpublished reports or based on observations, or personal communication; authors report conclusions that vary considerably between them. Very few experts have experience of the event and/or there is a very low level of agreement between experts.

Table 3. Description of the magnitude of the effects

Magnitude of the effect	Description of the effect
Indiscernible	Not usually distinguishable from normal day-to-day variation
Minor	Recognisable, but minor and/or reversible
Significant	Serious and substantive, but usually reversible
Severe	Extremely serious and/or irreversible

Table 4. Guidelines for determining the overall, national-scale impact of establishment and/or spread[2]

Overall impact	Description of impact
Extreme	The effects are likely to be severe at the national level. Implies that economic stability, societal values or social well-being would be significantly affected.
High	The effects are likely to be significant at the national level and severe within affected zones. Implies that the effects would be of national concern. However, significant effects on economic stability, societal values or social well-being would be limited to a given zone.
Moderate	The effects are likely to be minor on a national level and significant within affected zones. The effects are likely to be severe for directly affected parties.
Low	The effects are likely to be minor within affected zones and significant to directly affected parties. The effects are likely to be minor at the national level.
Very low	The effects are likely to be minor to directly affected parties. The effects are likely to be indiscernible at any other level.
Negligible	The effects are likely to be indiscernible at any level within Canada.

[1] Source: Fournie G, Jones BA, Beauvais W, Lubroth J, Njeumi F, Cameron A & Pfeiffer DU, 2014. The risk of rinderpest re-introduction in post-eradication era. *Prev Vet Med* 113 (2): 175-184.

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