RAPID QUALITATIVE RISK ASSESSMENT:
SARS Coronavirus 2 (SARS-CoV-2) in Farmed Mink

Iteration #1: June 12, 2020

Summary

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

Since the end of April, 2020, SARS-CoV-2 has been detected in mink on several farms in the Netherlands (Bruschke, 2020; Ministry of Agriculture Nature and Food Quality (the Netherlands), 2020; Oreshkova et al., 2020; ProMED-Mail, 2020; Wageningen University, 2020). In addition, various experimental studies with SARS-CoV-2 have been conducted on domestic ferrets, a species related to mink, demonstrating susceptibility to infection and transmission to in-contact ferrets (CSIRO, 2020; Friedrich-Loeffler-Institut, 2020; Kim et al., 2020; Richard et al., 2020; Shi et al., 2020). It is likely that further evidence related to infection in farmed mink will be forthcoming. As a result of this, and the need to make decisions regarding guidance for producers, this iterative risk assessment process was initiated.

An Emergency Collective Expert Appraisal Group was formed, consisting of volunteers from federal, provincial and territorial departments of public and animal health, veterinary associations, private veterinarians and academia. This group was convened to provide expert advice on certain aspects of the risk assessment, to discuss current knowledge and identify areas of uncertainty. The group meets regularly to discuss updated information and its effect on the risk. The findings and conclusions represent the consensual, but not necessarily unanimous, opinions of the working group participants, and do not necessarily represent the views of the participants' respective organizations.

The assessment makes a number of assumptions, including that: the initial source of exposure of farmed mink would be infected humans (though further spread via cats is also assessed), there will be some similarities in susceptibility between various mustelid species, biosecurity practices are aligned with the National Farm-Level Biosecurity Standard, and the context for the assessment is the current pandemic situation. The assessment results could be updated as more information becomes available.

Figure 1 describes the scenario pathway for this assessment:

1. **Human - mink**
   In order to become infected, a farmed mink must first be exposed to an infectious dose of the virus through direct or indirect contact with an infected human, and the animal must be susceptible to developing infection.

2. **Human - mink - human**
   If a farmed mink is exposed and infected, transmission of the virus to a susceptible human requires the mink to shed the virus (or to have virus present in exposed tissues) and then for

there to be sufficient exposure of one or more of: employees or contractors during pelting, employees or veterinarians by direct or indirect contact on the farm, or the general public via contact with a contaminated environment.

3. **Human - mink - wildlife**
   Transmission of infection to wildlife is dependent on sufficient shedding of the virus by infected mink, as well as direct or indirect contact with wildlife that are susceptible to developing infection.

4. **Human - mink – cat – human/other**
   The role of farm or feral cats in transmission requires that they be exposed to a sufficient dose of virus by the mink, followed by infection and shedding by the cat, and exposure of susceptible humans, wildlife or other mink to the cat.

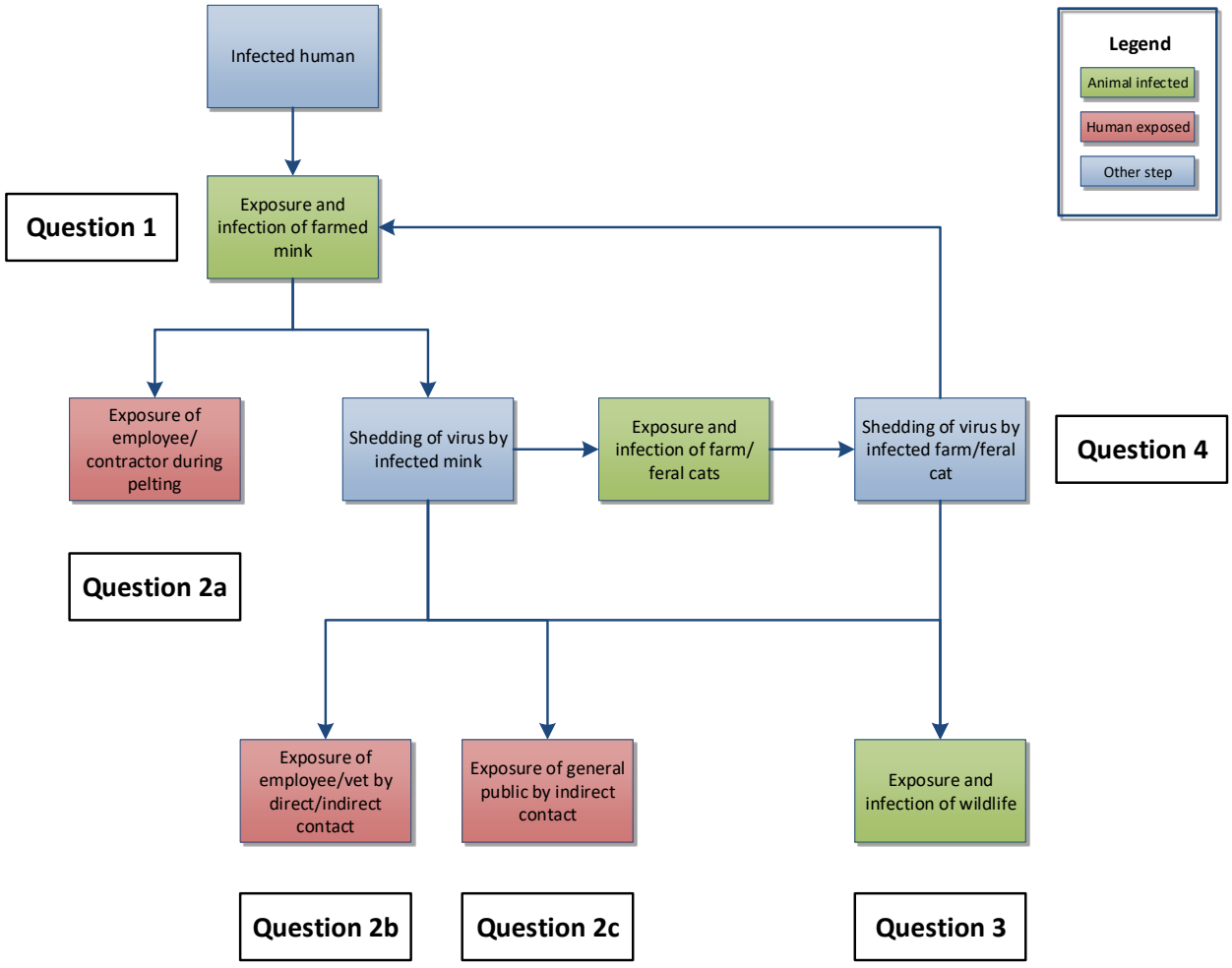

Figure 1: Scenario pathway illustrating the potential infection of farmed mink with SARS-CoV-2, and potential subsequent exposure of susceptible humans and animals.

This assessment addresses the following specific risk questions:

Question 1: What is the probability of exposure of Canadian farmed mink to SARS-CoV-2, and subsequent infection, through direct or indirect contact with infected humans (i.e., human-mink transmission), and what are the resulting health impacts on the mink and mink industry?

The probability of the exposure and infection of Canadian farmed mink to SARS-CoV-2 from infected humans is most likely low, but ranging from negligible to high due to variability. The outbreaks currently occurring in the Netherlands reveal that mink are clearly susceptible to infection. In Canada, the probability of exposure for mink farms is more limited, since they are in rural locations and they employ a small number of staff. Biosecurity in the mink industry is guided by the National Farm-Level Biosecurity Standard. Generally, biosecurity measures targeting the exclusion of visitors and preventing access to mink are good. The uncertainty is moderate.

If infection does occur, the magnitude of the effects on affected mink producers and the mink industry would most likely be significant. This would not necessarily be due to the disease itself, which seems to have relatively low morbidity and mortality in mink, but rather due to control measures taken to prevent further spread, labour issues, and the results of public perception. **The overall national-scale impact on farmed mink and the mink industry of this scenario is therefore considered to be moderate to high**.

The large amount of variability in the probability estimate is dependent on the geographical and temporal distribution of human cases in Canada, and this should be assessed regionally. Other risk factors causing variability include: seasonality (with a greater amount of human-mink contact from April to June), and the biosecurity practices employed by the farm.

Key uncertainties include: regional prevalence of symptomatic and asymptomatic human cases, the amount of shedding by asymptomatic people, virus survival in the environment, and infectious dose.

Question 2: What is the probability of exposure of humans to SARS-CoV-2 in Canada through direct or indirect contact with live farmed mink or mink carcasses (i.e., human-mink-human transmission), and what is the resulting human health impact at the national level?

SARS-CoV-2 is primarily a human pathogen. The probability of human exposure to SARS-CoV-2 from infected farmed mink in Canada is first dependent on the mink becoming infected from exposure to an infected human, as in question 1. The mink must then shed sufficient virus (or have virus present in exposed tissues), and sufficiently expose a susceptible human, to transmit the infection. The probability can be considered in terms of the overall pathway (i.e., human-mink-human transmission), or just the probability of mink-human transmission in cases where the mink have been infected (i.e., assuming the first part of the pathway has already occurred).

For employees and contractors involved in pelting:

- **The probability of human-mink-human transmission is most likely low**, but ranging from negligible to high due to variability. This is primarily a result of the probability of human-mink transmission, as in question 1.

- **Where mink have been infected, the probability of mink-human transmission is most likely moderate**, but ranging from very low to high due to variability. Before being cleaned, the pelts of infected animals would probably be contaminated with urine, feces, respiratory droplets and saliva, and employees/contractors often have close contact with the fur soon after euthanasia.
- The uncertainty is moderate.

For employees and veterinarians working with live mink on the farm:

- **The probability of human-mink-human transmission is most likely low,** but ranging from negligible to high due to variability. This is primarily a result of the probability of human-mink transmission, as in question 1.
- **Where mink have been infected, the probability of mink-human transmission is most likely moderate**, but ranging from very low to high due to variability. Information from the Netherlands suggests that this transmission is plausible, and dust particles in the air within the sheds have been shown to be positive by PCR. Other routes of exposure include contaminated cages, door handles, feed carts, and floor dust.
- The uncertainty is moderate.

For the general public:

- **The probability of human-mink-human transmission is most likely negligible**, but ranging from negligible to low due to variability. Biosecurity measures are in place to separate the public from farmed mink. Information from the Netherlands suggests that virus was not present in dust samples outside the mink sheds, and mink farms are typically located in sparsely-populated areas. Although manure-spreading is a potential pathway of transmission, manure is generally held on the farm before partially composted manure is spread on fields once a year. It is unlikely that the general public would contact a sufficient dose of virus via this route. **This probability does not change in cases where mink have been infected.** The uncertainty is moderate.

Given the current context of a global pandemic, with a vast number of cases resulting from exposure to sources other than farmed mink, **the overall national-scale impact on human health associated with this hazard is considered to be negligible to low**. The impact could be higher in cases involving highly susceptible individuals, though, on average, these individuals are unlikely to have contact with farmed mink.

In addition to the risk factors mentioned in question 1, other sources of variability in the probability estimates include: increased human-mink contact from August to November for pelting, whether mink are pelted on-site versus at a pelting plant, stage of illness in the animals and therefore the amount of shedding, husbandry practices, manure management, and environmental factors. The probability of a person being infected by another person is notably higher than any probability of being infected via farmed mink.

Key uncertainties include: extent of pelt contamination in symptomatic and asymptomatic animals, virus survival throughout the pelt-cleaning process and potential cross-contamination of pelts, within-herd prevalence, virus survival in manure and compost piles, and lack of transmission and pathology information from experimental studies in mink.

Question 3: What is the probability of exposure of wildlife to SARS-CoV-2 in Canada, and subsequent infection, through direct or indirect contact with live farmed mink or mink carcasses (i.e., human-mink-wildlife transmission), and what are the resulting impacts (including potential development of a virus wildlife reservoir)?

The probability of the exposure and infection of a wild animal in Canada to SARS-CoV-2 from farmed mink is most likely low, but ranging from negligible to high due to variability. Wild mustelids and felids are most likely to be susceptible. Mink farms generally have a perimeter fence which is meant to keep wildlife out and prevent mink from escaping. Housed in raised pens, contact with some pests and wildlife is mitigated and pest management practices are used to manage insects, rodents and where necessary wildlife. Rodents and avian species are most likely to gain access, but these species are thought to have low susceptibility to SARS-CoV-2. Manure is generally composted in a fenced area, and carcasses are buried or transported to a landfill to minimize exposure to a variety of pathogenic organisms. The uncertainty is high.

If infection does occur in a wild animal, the spread of infection would most likely be limited, since this virus is primarily adapted to humans. **The probability that an ongoing virus reservoir develops within a wild animal population in Canada is considered to be very low**, but with a high level of uncertainty. However, the effects of such a scenario could be significant, depending on the species affected, the morbidity and mortality experienced, and the extent of contact that species has with humans and other animals. The existence of a reservoir would create opportunity for the virus to mutate into something more pathogenic for humans or animals, or at least hamper public health efforts at vaccination or controlling spread. Other effects could include a fear of wildlife by humans, with potential consequences to wildlife due to human interference.

In addition to the risk factors mentioned in question 1, other sources of variability in the probability estimate includes: type of housing, stage of illness in the animals and therefore the amount of viral shedding, husbandry practices, environmental factors, and wild animal species susceptibility.

Key uncertainties include: virus survival in manure and compost piles, and the susceptibility of wild animal species in North America, such as bats, raccoons, skunks, and squirrels.

Question 4: What is the probability of exposure of farm or feral cats to SARS-CoV-2 in Canada through indirect contact with farmed mink, and subsequent exposure (+/- infection) of humans and animals (i.e., human-mink-cat-human/other transmission)? Impacts are assumed to be the same as in questions 1-3.

The probability of the exposure (+/- infection) of humans and animals in Canada to SARS-CoV-2 from farm or feral cats on mink farms is:

- **Most likely very low for employees and veterinarians on the farm**, but ranging from negligible to moderate due to variability. Although it is fairly likely that cats on affected farms would be exposed and infected, as has been observed in the Netherlands, it is unclear if cats would be able to contaminate the environment with a sufficient amount of virus to result in effective transmission. There has currently been no evidence of cat-human transmission of this virus, but it has been demonstrated that cats can transmit it to other cats. Direct contact between humans and these cats is often minimal, especially for feral cats. The uncertainty is moderate.

- **Most likely very low for the general public**, but ranging from negligible to low due to variability. In addition to the above considerations regarding transmission by cats, farms are in very rural areas and cats are unlikely to range far from the farms. Farm cats are exposed to few people, and feral cats tend to keep their distance from people. The uncertainty is moderate.
- **Most likely low for wildlife**, but ranging from negligible to moderate due to variability. In addition to the above considerations regarding transmission by cats, the nature of interaction between cats and susceptible wildlife is an important consideration. Wild mustelids and felids are most likely to be susceptible, but cats do not likely have close contact with these species (with the exception of other feral cats). Contact would be more likely for feral cats that leave the property. The uncertainty is high.
- **Most likely very low to low for farmed mink**, but ranging from negligible to high due to variability. In addition to the above considerations regarding transmission by cats, direct or indirect contact between cats and mink (including contact with cat feces) is unlikely unless the cats were to access mink feed on the cages. The uncertainty is moderate.

In addition to the risk factors mentioned in question 1, other sources of variability in the estimates include: type of cat (farm versus feral), type of housing, stage of illness in the animals and therefore the amount of shedding, husbandry practices, environmental factors, and wild animal species susceptibility. It should be noted that farm/feral cats may be exposed and infected from sources other than infected mink.

Key uncertainties include: virus survival in manure and compost piles, extent of shedding by cats, and the susceptibility of wild animal species in North America.

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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. 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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