One Health:
An examination of the global reach of COVID-19

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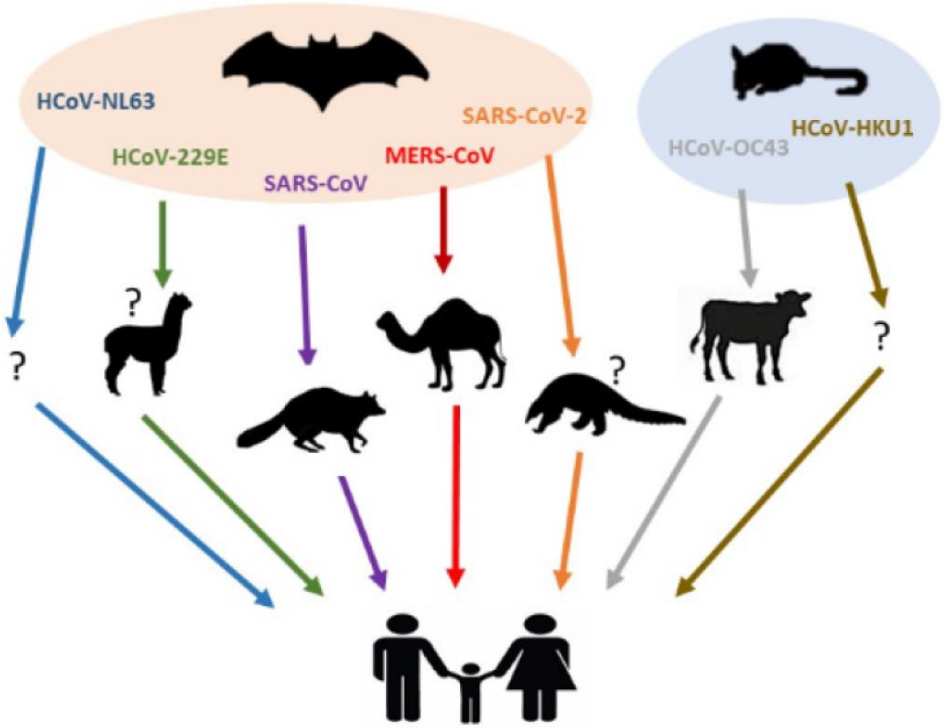
One Health:

Human, animal and environmental health are tightly interconnected and need to be studied in the context of each other



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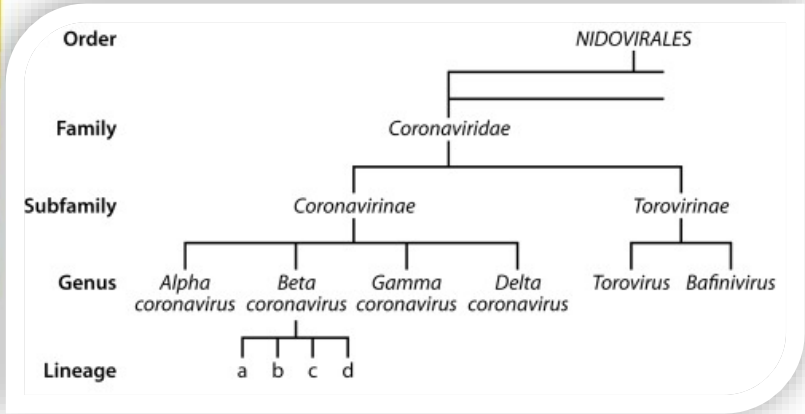
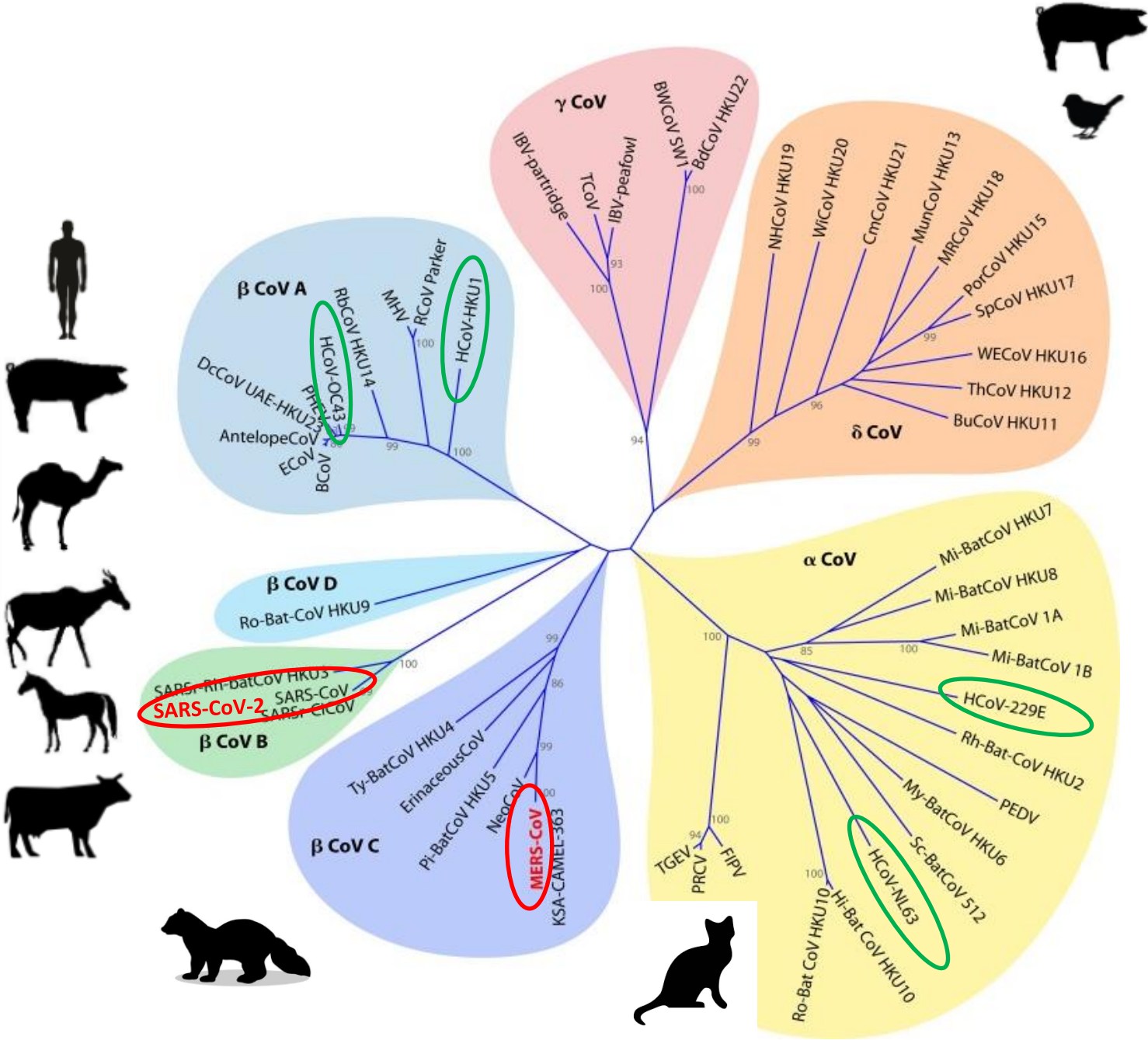
Ye et al. Int J Biol Sci. 2020

Taxonomy of *Coronaviridae*





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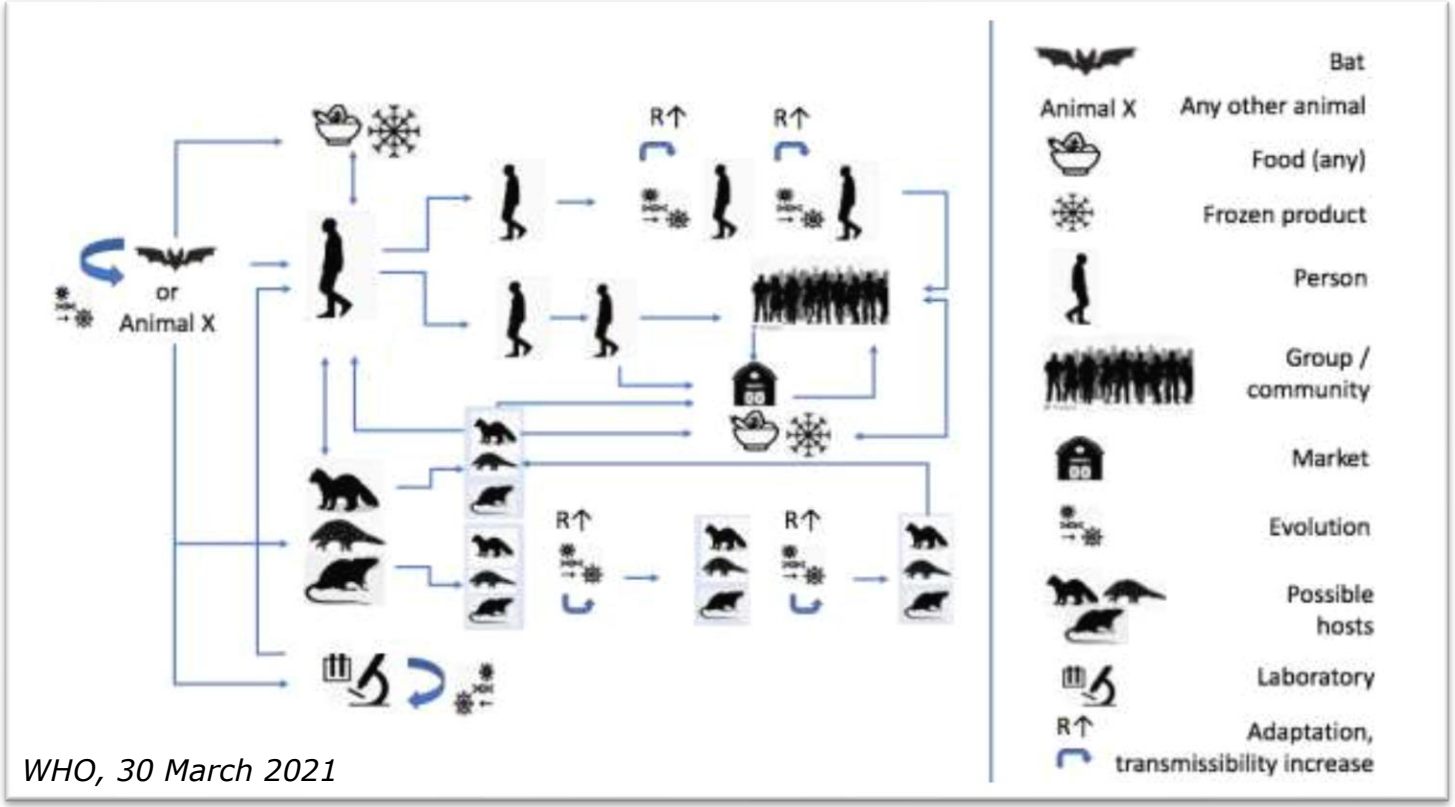
Chan et al. Clin Microbiol Rev 2015

One Health approach: WHO-convened Global Study of Origins of SARS-CoV-2



WHO, 30 March 2021

- Direct zoonotic spillover (*possible-to-likely*)
- Intermediate host (*likely to very likely*)
- Cold/ food chain products (*possible*)
- Laboratory incident (*extremely unlikely*)

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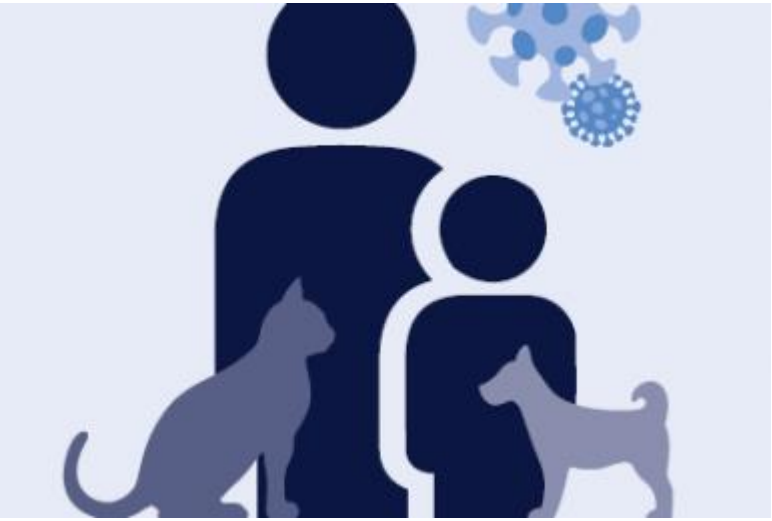
Why study COVID-19 using a One Health approach?

- Prevent animal-to-animal and animal-to-human transmission
- Monitor new mutations that may be seen as the virus adapts to a new species
- Prevent establishment of new zoonotic reservoirs
- Prevent future spillovers



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Timeline first reports of Covid-19 in animals (2020)

First report dog Hong Kong (27-02-20)

Diseased cat in Belgium, virus detected

Tigers, lions in New York zoo

23 April
First infected mink farm (The Netherlands)

17 infected mink farms in NL (1 July)

February → **March** → **April** → **May** → **June**

Hongkong

Dog	2/30
Cat	1/17
Hamster	0/2

- Cats and ferrets can transmit the infection
- Study demonstrated 15% seropositive cats in Wuhan

Fruit bats, hamsters, rabbits can be infected in contrast to pigs, chickens and ducks

2 infected mink farms DK

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The Netherlands: densely populated, urban and agricultural air pollution

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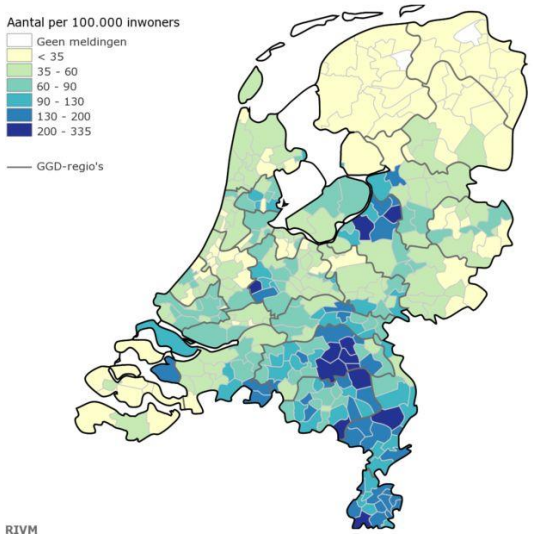
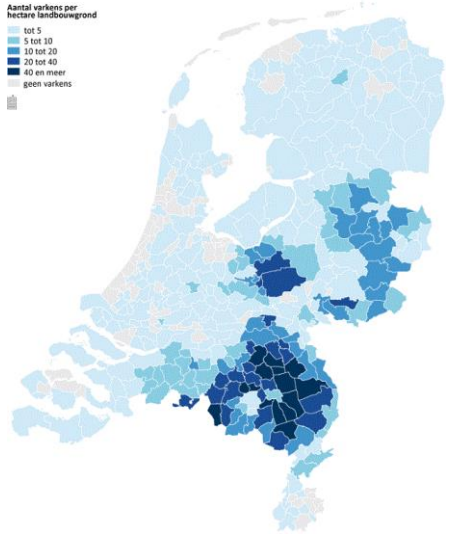
COVID-19 (Mar-Jun 2020) in The Netherlands: remarkable spatial correlations

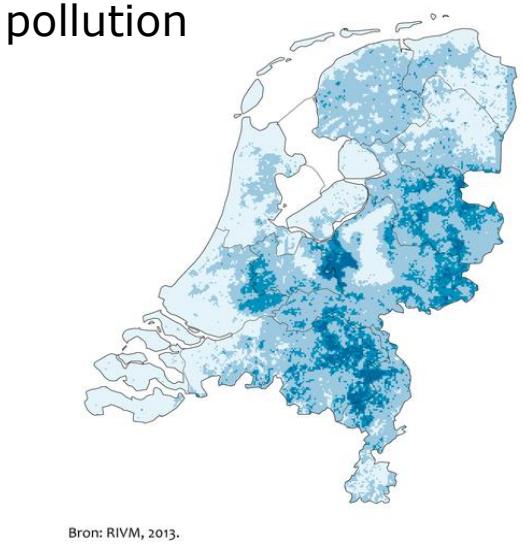
Hospitalizations until June 12, 2020



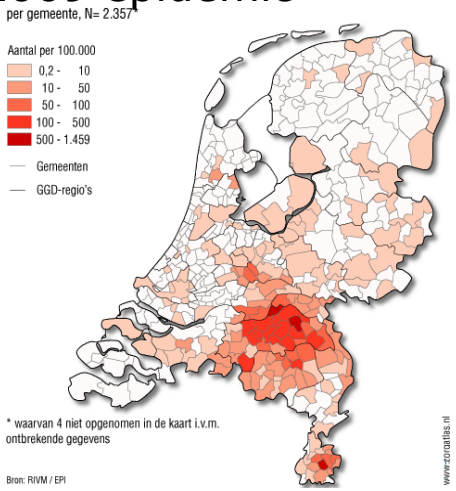
Pig farms



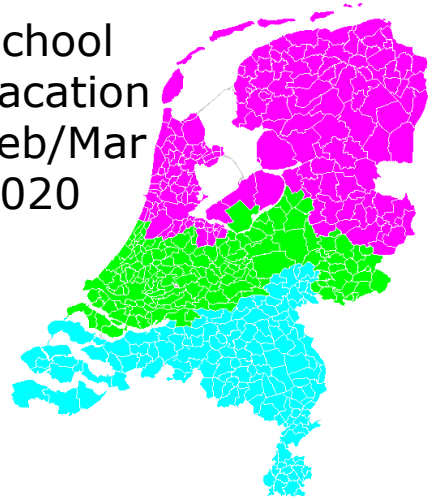
Ammonia air pollution



Q fever patients in 2009 epidemic



School vacation Feb/Mar 2020



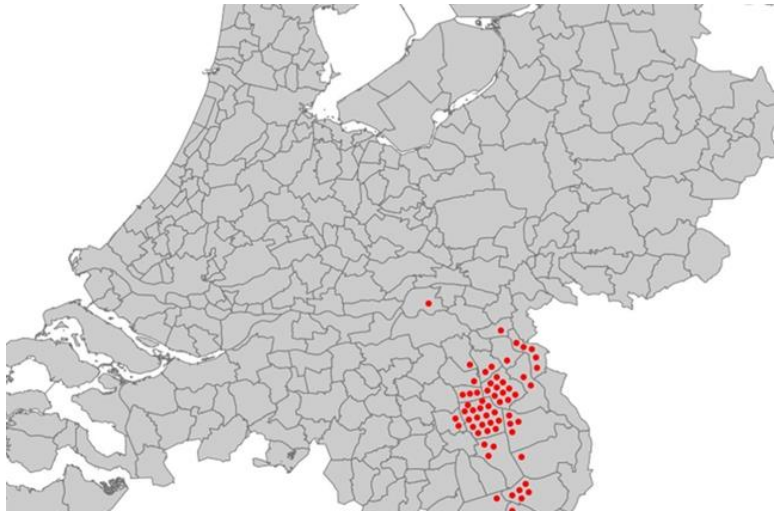
Carnival

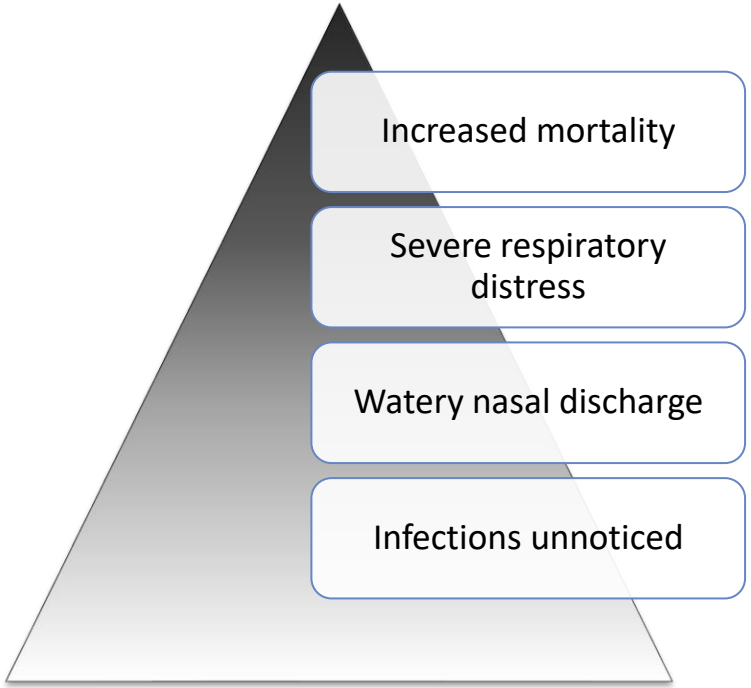
One Health approach to SARS-CoV-2 outbreak investigation on mink farms

- **ANIMAL** - Spread of infection in minks and farm cats and dogs?
- **ENVIRONMENT** - Viral contamination in mink houses and outdoor air?
- **HUMAN** - Spillover events to humans?

netherlands centre for one health

SARS-CoV-2 infection in mink farms





- Initiated by human-to-mink transmission
- Until end 2020: 69 farms in NL infected - despite preventive measures
- January 2021: mink farming in NL banned
- Worldwide, 10 countries reported infected mink farms

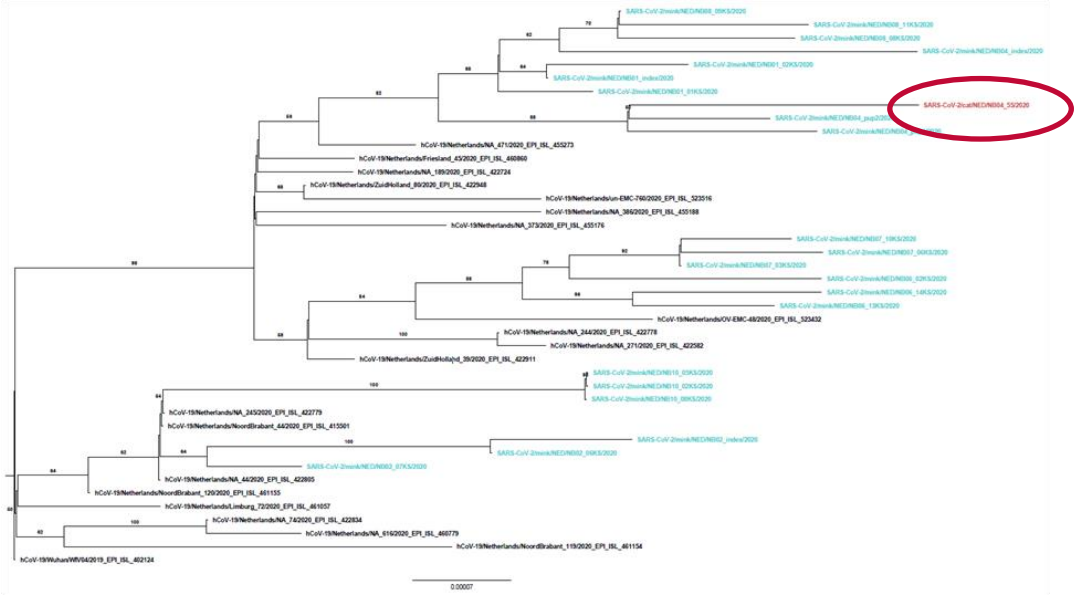
Oreshkova et al. Eurosurveillance 2020
Molenaar et al. Vet Pathol 2020

Mink-to-cat transmission

Evidence of SARS-CoV-2 infection in 12 feral cats and 2 dogs

Serum ELISA and VNT+ : 11/62 (17.7%) cats and 2/13 (15.4%) dogs
Throat swab PCR+ : 3/99 cats (3%) and 1/13 dogs (8%)

One cat sequence generated: clustered with mink sequences
Mink-to-cat most likely route of introduction



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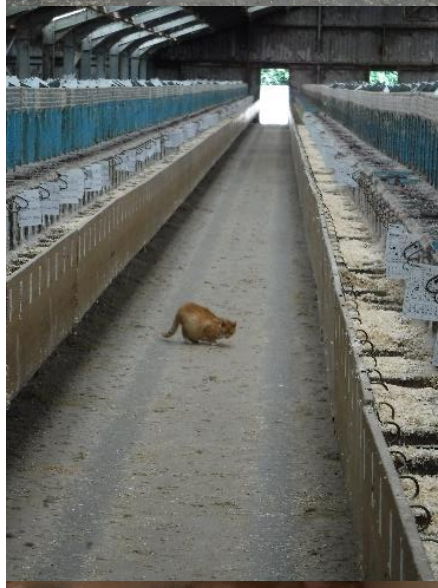
Van Aart et al. manuscript under review.



Environmental sampling SARS-CoV-2 RNA

Mink housing

Indoor air

Outdoor air, premises

Outdoor air >25m from farm

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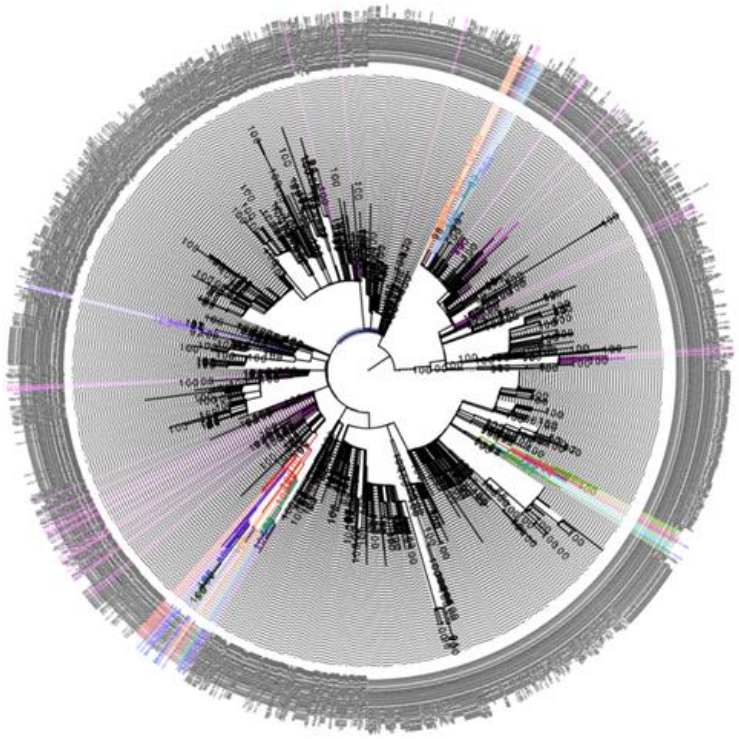
De Rooij et al. manuscript under review.



Oude Munnink et al., Science 2021

Mink-to-human infections

- At the first 16 farms, 66/97 mink workers/family tested positive (68%)
- All 18 human sequences were near-identical to mink or clustered deeply within the mink sequences

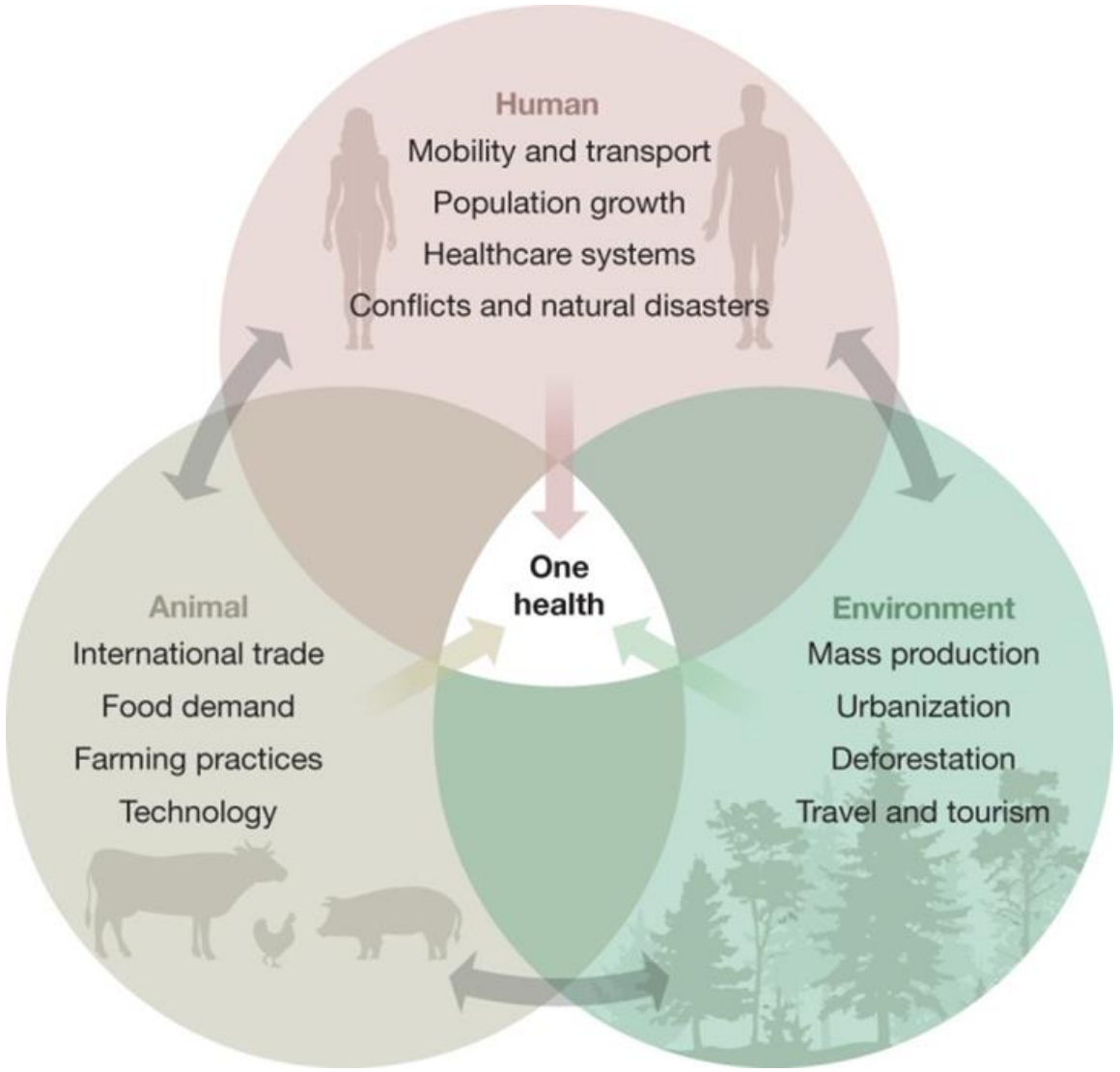
No spillover to nearby human population

- All COVID-19 patients in the area that could be sequenced had different virus sequences

Lessons learned for future challenges

One Health ~ Planetary Health

Close collaboration between animal, public health, and environmental authorities and scientists is imperative to better understand and prevent emerging infectious and non-infectious diseases



Bedford et al. Nature, 2019.