



Food and Agriculture  
Organization of the  
United Nations

# Exposure of humans or animals to SARS-CoV-2 from wild, livestock, companion and aquatic animals

Qualitative exposure assessment

## Summary





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# Preamble

The novel zoonotic coronavirus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), causative agent of the ongoing coronavirus disease 2019 (COVID-19) pandemic in humans, has demonstrated the ability to infect different animal species. The Food and Agriculture Organization of the United Nations (FAO) received several requests from Members to provide advice on surveillance or testing for SARS-CoV-2 in animals, which led to the review of available information on SARS-CoV-2 and betacoronaviruses in animals. While knowledge of SARS-CoV-2 in animals is still evolving, decisions on mitigation measures, investigations and research in animals, as well as communication messages should be based on currently available evidence to target actions in the face of limited resources. This qualitative exposure assessment aims to support One Health partners, including veterinary services and research institutions, in prioritizing animal species for targeted field investigations or research studies aimed at generating data and knowledge on potential SARS-CoV-2 animal hosts and their role in the maintenance and/or spread of the virus. Countries are encouraged to utilize information and results from FAO's qualitative exposure assessment for country-specific assessments, incorporating local realities and national data, and in the planning of national interventions (e.g. investigations in animals, research, etc.). FAO is coordinating this global effort with partner organizations and research institutions. The assessment is based upon a review of information available up to 30 June 2020 and will be revised as circumstances change and new information becomes available.

The reader should note that the uncertainty in the assessment of the different levels of likelihood remains generally medium to high since there is a need for a better understanding of SARS-CoV-2 characteristics and the epidemiology of infection to provide a more precise assessment. At the time of preparation of this document (30 June 2020), the COVID-19 pandemic is propagated by human-to-human transmission and the reader is referred to the World Health Organization (WHO) for information regarding all public health aspects.

Two documents are available in English:

- Exposure of humans or animals to SARS-CoV-2 from wild, livestock, companion and aquatic animals – qualitative exposure assessment:  
<http://www.fao.org/documents/card/en/c/ca9959en/>
- Supplementary tables on susceptibility of animals to SARS-CoV-2 based on predicted ACE2 affinity to bind SARS-CoV-2 receptor binding domain – July 2020:  
<http://www.fao.org/3/ca9959en/supplementary.pdf>



# Summary

The objective of this qualitative exposure assessment is to provide:

- I. an assessment of the risk of human or animal exposure to SARS-CoV-2 through contact with, handling or consumption of wild, domestic and aquatic animal species<sup>◆</sup> or their products;
- II. an identification of current knowledge gaps regarding the zoonotic origin or animal–human spillover of SARS-CoV-2 and recommendations for priority studies;
- III. a summary of available evidence for SARS-CoV-2 susceptibility of different animal species;
- IV. evidence-based recommendations on how to prioritize animal species for targeted field investigations or research studies; and
- V. recommendations for targeted One Health investigations and epidemiological, laboratory, anthropological or seasonality studies to fill critical knowledge gaps evidenced by this exposure assessment.

Any measures implemented or strengthened at country level to mitigate the risk of exposure of humans and animals to SARS-CoV-2 from susceptible wild, livestock, companion and aquatic animals, should be based on the results of **country-specific risk assessment and critical review** of local animal husbandry and marketing practices, using the current knowledge outlined in this document. Risk assessments should be performed according to international guidance (e.g. [OIE, 2019](#); [FAO, 2011](#); [FAO and WHO, 2007](#)).

The likelihood of human or animal **infection** (post-exposure) is **not** assessed in this document. It requires the consideration of a variety of additional factors, which are not presented here. Following exposure, human or animal infection may or may not occur. It is also important to note that during the current COVID-19 pandemic the primary source of human infection is human-to-human transmission.

The likelihood of **exposure of humans or animals** to SARS-CoV-2 in **COVID-19 affected areas** through:

1. **Contact with wild animals** is considered:
  - **Low, i.e. unlikely to occur**, for **wild felines, Old World monkeys, New World monkeys (*Callitrichidae* family), species of the *Mustelidae* family, species of the *Cricetidae* family, tree shrews of the *Tupaiaidae* family, bats of the *Rhinolophidae* and *Pteropodidae* families, and pangolins kept in congregation areas, markets, wildlife ranches, wildlife farms, zoo and circus facilities.**
  - **Very low, i.e. very unlikely to occur**, for the above-mentioned species in their natural habitats in **Southeast Asia and sub-Saharan Africa**, and **negligible, i.e. extremely unlikely to occur**, for these species in their natural habitats in **other areas of the world and for wild swine and wild birds** in general.

<sup>◆</sup> The source of infection for the assessed animal species may have been a human COVID-19 case (reverse zoonosis), another infected animal or a contaminated environment.

- **The likelihood of exposure cannot currently be assessed<sup>o</sup> for other live mammalian wildlife species, reptiles or predatory invertebrates** as the information available is limited<sup>■</sup> to their angiotensin converting enzyme 2 (ACE2) binding affinity to SARS-CoV-2 receptor binding domain (RBD).
2. **Contact with livestock** is considered:
    - **Negligible, i.e. extremely unlikely to occur**, for **live pigs and poultry** in general.
    - The **likelihood of exposure cannot currently be assessed<sup>o</sup>** for **live ovine, caprine, bovine, camelid, rabbit and equine species** as the information available is limited<sup>■</sup> to their ACE2 binding affinity to SARS-CoV-2 RBD.
  3. **Contact with live companion animals** is considered:
    - **Moderate, i.e. potentially occurring**, for **cats, ferrets and hamsters, and susceptible uncommon exotic pets, such as monkeys and bats, owned by or in contact with COVID-19 patients**, infected animals or environments known to be contaminated with SARS-CoV-2. It is considered **low, i.e. unlikely to occur**, for these species **in other sites** with unknown infection or contamination status (including live cats kept in markets as food and stray cats).
    - **Low, i.e. unlikely to occur**, for **companion dogs owned by or in contact with COVID-19 patients**, infected animals or environments known to be contaminated with SARS-CoV-2; and **very low, i.e. very unlikely to occur**, for dogs **in other sites** with unknown infection or contamination status (including live dogs kept in markets as food and stray dogs).
    - **Negligible, i.e. extremely unlikely to occur**, for **companion birds** in general.
    - The **likelihood of exposure cannot currently be assessed<sup>o</sup> for other mammals or reptiles kept as exotic pets** as the information available is limited<sup>■</sup> to their ACE2 binding affinity to SARS-CoV-2 RBD.
  4. **Contact with aquatic animals** is considered:
    - **Negligible, i.e. extremely unlikely to occur**, for **all aquatic mammals** (except captive dolphins), **fish, amphibians, molluscs and crustaceans**.
    - The **likelihood of exposure cannot currently be assessed<sup>o</sup>** for **captive dolphins**, as the information available is limited<sup>■</sup> to their ACE2 binding affinity to SARS-CoV-2 RBD.
  5. **Handling or consumption of animal carcasses, meat/organs, body fluids and excretions** is considered:
    - **Low, i.e. unlikely to occur**, for **products originating from felines, Old World monkeys, New World monkeys (*Callitrichidae* family), species of the *Mustelidae* and *Cricetidae* families, tree shrews of the *Tupaiaidae* family, bats of the *Rhinolophidae* and *Pteropodidae* families, pangolins and dogs**, processed and/or sold as raw products in markets or retail shops **in any condition**.

<sup>o</sup> The likelihoods for conditions that cannot be assessed could be any level between negligible and high.

<sup>■</sup> Once information from ex-vivo cell or experimental animal infection studies, or evidence from comprehensive epidemiological or animal pathology studies, becomes available, the likelihood of exposure for these species will be assessed in future updates of this document.



- **Low, i.e. unlikely to occur**, for **raw products originating from any other animal species (wild, domestic or aquatic)**, processed and/or sold in markets or retail shops **in conditions not meeting the Codex Alimentarius food hygiene standards (Codex Alimentarius Commission [CAC], 2009)**, where **cross-contamination** from the environment, hitherto unidentified animal hosts or a SARS-CoV-2 infected human **is likely to have occurred**.
- **Negligible, i.e. extremely unlikely to occur**, for **sufficiently heat-treated products originating from any animal species (wild, domestic or aquatic)**, as long as there is no opportunity for cross-contamination after heat treatment, in addition to **raw products of poultry, pigs and aquatic animals** if processed and/or sold in markets or retail shops **in conditions meeting the Codex Alimentarius food hygiene standards (CAC, 2009)**.
- **The likelihood of exposure cannot currently be assessed<sup>o</sup>** for **raw products originating from other mammalian wildlife species, reptiles or predatory invertebrates or from most livestock species (other than pigs and poultry) in any condition** because the information available is only limited<sup>■</sup> to their ACE2 binding affinity to SARS-CoV-2 RBD.

In the assessment, the uncertainty of the different levels of likelihood generally remains medium (small sample data set(s), fair correlation/good fit, reliable method) to high (lack of data, limited data, or lack of conclusive data, weak correlation or crude speculation) due to the information gaps outlined.

Studies investigating the ACE2 receptors found in different animal species and their potential to bind SARS-CoV-2 RBD are summarized in the [supplementary tables](#) of the exposure assessment. The reader should note, however, that these require confirmation by *ex-vivo* cell or experimental animal infection studies and evidence from comprehensive epidemiological and animal pathology studies. Discrepancies have been observed in which animals with predicted high-binding ACE2 sequences have had poor susceptibility and limited SARS-CoV-2 infection. It has also been suggested that host binding involved different receptors in some animals and these animals have become infected despite predicted low-binding ACE2 sequences (Koopmans, personal communication, April 2020).

**Specifying the name of some animal species in this assessment does not imply a role in SARS-CoV-2 zoonotic spillover** and the results of this assessment do not justify any measures that may subject these species to unnecessary stress, influence their trade or affect their conservation status.

**A direct precursor virus has not been detected in any wild animal species to date**, therefore it is not known if the precursor virus is still circulating in the original reservoir or intermediate host. However, the ongoing pandemic involves millions of human cases shedding high levels of the virus and thereby creating new contaminated environments other than the original natural reservoir. This has been taken into account in the assessment together with evidenced susceptibility of different animal species.

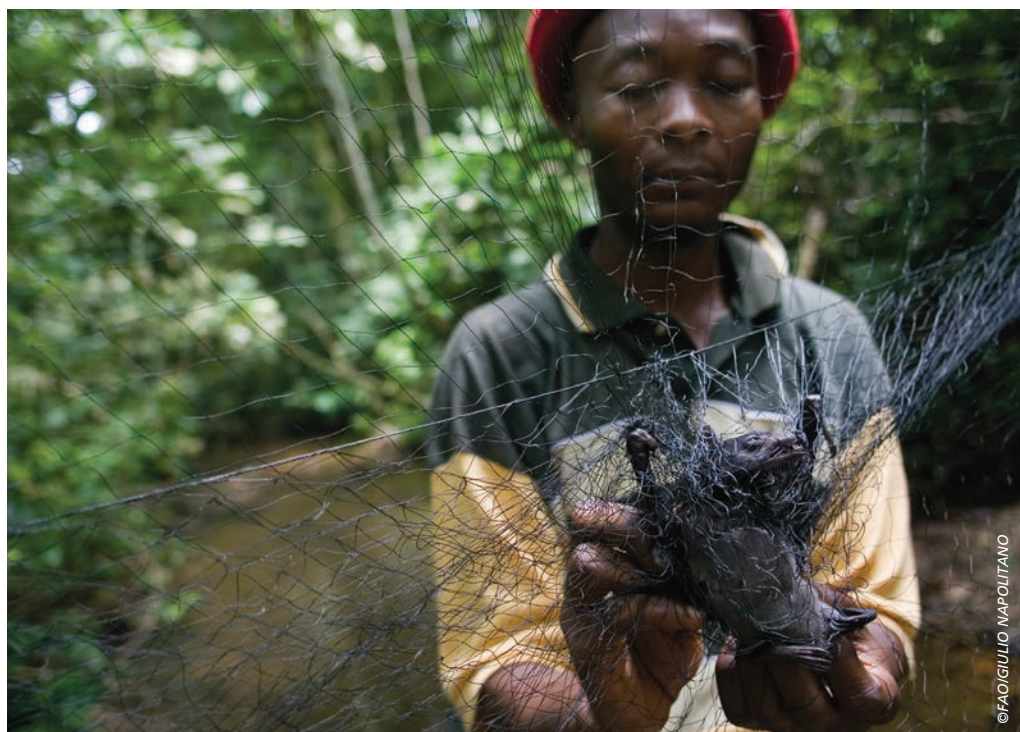
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<sup>o</sup> The likelihoods for conditions that cannot be assessed could be any level between negligible and high.

<sup>■</sup> Once information from *ex-vivo* cell or experimental animal infection studies, or evidence from comprehensive epidemiological or animal pathology studies, becomes available, the likelihood of exposure for these species will be assessed in future updates of this document.

At this early stage, when available data is not sufficient to draw specific conclusions, **FAO discourages sampling surveys as part of active surveillance for SARS-CoV-2 in animal species** that would distract time and resources away from the other responsibilities of veterinary services. Instead, FAO encourages public health, veterinary and wildlife authorities, and forestry and natural resources management to work closely together through a One Health approach to investigate SARS-CoV-2 transmission between animals and humans – provided conditions and resources allow. A suggested approach for field investigation in animals is provided.

From a risk management perspective, it is important to consider that yet another zoonotic pathogen, of probable bat origin and able to infect multiple animal species, was able to jump the species barrier and cause a pandemic in humans of unprecedented proportion. A process of country assessment and review – which includes reduction of contact between humans or domestic animals with bats or other susceptible wild animals that might act as bridge species – will lead to evidence-based actions, which reduce the likelihood and impact of future emergence and spillover of zoonotic pathogens with pandemic potential. Maintenance of strict biosecurity measures; respecting standards of the Codex Alimentarius basic texts on food hygiene ([CAC, 2009](#)), wildlife trade controls and restrictions, including bans on illegal trade; and/or behaviour change in consumers and traders would require additional medium- to long-term engagement. Such measures, as informed by national risk assessment, should take into account impact on livelihoods and food security.



Capturing bats for research, Democratic Republic of the Congo

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