



The risk of highly pathogenic avian influenza in the Southern Ocean: a practical guide for operators and scientists interacting with wildlife

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Advice from avian influenza experts suggests that there is a high risk that highly pathogenic avian influenza will arrive in the Southern Ocean during the austral summers.

Summary

Since the beginning of 2022, the increasing intensity of highly pathogenic avian influenza (HPAI) H5N1 outbreaks has resulted in the deaths of hundreds of thousands of seabirds in the Northern Hemisphere, around the Atlantic and Pacific Oceans and southern Africa. The Scientific Committee on Antarctic Research (SCAR) Antarctic Wildlife Health Network (AWHN) is highly concerned about the probable arrival and subsequent impact that HPAI H5N1 might have on Southern Ocean wildlife. Due to the heightened risk of HPAI being introduced to Antarctica by migrating seabirds, the AWHN recommends that:

- People working with or close to wildlife should assume that HPAI will arrive in the sub-Antarctic and Antarctica and take precautions to protect themselves when working around wildlife (including appropriate personal protective equipment; PPE) and maintain the highest biosecurity to prevent transmission between wildlife aggregations.

- All national programmes (NPs), tourism and fishery operators should monitor colonies for signs of HPAI before approaching, especially in migratory species such as skuas, gulls and giant petrels. Visitors from tourism and fishery operations should not enter colonies and high-wildlife-density areas with suspected HPAI, and NPs should expedite risk analysis as to which activities need to continue.
- A detailed protocol on how to assess wildlife aggregations for HPAI prior to a visit and what to do if HPAI is detected should be provided to all stakeholders physically present in Antarctica this season.
- If you detect signs of HPAI, do not enter colonies and do report these to your permit issuer. Videos of affected animals (collected from a distance) are very helpful for experts to help determine whether or not this is HPAI.
- Operators should refresh themselves with and review all biosecurity and any response guidelines regarding unusual/mass mortality events.

This document aims to:

- 1) Outline the likely risk to Southern Ocean taxa
- 2) Suggest which risks can be mitigated in light of human activity, transmission into and out of Antarctica and the sub-Antarctic regions by all operators as well as

movements between sites within the Southern Ocean (primarily for science and tourism)

- 3) Start discussions with NPs about ongoing monitoring for disease and consequences

What is avian influenza?

Avian influenza virus (AIV) comprises the avian strains of influenza A virus (species *Alphanfluenzavirus influenzae*, family *Orthomyxoviridae*). There is a large diversity of AIVs found in wild birds, comprising 16 haemagglutinin (HA) and 9 neuraminidase (NA) subtypes. The AIVs maintained in wild birds are low-pathogenic avian influenza (LPAI) viruses, which cause no clinical signs of disease in wild birds. Of concern are subtypes H5 and H7, which may evolve in poultry to become highly pathogenic (Horimoto & Kawaokade 2005, Monne *et al.* 2014, Bruin *et al.* 2022). These HPAI viruses can range from causing no clinical disease to 100% mortality and have devastating consequences when they spill over into wild birds. The current outbreaks of global concern are caused by clade 2.3.4.4.b HPAI H5N1 viruses.

While most HPAI viruses are rapidly eradicated through stamping out, the current HPAI panzootic has a long history. In 1996, an HPAI H5N1 virus emerged in Asia, and this viral lineage (referred to as the goose/guandong (Gs/Gd) lineage) has had enduring circulation and diversification since (Wille & Barr 2022, Xie *et al.* 2023). This lineage is endemic in poultry in many countries, and there have been notable epizootics in wild birds prior to the current panzootic, including in 2005, 2014 and 2016 (Liu *et al.* 2005, Verhagen *et al.* 2015, Xie *et al.* 2023).

In addition to the HA-NA subtype classification system, Gs/Gd HPAI H5 viruses are categorized based upon their HA lineage (e.g. 2.3.4.4b), which together are associated with different epidemiologies, ecologies, pathogenicities, virulences and human health risks. With the emergence of 2.3.4.4.b HPAI H5N1 in 2021 (Pohlmann *et al.* 2022), we have seen a substantial shift in the epidemiology of this virus, resulting in an enormous range expansion facilitated by wild bird migration (i.e. two independent introductions into North America; Alkie *et al.* 2022), an increase in the number and magnitude of wild bird and poultry outbreaks, a substantial host range expansion (i.e. widespread outbreaks in seabirds for the first time) and activity throughout the year rather than being limited to the Northern Hemisphere autumn and winter (EFSA *et al.* 2022, Grass *et al.* 2022). Hereafter, lineage 2.3.4.4b HPAI H5N1 will be referred to as HPAI for clarity.

What is the risk to humans?

There have been 863 human cases of HPAI H5N1, with 456 deaths in during 2003–2021 (Wille & Barr 2022).

This translates to a low risk of infection in humans but a high risk of mortality if infected (~50%). Unlike pre-2.3.4.4 HPAI H5N1, human infections with clade 2.3.4.4 HPAI H5Nx have lower mortality, with 40% reported (across all cases in China; BNO News 2021). Human cases caused by the currently circulating lineage of HPAI H5Nx (lineage 2.3.4.4) have been reported in China, Laos, Russia, Nigeria, the UK, the USA, Ecuador and Chile, with no examples of human-to-human transmission detected (WHO 2022, 2023a,b, Wille & Barr 2022). While the risk of infection to the general public is 'low' or 'very low', the risk of infection in occupationally infected people (e.g. poultry workers) is 'low to medium', although with high uncertainty (Wille & Barr 2022, HAIRS 2023). To date, nearly all human infections with HPAI have been in people closely interacting directly for prolonged periods of time with poultry; however, there have been rare cases probably involving contact with infected wildlife (Gilsdorf *et al.* 2006, WHO 2023b). If NPs decide to work at affected sites, we suggest that a detailed risk assessment and plan be developed and that only appropriately trained field staff in appropriate PPE enter colonies with suspected HPAI and *do not handle sick, dying or dead birds unless specifically trained and permitted for HPAI detection.*

How is it spread?

HPAI is transmitted via the faecal-oral route, respiratory droplets, direct contact and environmental contamination (mostly water infected faeces and infected carcasses; Bertran *et al.* 2017). The consumption of infected birds or carcasses has led to mortality in raptors (Stokstad 2022) and other predatory or scavenging birds such as skuas (Banyard *et al.* 2022), and this has also been found to facilitate the spread of the virus throughout colonies. It has been reported as an important transmission route for many mammals, including sea lion infections (Leguia *et al.* 2023). In sandwich terns, necrophilia has also been identified as a route of transmission in adult birds (Rijks *et al.* 2022).

Colonial nesting seabirds may be at greater risk of disease spread due to the proximity of individuals and nests over a long period of time, increasing direct contact rates among individuals or with infected faeces and water (Vittecoq *et al.* 2017, Boulinier 2023).

HPAI in seabirds and the risk to Southern Ocean wildlife

To date, HPAI has affected 320 species belonging to 21 orders of birds, although waterbirds and seabirds (which are also the natural reservoir for LPAI; Olsen *et al.* 2006) have been disproportionately affected (EFSA *et al.* 2023, Klaassen & Wille 2023).

Since 2022, a substantial increase in outbreaks of HPAI has led to considerable mortality in seabirds in the Northern Hemisphere, southern Africa and the Atlantic and Pacific oceans (EFSA *et al.* 2023). Focusing on only the Southern Hemisphere, due to the proximity to Antarctica, outbreaks in seabirds have thus far occurred in Africa and South America, whereas Australia remains free from HPAI (Abolnik *et al.* 2023, Gamarra-Toledo *et al.* 2023, Wille & Klaassen 2023). Outbreaks in seabird colonies of southern Africa began in *ca.* 2017, and repeated detections in South African and Namibian seabirds include African penguins (*Spheniscus demersus*), swift terns (*Thalasseus bergii*) and Cape cormorants (*Phalacrocorax capensis*; Khomeiko *et al.* 2018, Molini *et al.* 2020), all of which are taxonomically related to Southern Ocean seabirds. There were multiple independent incursion events of HPAI into South America, and the virus travelled across the 6000 km length of the continent in ~6 months (Breed *et al.* 2023, WAHIS 2023). Heavily affected were Peruvian pelicans (*Pelecanus thagus*, $n = 61\ 844$), guanay cormorants (*Leucocarbo bougainvillii*, $n = 207\ 427$), Peruvian boobies (*Sula variegata*, $n = 236\ 060$), Humboldt penguins (*Spheniscus humboldti*, $n = 2517$) and Magellanic penguins (*Spheniscus magellanicus*, $n = 460$; Ministerio de Salud del Perú 2022, 2023, SAG 2023). Of great concern were the thousands of affected kelp gulls (*Larus dominicanus*), a species known to migrate between the Antarctic Peninsula and South America (<https://www.dge.gob.pe/influenza-aviar-ah5/#aves>; Jimenez-Bluhm *et al.* 2023, Azat *et al.* Preprint). These numbers represent the number of seabirds reported dead during HPAI outbreaks, but actual numbers of individuals affected are probably much higher.

In addition to birds, HPAI has been linked to a number of marine mammal deaths, including harbour seals (*Phoca vitulina*) and grey seals (*Halichoerus grypus*) in the USA and Canada, cetaceans and ~20 000 South American sea lions (*Otaria flavescens*) in Peru and Chile (Ann 2022, NOAA Fisheries 2022, Argentina Ministerio de Economía, Secretaría de Agricultura, Ganadería y Pesca 2023a,b,c, Chile Servicio Agrícola y Ganadero 2023, Gamarra-Toledo *et al.* 2023, Leguia *et al.* 2023, Peru Ministerio de Salud 2023, Murawski *et al.* Preprint), as well as recent detections in sea lions in Argentina, including Rio Grande, Province of Tierra del Fuego, Antarctica (Argentina Ministerio de Economía, Secretaría de Agricultura, Ganadería y Pesca 2023a,b,c).

A detailed risk assessment (Dewar *et al.* 2023) identified that an incursion event was most likely (with a high likelihood) to be from South America (Tierra del Fuego or Patagonia) to the Antarctic Peninsula via wild birds, although such an event occurring via pinnipeds from South America represented a medium risk, as there are few records of pinnipeds moving between these regions. Viral incursion from South America via the Falkland

Islands (Malvinas) also represented a medium risk. Key avian species implicated in viral introduction included kelp gull, brown skua (*Stercorarius antarcticus*), southern giant petrel (*Macronectes giganteus*) and snowy sheathbill (*Chionis albus*), all of which are species known to traverse South America and the Antarctic Peninsula.

Monitoring for early detection of HPAI

HPAI will most probably be introduced and transmitted to wildlife in Antarctica and sub-Antarctic islands via long-distance migratory species for which HPAI does not preclude long-distance flight. It could also be introduced by humans via contaminated clothing and equipment.

During the 2022/2023 season, there was a combination of passive and active HPAI surveillance undertaken in Antarctica Lisovski *et al.* (Preprint). Samples from these initiatives are still being tested or are under review. It is recommended that continued monitoring of HPAI along migratory pathways continue in the lead up to the 2023/2024 season, as this will enable all operators to assess the risk and probable arrival of HPAI into the sub-Antarctic islands and Antarctica. The Antarctic Wildlife Health Network has established a 'monitoring database' for the recording of outbreaks in the region to assist in monitoring the movement of HPAI (<https://www.scar.org/resources/hpai-monitoring-project/>). It is also recommended that all operators report all suspected outbreaks to their competent authority. We recommend working with seabird biologists to identify whether HPAI is already present and the important migratory species that may act as vectors for the region (as noted above) to monitor important flyways and the movement of HPAI towards the Southern Ocean.

Detecting and responding to possible outbreaks

Mass mortality events can occur in times of food stress. These events can be hard to distinguish from mortality due to disease or contaminants. Furthermore, in addition to deaths on colonies (Paradell *et al.* 2023), many birds may die at sea (Paradell *et al.* 2023), making it difficult to notice the true scale of the impacts of an infectious agent such as HPAI and to get an accurate account of the actual mortality rate for such colonies (Oriol *et al.* 2023). Ongoing disease monitoring programmes aim to resolve background and endemic diseases *vs* introduced and emerging diseases that pose a risk to populations. Despite this, where mass mortality occurs, it is necessary to react in a precautionary manner because of the risk of HPAI to visitors and wildlife alike and the high risk of spreading it to other colonies. If unusually large numbers or clusters of dead animals are observed, it is best to assume a mass mortality event due

to infectious disease and close the site until further investigation. As a rule, the organization that authorizes your visit or permit should be alerted, which may differ between Antarctica and the sub-Antarctic islands.

We strongly advise people against entering possibly infected colonies, touching sick or dying birds or taking any samples *unless* 1) it is essential to do so to collect samples, 2) they have been trained to do so, 3) they are wearing appropriate PPE and taking appropriate biosecurity precautions and 4) they have permits to collect diseased samples.

To identify potential presence of HPAI in wildlife, some of the most *common observations* in the current outbreaks in the Northern Hemisphere and South America include:

- *Neurological signs such as loss of coordination and balance, trembling head and body (convulsions) or twisting of the neck*
- *Walking or swimming in circles*
- *Sudden and rapid increases in the number of birds found dead between visits*
- *Lethargy and depression, unresponsiveness, lying down, drooping wings, dragging legs and/or partial paralysis*
- *Closed and excessively watery eyes, possibly with an opaque cornea or darkened iris (e.g. gannets)*
- *Respiratory distress such as gaping (mouth breathing), nasal snicking (coughing sound), sneezing, gurgling or rattling*
- *Discoloured or loose watery droppings (bright green in some species)*
- *Conjunctivitis (e.g. African penguins - cloudy eyes)*

Italicized points are practical observations that could be made via binoculars prior to landing or approaching the colony. In the event of an outbreak, it would be expected that multiple of these behavioural signs are manifested by multiple individuals. If in doubt, it is best to refrain from approaching the colony and reporting for someone else to confirm. Examples of disease signs observed in infected seabirds in recent outbreaks include:

- <https://wwwnc.cdc.gov/eid/article/28/12/22-1292-vid1>
- <https://twitter.com/i/status/1542423370511302656>
- <https://twitter.com/gannetrocks/status/1549641794165538817>
- <https://photos.app.goo.gl/u9f3jpuy4SKQr1Lw9>

One of the most practical changes that visitors can make prior to approaching a colony is a site assessment looking for signs of disease (listed above). Experienced researchers, guides and naturalists will be especially good at spotting atypical behaviour and spasms, which could be integrated into a site evaluation prior to landing. If one is unsure as to whether the behaviour is typical of HPAI, video footage could be taken using a mobile phone and sent to the Antarctic Wildlife Health Network for verification by an expert team

(antarcticwildlifehealthnetwork@gmail.com). In case of an abnormal number of dead individuals, panoramic pictures should be taken. *Do not approach colonies if there is a suspected disease outbreak.*

Prevention and control

Given that Antarctica and the sub-Antarctic islands are at high risk, personnel from all operators living, working and visiting these regions should *act as if HPAI will arrive* and should take appropriate precautions. Responses may be stepped up if cases are confirmed. Suggested prevention and control measures that operators can immediately implement to prevent the spread of HPAI are outlined in this section.

Before leaving for Antarctica and the sub-Antarctic islands

- 1) All personnel including but not limited to expeditioners, guides and crew working in other wildlife areas (e.g. seabird colonies, the Arctic, Alaska, etc.) should thoroughly remove any soiled material (i.e. soil, faeces) from their boots and disinfect all clothing, footwear and any equipment before leaving for Antarctica and the sub-Antarctic islands to prevent introduction of HPAI from other wildlife areas. It is recommended that expeditioners and field guides not wear clothing or boots used in fieldwork in the Northern Hemisphere and to have separate field gear for both regions to reduce the risk of transmission given active cases in the north, especially the Arctic (if possible). If not possible, thoroughly disinfect everything.
- 2) All personnel, including tourists, should remove all soiled material and disinfect footwear before boarding a vessel or aircraft, especially if they have been near wildlife colonies before boarding (e.g. in Ushuaia or Punta Arenas).
- 3) The use of Virkon™ S, F10 or soap followed by 10% bleach is recommended for disinfection of boots and outer clothing.

Before visiting a colony or wildlife aggregation

- 1) In general, region-specific advice/regulation may exist, so we suggest adopting whichever is the more precautionary.
- 2) To identify whether a colony is potentially infected with HPAI, an appropriately trained or experienced guide/research team should be sent via small boat, avoid landing if possible (or via a high vantage point at remote southern colonies) and observe the colony using binoculars to look for carcasses and behaviour of live birds (listed above) before entering the site or sending tourists/parties to shore. In case of terrestrial approaching, observations using binoculars should be made 150 m from the closest animal aggregation.

- 3) If there are signs of an unusual/mass mortality event or behavioural signs consistent with HPAI within a colony, the visit should be aborted. *All equipment and clothing should be completely disinfected as soon as possible* and the observations reported to your competent authority immediately. There may be specific reporting forms or procedures, particularly for the sub-Antarctic islands.
- 4) In general, all equipment (including boots, backpacks, hiking poles, tripods, camping equipment, cones or route markers, etc.) should be clean and free of any soiled material (i.e. soil, faeces) and disinfected before disembarking the boat/leaving base and every time after visiting a colony.

During a visit

- 1) Unless specifically permitted to do otherwise, visitors to wildlife colonies should always keep *a minimum distance of 5 m from wildlife*, in addition to strict adherence to Antarctic Treaty Consultative Meeting (ATCM) general guidelines, International Association of Antarctica Tour Operators (IAATO) guidelines or any other local requirements (https://documents.ats.aq/recatt/att483_e.pdf), given that a greater distance may be required for different animal species and age cohorts. If an animal spontaneously approaches an individual or a group of visitors, the visitors should retreat to ensure this minimum distance is rigorously adhered to unless specifically studying or sampling animals and being permitted to do so.
- 2) HPAI can survive in the environment for months at temperatures of $\sim 4^{\circ}\text{C}$; therefore, to prevent the spread and contamination of clothing, people should not sit on or lie on the ground close to animal activity or faecal matter (within 10 m of nests, haul-out sites or pathways). Freshwater pools should also be avoided, as HPAI can survive and be spread by water.
- 3) To minimize animal exposure to equipment/potential fomite transmission (i.e. transmission from objects or equipment carrying infection), field equipment should not be left unattended and should be kept away from wildlife. If necessary, consider grouping separate items onto a disinfected ground sheet or similar.
- 4) *Visitors must adhere to strict recommendations for personal hygiene at all times* (frequent hand washing for the appropriate time and regular disinfection).
- 5) *Visitors must never touch birds, dead or alive, unless they have a permit that, in this case, specifically includes birds with suspected disease.*

Post-visit

- 1) All equipment (including boots, tripods and anything that may have been in contact with the ground) should also be cleaned of any soiled material (i.e. soil, faeces) and disinfected upon returning to the

ship or base after visiting a wildlife colony or shore visit. Wear a mask to prevent inhalation of aerosols during cleaning.

- 2) Field equipment should be thoroughly disinfected.

General recommendations

- 1) All logistics providers and expeditions should be on high alert for HPAI from September through to April, *assume HPAI will arrive in the Southern Ocean* and take appropriate precautions.
- 2) Ensure detailed risk assessments and response plans have been developed prior to the beginning of the season.
- 3) We recommend a phased approach be used for conducting research and tourism activities in relation to HPAI, similar to the response plan developed by the British Antarctic Survey (BAS), which can be found at <https://www.comnap.aq/s/United-Kingdom-ATCM45-IP039-2023.pdf>. For example:
 - a) Prior to HPAI arrival in Antarctica:
 - Implement cleaning and biosecurity measures as outlined above.
 - Conduct pre-entry checks of colonies to look for signs of HPAI and continue to monitor for signs as you move around the colony.
 - Follow normal occupational health and safety procedures for working with wildlife.
 - b) If HPAI is confirmed in the sub-Antarctic or Antarctic region:
 - In addition to the steps above, we also recommend wearing additional PPE, including face masks and gloves, when handling seabirds or when working close to wildlife, as the colony being visited maybe infected but not yet showing signs of infection.
 - c) If HPAI is suspected at a colony:
 - All non-essential personnel should retreat from the area and the site be closed.
- 4) All personnel should be appropriately trained in working with potentially infectious animals and in the correct procedures for the donning and removing of PPE, and appropriate facilities for waste disposal should be identified. The World Health Organization (WHO) has online training for this (<https://openwho.org/courses/IPC-PPE-EN>).
- 5) Anyone responsible for groups visiting/transiting through wildlife colonies should be briefed on identifying the signs of mass mortality events and HPAI behavioural signs and abort visits if signs of mass mortality are seen.
- 6) Minimize movements between wildlife aggregations without biosecurity (e.g. fieldworkers walking between aggregations within a single day). To avoid transmission through fomites, disinfect outer clothing using soap and warm water or spray with disinfectant such as Virkon S every day prior to

and after work with animals and in between colonies (if researchers visit more than one colony per day).

- 7) Field equipment should be thoroughly disinfected prior to and after animal handling, especially when working in different areas or colonies. Wherever possible, it is recommended that field/sampling equipment not be shared between locations if appropriate disinfection cannot be achieved. The use of 70–90% ethanol, Virkon S, F10 or 10% bleach (sodium hypochlorite) and soap is recommended by as per WOAH & IUCN (2022) and FAO (2023) guidelines.

Response to suspected avian influenza outbreak

- 1) Abort a visit if signs of HPAI are seen.
 - a) Do not enter colonies with suspected HPAI.
 - b) *Do not touch dead, sick or dying birds.*
 - c) Due to the limited facilities to appropriately dispose of carcasses in Antarctica and the sub-Antarctic islands, it is not recommended that carcasses be removed from colonies. Please note, carcasses cannot be buried or composted in Antarctica and should be incinerated. However, if carcasses are to be removed, a risk assessment will need to be conducted and all personnel should wear appropriate PPE (see recommendations in Breed *et al.* 2023).
 - d) *Immediately report the event following your organization's reporting procedures* and collect evidence such as videos from a distance.
- 2) Sampling requires appropriate authorisation/permitting and, if done without training, PPE and containment, could do more harm than good as well as being a breach of permits or the law.
- 3) The suspected event *should be reported immediately to the following:*
 - a) The national competent authority that permits/authorizes the operation (relevant contacts are listed below).
 - b) NPs and authorities are required to report the event to the World Organisation for Animal Health (WOAH) as HPAI is a globally reportable disease.

Other operators in the region should also be informed of any suspected cases, including IAATO if suspected cases are located near sites where tourist activities occur.

The Antarctic Wildlife Health Network has established an online monitoring database for the recording and monitoring of HPAI in the Southern Ocean. All operators to the Antarctic and sub-Antarctic islands are encouraged to share information of suspected outbreak (s) and their locations with the Antarctic Wildlife Health Network database. Information requested includes.:

- Organism ID.
- Date.

- Time in UTC.
- Location, including name of site and coordinates (use a GPS if available).
- Name of observer, organization and vessel (if applicable).
- Area affected.
- Species (scientific name) present, age class and sex ratio and which one(s) seem(s) affected by the outbreak (if available).
- Indication of the number of animals present and infected - if possible, count the dead and dying and estimate the percentage of each among the colony.
- Any behavioural or other clinical signs noted.
- Photographs and/or videos of unusual behaviours but also of groups of apparently healthy and unhealthy/dead individuals.

If a landing was conducted and later the presence of HPAI is suspected, all clothing, footwear and equipment should be cleaned and disinfected with soap/detergent and water to remove dirt and then sprayed with or soaked in disinfectant (e.g. 70–90% ethanol, 1% Virkon S, F10 or soap or 10% commercial bleach (sodium hypochlorite)), as per WOAH & IUCN (2022) and FAO (2023) guidelines.

- 4) If a national competent authority permits/authorizes an investigation team, they must be adequately trained and aware of all risks. The team must follow guidelines on health and safety and ensure adequate PPE is worn at all times. All teams must be trained in the proper donning and removal of PPE to reduce the risk of infection. All PPE must be disposed of appropriately and according to guidelines on the storage of biologically hazardous waste. The team will not visit any unaffected colonies after visiting the affected colony without thorough disinfection of all equipment and clothing to reduce the spread of HPAI. Specific guidelines for fieldworkers and investigation teams can be found in Dewar *et al.* (2023).

Contacts

- Antarctic national competent authorities: <https://www.ats.aq/devAS/Ats/NationalCompetentAuthorities?lang=e>.
- The International Association of Antarctica Tour Operators (IAATO): operations@iaato.org; +1 401 608 2090; www.iaato.org.
- The World Organisation for Animal Health (WOAH): as HPAI is a globally notifiable disease, the WOA *needs to be notified if there is any suspected outbreak.*

Submission of a suspected outbreak can additionally be reported to the International Society for Infectious Diseases, Program for Monitoring Emerging Diseases (ProMED) website using the following link: <https://promedmail.org/submitinfo>.

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Author contributions

MD and TH: concept of paper, formation of recommendations, writing and formatting paper. MW and RETV: avian influenza expertise, collation of information on current outbreaks, writing of paper, risk assessment, formation of recommendations. AG, TB, AS, AV, NR, JB, AL and AB: formation of recommendations and writing of paper.

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