Qualitative Risk Assessment Template

Summary of Overall Risk

Context

This risk assessment was compiled according to terms of reference provided by the Scottish Government regarding time of delivery, title of veterinary risk assessment (VRA) and level of detail required. EPIC scientists have created a generic framework suitable for VRAs; collated and updated existing information on risks. This document may require updating as new information becomes available or legislation develops, or if more in-depth assessment is necessary.

Definitions of risk level

Table 1. Definitions for the qualitative risk terms used in this assessment, based on EFSA (2006) and OIE (2012).

Risk level	Definition
Negligible	Event is so rare, does not merit consideration
Very low	Event is very rare, but cannot be excluded
Low	Event is rare, but does occur
Medium	Event occurs regularly
High	Event occurs very often
Very high	Event occurs almost certainly

Table 2. Qualitative categories for expressing uncertainty given the available evidence; based on definitions within the literature (EFSA, 2006; ECDC, 2011, Spiegelhalter & Riesch, 2011)

Uncertainty category and definition	Type of information/evidence to support uncertainty category
Low Further research is very unlikely to change our confidence in the assessed risk	• Solid and complete data available (e.g. long term monitoring results) • Peer reviewed published studies where design and analysis reduce bias (e.g. systematic reviews, randomised control trials, outbreak reports using analytical epidemiology) • Complementary evidence provided in multiple references • Expert group risk assessments, specialised expert knowledge, consensus opinion of experts • Established surveillance systems by recognised authoritative institutions • Authors report similar conclusions
Medium Further research is likely to have an important impact on our confidence in the risk estimate	• Some but no complete data available • Non peer-reviewed published studies/reports • Observational studies/surveillance reports/outbreak reports • Individual (expert) opinion • Evidence provided in a small number of references • Authors report conclusions that vary from one another
High Further research is very likely to have an important impact on our confidence in the risk estimate	• Scarce or no data available • No published scientific studies available • Evidence is provided in grey literature (unpublished reports, observations, personal communication) • Individual (non-expert) opinion • Authors report conclusions that vary considerably between them

Risk Question:

What is the change in likelihood of onward transmission of highly pathogenic avian influenza virus (HPAIV) H5N1 to other wild birds, other wildlife, and poultry and other captive birds, if carcasses of wild birds believed to have died of HPAI H5N1 are removed in the event of mass mortality in Great Britain (GB), compared to leaving carcasses in situ?

Summary of overall risk

	Without mitigation (carcass removal)	With mitigation (carcass removal)
Likelihood that other wild birds are infected with HPAI H5N1 virus due to a mass mortality event in Great Britain (GB):	**High (in high bird density areas)** **Medium (in low bird density areas)**	**High (in high bird density areas)** **Low (in low bird density areas)**
Likelihood that carnivorous mammalian wildlife species are infected with HPAI H5N1 virus due to a mass mortality event in GB:	**Medium**	**Medium**
Likelihood that poultry and other captive birds are infected with HPAI H5N1 virus due to a mass mortality event in GB:	**Low**	**Low**

Key uncertainties:

- Limited evidence for the likelihood and routes of infection through direct contact with wild bird carcasses.
- The relative contribution of carcasses and live birds to overall environmental contamination, and therefore to indirect transmission, is unknown.
- Limited evidence to quantify the likelihood of direct vs. indirect transmission occurring.

Level of uncertainty in the risk estimate given available evidence:
(provide range of levels of uncertainty identified)

Overall uncertainty in the risk estimates is **high** for all outcomes.

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Risk Assessment

1. Executive Summary:

Great Britain has been experiencing a major avian influenza outbreak in 2021/22, associated with a widespread outbreak affecting multiple European countries. Mass mortality (i.e. large numbers of dead birds within a defined area) has occurred in wild birds, including seabirds. Removal of wild bird carcasses in the event of mass mortality due to highly pathogenic avian influenza (HPAI) H5N1 has been proposed as a control measure to reduce onward transmission of the virus.

This risk assessment aims to provide a qualitative assessment of the likelihood of onward transmission of HPAIV H5N1 from wild bird carcasses to wild birds, other wildlife, and poultry and other captive birds, comparing scenarios where carcasses remain in the environment at sites of mass mortalities and where they are removed. This risk assessment is not intended to address sporadic bird deaths due to HPAI H5N1, but to support decision making in situations where large numbers of HPAIV H5N1-infected carcasses are present within a defined location and carcass removal may be considered.

Indirect transmission due to environmental contamination appears to be the main driver of infection for wild aquatic birds. Influenza A viruses can remain infective for several months in surface water samples at low temperatures and waterborne transmission appears to be the primary driver of AI infection in aquatic birds, although this evidence is not specific to HPAIV H5N1. In areas of high bird density (e.g., seabird nesting sites), carcass removal is likely to be least effective at reducing the overall viral load due to extensive environmental contamination which has already occurred from both live and dead birds. Environmental contamination is likely to come mainly from live birds rather than carcasses, although there is a lack of data to quantify this at present so uncertainty is high. Human access to remove carcasses at high density locations is likely to result in disturbance of live wild birds. Impacts will vary by species, but this could result in increased movement of birds, both at the original location and to other sites, with potential for greater spread of infection. Stress due to disturbance from carcass removal has the potential to increase the birds' susceptibility to infection (high uncertainty). Fomite contamination from human access to highly contaminated areas (e.g. for carcass removal) and subsequent transmission to other sites is also a potential issue, unless scrupulous cleaning and disinfection is carried out.

In areas of low bird density (e.g., beaches with few live birds present), background levels of environmental contamination are likely to be lower, hence removal of carcasses may have relatively more impact on the local viral load in the environment. In those circumstances, the likelihood of disturbance to birds and other wildlife species is also likely to be low. However, carcass removal is unlikely to remove all dead birds due to ongoing mortality, natural movement of carcasses (e.g. with currents or tides), and practical difficulties ensuring complete removal of all dead birds, which will reduce the effectiveness of this strategy at preventing further transmission. Carcass removal is likely to have the greatest impact on reducing the viral load present in carcasses if carried out as soon as possible after death, when the levels of virus present in carcasses is highest.

Scavenging appears to be the main route where direct transmission from infected carcasses to susceptible birds and carnivorous mammalian wildlife is likely to occur. Carcass removal may therefore help to reduce the likelihood of infection in wild birds and mammals which scavenge on wild bird carcasses to a greater extent than in the wild bird population as a whole, where the risk of transmission from live birds or the environment likely outweighs the risk from carcasses.

The likelihood of direct and indirect infection of poultry and other captive birds from wild bird mass mortality events is estimated to be low, regardless of whether carcasses are removed or not in locations where mass mortality has occurred. This is driven by the fact that only a small proportion of poultry and other captive bird premises are likely to be close to mass mortality events, and that contamination of these premises is more likely to originate from live birds than

from carcasses.

This risk assessment does not cover health risks from carcasses for humans or domestic mammals, potential risks of transport and disposal of carcasses, or the impact of carcass removal on wild bird welfare. Decisions around whether carcass removal should be carried out on a case-by-case basis and these factors must be taken into consideration. There may be pressure from stakeholders, including the general public, for carcasses to be removed in the event of mass mortality. The evidence available at present indicates that but costs are likely to be high for limited benefit in many scenarios.

The uncertainty around the risk estimates and associated conclusions are high due to limited evidence, particularly around the quantification of the relative contribution of carcasses to onward transmission of the virus, and of the completeness of carcass removal. Due to the combined sparsity of data and high uncertainty, the conclusions of this risk assessment may change as new evidence becomes available. There is preliminary evidence from Continental Europe that carcass removal may reduce the spread of infection where mitigation of the potential negative impacts is feasible (1) but more detailed information is not yet available.

2. Risk question:

What is the change in likelihood of onward transmission of high pathogenicity avian influenza (HPAI) HPAIV H5N1 to other wild birds, other wildlife, and poultry and other captive birds, if carcasses of wild birds believed to have died of HPAI H5N1 are removed in the event of mass mortality?

3. Background

The UK and other European countries have been experiencing their largest ever avian influenza outbreak in 2021/2022. At the end of the 2021/2022 outbreak season (30th September 2022), Great Britain had reported 152 confirmed outbreaks in poultry and other captive birds (England: 134; Scotland: 11; Wales: 7) and 1,727 findings in wild birds (England: 1,052; Scotland: 606; Wales: 69). Mass mortality has been observed in wild bird populations in Great Britain, including seabirds (e.g. in gannet colonies in coastal areas during the breeding season) and waterfowl (e.g. Svalbard barnacle geese on the Solway Firth).

The question of whether bird carcasses should be removed when mass mortality events occur in order to prevent or reduce onward transmission of the virus, has been raised by the Scottish Avian Flu Wild Bird Task Force led by NatureScot, and the England & Wales Avian Influenza Wild Bird Recovery Advisory Group. A statement from the Scientific Task Force on Avian Influenza and Wild Birds (2022) co-convened by the Convention on Migratory Species (CMS) and the United Nations Food and Agriculture Organization, available online at https://www.woah.org/app/uploads/2022/03/avian-influenza-0.pdf, advises that removal and disposal of carcasses may be deemed appropriate, depending on national legislation, and outlines risk assessment considerations for each incident where carcass removal is considered.

4. Legislation, definitions and assumptions

Avian influenza is a notifiable animal disease in Great Britain (GB). The Notifiable Avian Disease Control Strategy for Great Britain and Mitigation strategy for avian influenza in wild birds in England and Wales outline the strategies to prevent HPAI incursion and the measures to control an outbreak should the disease be confirmed. Animal health and wildlife conservation are devolved matters. The current legislation for England, Scotland and Wales does not mandate control measures for HPAI in wild birds.

4.1 HPAI surveillance and control in wild bird populations in GB.

APHA carries out year-round avian influenza surveillance of dead wild birds submitted via public reports and warden patrols across Great Britain on behalf of Defra, Welsh Government and Scottish Government (1). Findings are reported on a weekly basis.

4.2 Assumptions

- The current risk level for avian influenza in Great Britain will influence the background risk of HPAIV H5N1 being present in the wild bird population. The likelihood of HPAI H5N1 occurring within a local bird population will be influenced by the general risk level for GB, and also by species susceptibility (2), season (3), and proximity to cases in wild birds and poultry or other captive birds. Current disease control zones for poultry and other captive birds can be viewed on the Animal and Plant Health Agency (APHA) interactive map. **This risk assessment assumes that mass mortality due to HPAI H5N1 has already occurred within one or more wild bird populations in GB**. This risk assessment aims to assess how the risk of onward transmission of HPAIV H5N1 virus to other birds and animals is affected by removal of wild bird carcasses. This document is intended to provide evidence to support decision making about whether carcass removal should be carried out, but other considerations should also be taken into account in making this decision:
    - Transport and disposal of carcasses is not included in this risk assessment. It is assumed that carcass disposal is carried out in accordance with the appropriate Animal By-Products (ABP) regulations, but there are potential risks of transmission from removal and transport of dead birds. Collection of carcasses for removal within the original location is included in the risk assessment.
    - Similarly, the potential for human infection with HPAI H5N1 is not included in this risk assessment, but is an important consideration in decisions about whether to conduct carcass removal. Information about the risks to human health is available at https://www.gov.uk/government/collections/avian-influenza-guidance-data-and-analysis. Guidance for people working with infected poultry is available and is also likely to be relevant for people working with infected wild birds. It is assumed that guidance from public health professionals will be included in decision making.
- Quantitative definitions are not provided for “mass mortality”. In the event of an outbreak, the numbers of dead wild birds can be very high, for example as observed in Svalbard barnacle geese on the Solway Firth in winter 2021-22. This risk assessment is not intended to address sporadic bird deaths due to HPAI H5N1, but to support decision making in situations where large numbers of HPAIV H5N1-infected carcasses are present within a defined location and carcass removal may be considered.
- Local wild bird density at locations where mass mortality has occurred is an important consideration for the likely effectiveness of carcass removal, and is not defined quantitatively for the purposes of the risk assessment. Areas of high bird density would be where large numbers of birds gather in a limited area e.g. to nest or feed. Low density areas are where few birds are present and do not congregate together.
- While mass mortality is likely to comprise birds of the same species, and usually species which gather in large groups, in the event of mass mortality due to HPAI H5N1, we assume that mortality of all wild birds of any species due to HPAI H5N1 within the local area is part of the same event for the purposes of decision-making around carcass removal.
- The spread of HPAI H5N1 to scavenger species, including birds and other wild carnivores, is considered, but the risk assessment does not address removal of carcasses other than wild birds.
- Carcass removal is the only mitigation considered in this risk assessment, in order to permit comparison of risk levels with and without carcass removal. Other mitigation options are in any case limited in natural habitats. The details of carcass removal (e.g. location, frequency of removal, area covered, time from death of birds to removal) are not defined for the purposes of the risk assessment as they are likely to be subject to local variation, depending on the circumstances of the mass mortality event.
- Carcass removal is unlikely to result in 100% of carcasses removed due to ongoing mortality, natural movement of carcasses, unobserved carcasses, carcasses at sea yet to

wash up, potentially challenging topography and considerations of cost and feasibility. It is assumed that carcass removal will reduce the number of carcasses remaining in the environment but will not remove all carcasses or eliminate local environmental contamination, and therefore will not eliminate the risk of transmission.
- Health and safety considerations of collecting carcases are a priority while HPAI H5N1 remains an infection of birds. However, in the event of the virus mutating to cause more frequent infections in humans or other mammals, this risk assessment would need to consider the risk to public health, and would be updated accordingly in collaboration with public health agencies.

5. Hazard identification

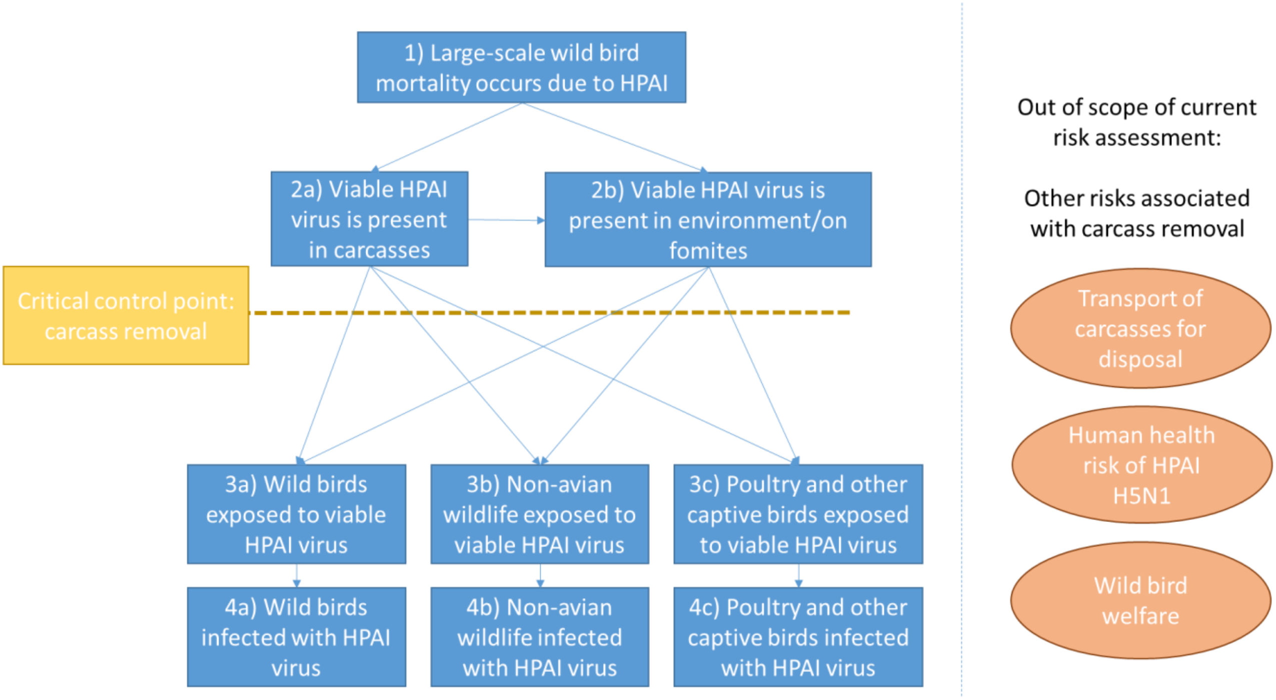
The hazard of interest is: Highly pathogenic avian influenza (HPAI) virus H5N1.

HPAI H5N1 is the hazard of interest, but some evidence included in the risk assessment relates to other HPAI H5 strains (mainly H5N8) when no relevant information is available for H5N1. Where evidence relates to a subtype other than H5N1, this will be made clear throughout the document.

6. Risk assessment

6.1 Potential risk pathway(s).

Figure 1: Risk pathway diagram to address the question: *What is the change in likelihood of onward transmission of HPAI H5N1 to other wild birds, other wildlife, and poultry and other captive birds, if carcasses of wild birds believed to have died of highly pathogenic avian influenza (HPAI) H5N1 are removed in the event of mass mortality?*



Two major routes of exposure and infection are considered: direct exposure via direct contact with infected carcasses (node 2a risk pathway – see Figure 1) and indirect exposure via contaminated environments or fomites (node 2b). Both routes have been considered in combination in the assessment of risk for nodes 3a, 3b and 3c, as exposure will occur via both direct and indirect routes.

In this VRA, it is assumed that node 1 has already occurred. The inclusion of this node is for purposes of clarity and for future outbreak assessments. From node 2a and 2b onwards, it is assumed that all carcasses referred to in the pathway are dead birds which have succumbed to HPAI H5N1.

Carcass removal is considered as a mitigation measure from nodes 3a-3c onwards.

Likelihood levels for each pathway were determined using matrix multiplication of likelihood levels for each node, as defined by Gale et al. (4). Within nodes, the likelihood for each node was calculated using matrix multiplication (i.e. the lowest level taken) when the steps within the node were subsequent and in series, but was calculated additively (i.e. the highest level taken) when alternative parallel paths were available (in this risk assessment, where direct and indirect exposure could both occur simultaneously). Matrix multiplication was used to combine all nodes with the exception of the following combinations, which were calculated additively:

- 3a.1 and 3a.2
- 4a.3 and 4a.4
- 3b.1 and 3b.2
- 4b.3 and 4b.4
- 3c.1 and 3c.2
- 4c.3 and 4c.4

6.2 **Introduction and exposure pathways:** Estimation of each risk pathway, summary of risk factors, mitigation factors, uncertainties, assumptions, risk estimate and level of confidence.

Risk Pathway (Nodes)	Risk Factors	Available Evidence	Uncertainty/Variability	Potential Mitigating Factors or Control Measures	Likelihood estimate
Node 1: Likelihood that mass wild bird mortality occurs from HPAI H5N1					NA – It is assumed that this step has occurred.
1.1	Likelihood that mass wild bird mortality occurs depends on: Likelihood of mortality from infection.	Mass wild bird mortality associated with HPAI has been reported for a number of species in GB. In particular, this has included seabird species whilst present in GB breeding colonies (e.g. gannets), aquatic species overwintering in GB (e.g., barnacle geese), and corvids at roosting sites. Different virus strains may result in varying levels of mortality in wild birds, depending on the strain present within the population (5) and species susceptibility. A higher viral dose at the time of infection may also increase the likelihood of mortality. Mass mortality is more likely to be observed in social species of birds that gather in large groups. Mass mortality events may involve more than one species e.g., large numbers of carcasses of one species (e.g., seabirds) and small numbers of associated carcasses of other species (e.g., raptors).	NA – It is assumed that this step has occurred.		NA – It is assumed that this step has occurred.
Node 2a: Likelihood that viable HPAI H5N1 virus is present in carcasses that remain in the environment.					**High**
2a.1	Likelihood that infected carcasses are present in the environment.	Where mass mortality has occurred, infected birds and carcasses will remain in the environment in the absence of interventions, with the potential for survival of viable virus. Wild bird carcasses may remain at the location where death occurred or may move to other locations through natural processes (e.g., currents, wind, tides, movement by wild or domesticated animals and birds – especially carrion eaters).	Uncertainty is low but some variability due to species and environmental conditions.	NA	Very high
2a.2	The likelihood that the virus persists in carcasses for long enough to create a risk of onward exposure.	HPAI H5N1 virus survives well in carcasses of infected birds. The level of virus present in carcasses and associated tissues declines with increasing time after death occurs. Prolonged survival (up to 240 days under certain environmental conditions) has been reported (6,7). Virus survival varies between different types of tissues in the carcasses of birds which have died from HPAI H5N1. From	Medium uncertainty about how virus survival in carcasses varies with environmental conditions.	NA	High

Risk Pathway (Nodes)	Risk Factors	Available Evidence	Uncertainty/Variability	Potential Mitigating Factors or Control Measures	Likelihood estimate
		experimental work in chickens, virus persists for the shortest time in liver (20 days at 4°C) and the longest in feathers (240 days at 4°C), with intermediate survival in muscle tissue (160 days at 4°C) (7). Virus infectivity persists in detached duck feathers for up to 160 days at 4°C (6). It is possible that feathers which have detached from carcasses may act as fomites with the potential to move over long distances, and that detached feathers may still remain in the environment if carcasses are removed. Virus is inactivated more slowly at lower temperatures. For example, virus can survive in chicken feathers for 240 days at 4°C and for 30 days at 20°C (7). Viral loads in carcasses decrease over time as functions of temperature and time. Low air and water temperatures in Great Britain for large parts of the year will prolong virus survival in carcasses. Temperature in natural environments will vary widely depending on local conditions, diurnal variation, etc. making it more challenging to predict virus survival under these conditions. Virus survival in carcasses may vary between different species of wild birds, depending for example on the viral load at the time of death, but no evidence is available currently for wild bird species. The state of decomposition of carcasses will influence the likelihood of viable virus remaining present. Once carcasses have reached an advanced state of decomposition (i.e. skeletonisation), limited infective virus will remain (8). The time taken for this process to occur will vary with environmental conditions. There is evidence that the thermal and pH stability of HPAIV H5N1 varies between different strains of the virus (9,10). Rates of virus inactivation in carcasses may therefore differ depending on the virus strain present.	High variability according to environmental conditions and level of decomposition of carcasses.		
Node 2b: Likelihood that viable HPAI H5N1 virus is present in the environment/on fomites					**High**

Risk Pathway (Nodes)	Risk Factors	Available Evidence	Uncertainty/Variability	Potential Mitigating Factors or Control Measures	Likelihood estimate
2b.1	Likelihood that infected birds (dead or alive) are present in the environment.	Where mass mortality has occurred, infected birds and carcasses will be present in the environment, with the potential for environmental contamination to occur. Carcasses may remain at the location where death occurred or move to other locations via natural processes, such as tides, currents or scavenging, potentially contaminating other sites.	Medium – there is limited evidence around the fate of wild bird carcasses remaining in the environment.	NA	Very high
2b.2	Likelihood that infected birds (dead or alive) release virus into the environment.	HPAI H5N1 is shed in the faeces of live infected birds, resulting in environmental contamination (11). The proportion of viral environmental contamination resulting from the presence of dead birds is not known, but is assumed that there is some potential for carcasses to contaminate the immediate environment with HPAI H5N1, including by feathers. Body fluids may leak as decomposition of carcasses progresses, (8), resulting in contamination of the environment.	Low uncertainty that both live birds and carcasses will result in some degree of environmental contamination, but high uncertainty regarding their relative contribution.	NA	High
2b.3	The likelihood that the virus persists in the environment for long enough to create a risk of onward exposure.	HPAIV is inactivated more rapidly at higher temperatures. Influenza A viruses can remain infective for several months in surface water samples at low temperatures (12,13) and waterborne transmission appears to be the primary driver of AI infection in aquatic birds (14,15), although this evidence is not specific to HPAIV H5N1. Laboratory studies on survivability of H5N1 found that HPAIV H5 N1 strains behaved similarly to LPAI viruses, with all viruses surviving longest at lower temperatures, lower salinity (9), and a neutral or slightly alkaline pH (16). There is some evidence that the thermal and pH stability of HPAI H5N1 varies between different strains of the virus (9,10). Rates of virus inactivation in carcasses and the environment may therefore differ depending on the virus strain present. The temperature, humidity and surface material of the environment or fomites all influence the persistence of HPAI H5N1. Prolonged survival occurred in chicken faeces and soil and on glass and galvanized metal, but survival on wood and concrete was limited (17). HPAI H5N1 can remain infective in wet poultry faeces for up to 8 weeks at 4°C, but viruses are inactivated by drying of faeces (18). HPAI H5N1	Medium uncertainty as there is good evidence that environmental transmission is important. High variability depending on environmental conditions.	NA	High

Risk Pathway (Nodes)	Risk Factors	Available Evidence	Uncertainty/Variability	Potential Mitigating Factors or Control Measures	Likelihood estimate
		can also survive on plastic surfaces and human skin and shows prolonged survival compared to other virus subtypes, suggesting a higher risk of transmission via contact with fomites (19).			
Node 3a: Likelihood that wild birds are exposed to HPAI H5N1 virus					Without mitigation: **High (in high bird density areas)** **Medium (in low bird density areas)** With mitigation: **High (in high bird density areas)** **Low (in low bird density areas)**
3a.1	Likelihood of direct contact of live birds with at least one carcass.	Large numbers of carcasses are likely to be present within affected areas in the event of mass mortality due to HPAI. A higher number of carcasses in the vicinity of susceptible live birds will increase the likelihood of exposure occurring via direct contact between live and dead birds. Closer proximity of carcasses to susceptible wild birds may increase the likelihood of direct or indirect exposure. Wild bird carcasses may remain at the location where death occurred or may move to other locations through natural process (e.g., currents, wind, tides). Natural movement of carcasses may reduce the likelihood of direct exposure of birds at the original location but could carry the virus to new locations, increasing the number of birds exposed. Limited evidence is available about natural movement of carcasses, although a study of carcass drift in the Gulf of Mexico found that carcasses of seabirds that die further offshore are less	Medium uncertainty – there is some evidence about bird behaviour and contact between wild birds (mainly re. scavenging), but limited information on contact with carcasses.	Carcass removal would reduce the number of carcasses present in the environment, potentially reducing the risk of direct contact between live and dead birds, particularly where carcasses are located close to live birds. However, the completeness and timeliness of carcass removal is likely to be highly variable depending on local conditions. Carcass removal could disturb birds, particular in areas of high density such as nesting sites, and result in increased movement and moving within the site, or increased movement of live birds to other	Without mitigation: High (in high bird density areas) Medium (in low bird density areas) With mitigation: Medium(in high bird density areas) Low (in low bird density

Risk Pathway (Nodes)	Risk Factors	Available Evidence	Uncertainty/Variability	Potential Mitigating Factors or Control Measures	Likelihood estimate
		likely to reach the shore (20). Direct contact between live birds and carcasses will be greatly affected by the birds' natural behaviour (e.g., nesting, social interaction, aggregation), whereby live birds may come into direct contact with carcasses (e.g. in high bird density areas such as nesting sites). Exposure of wild birds to HPAIV H5N1 through direct contact with carcasses may be more likely to occur when carcasses are present in areas where there is a high density of birds (e.g. nesting sites) than in areas of lower bird density (e.g., beaches). Feeding behaviour is also particularly important. Scavenging of HPAI H5N1-infected carcasses may occur from birds of either the same or different species as the deceased bird, resulting in exposure. For example, highest likelihood of exposure may be for scavengers such as raptors, gulls, skuas, and corvids. Scavenging may reduce the likelihood of exposure of other birds through a reduction in carcass material but at increased risk to the scavenger (21).		sites. This could cause increased transmission locally due to increased bird movement and contact rates and transmission of HPAI to new areas through movement of infected birds, It may also interrupt natural behaviour of birds, who may already be subject to other stressors, with unintended negative consequences for health. Carcass removal may reduce the density of bird populations at the carcass location if birds would gather to scavenge on carcasses. Carcass removal may have a greater effect on reducing direct exposure if conducted in high density areas, but may carry higher risks of disturbance of birds.	areas)
3a.2	Likelihood of indirect contact between live birds and contaminated environments.	Environmental contamination is more likely to occur in areas where high numbers of live birds and/or carcasses are present. Indirect contact between live birds and environments contaminated by carcasses will be affected by the birds' natural behaviour (e.g. feeding, nesting, roosting, washing, and social interaction). Any behaviour which brings more birds into highly contaminated environments has the potential to increase the likelihood of exposure. This will vary greatly between species, with some examples of high risk species including: congregating winter wildfowl and waders, breeding seabirds, and released gamebirds.	High uncertainty around the level of contamination in the environment and the relative contributions to contamination from carcasses vs. other sources (e.g., live birds).	Carcass removal would reduce the number of carcasses present in the environment in proximity to susceptible birds, potentially reducing the risk of indirect contact. However, the relative contribution of carcasses to levels of environmental contamination, which appears to be the main route for transmission to other aquatic birds, is unknown. The background level of contamination from live birds is likely to be the main source of exposure. Large numbers of carcasses within a small area are likely to attract scavenging bird species, potentially resulting in increased indirect contact via the environment as well as increased direct contact via	Without mitigation: High (in high bird density areas which are likely to be more contaminated) Medium (in low bird density areas which are likely to be less contaminated) With mitigation: High (in high

Risk Pathway (Nodes)	Risk Factors	Available Evidence	Uncertainty/Variability	Potential Mitigating Factors or Control Measures	Likelihood estimate
				scavenging. Carcass removal would help to prevent scavenging birds from congregating at sites of mass mortality and encountering the virus in the environment. More rapid carcass removal could also reduce the level of environmental contamination from carcasses – the benefits of removal are likely to be limited if carcasses are already heavily decomposed. In low density areas, where background environmental contamination is likely to be lower, carcass removal may be more effective at reducing overall viral loads than in high density areas, where the environment is likely to have been contaminated heavily by live birds. In these cases exposure risk is inherently lower as the population density is lower, unless carcasses and live birds cluster unevenly across these landscapes. Carcass collection itself could lead to increased contamination as fomite transmission on footwear, clothing and equipment could increase virus dissemination within the site. This will vary with the degree of contamination, feasibility of good biosecurity and environmental conditions.	bird density areas which are likely to be more contaminated) Low (in low bird density areas which are likely to be less contaminated)
Node 4a: Likelihood that wild birds are infected with HPAI H5N1 virus.					**Without mitigation: High** **With mitigation: High**

Risk Pathway (Nodes)	Risk Factors	Available Evidence	Uncertainty/Variability	Potential Mitigating Factors or Control Measures	Likelihood estimate
4a.1	Likelihood that the wild bird species is susceptible to infection.	HPAIV H5N1 infection has been identified in a wide range of wild bird species in the UK (2). Susceptibility to infection, clinical outcomes and viral shedding all appear to vary between different wild bird species (22,23). In common with most infectious diseases, the likelihood of infection and poorer clinical outcomes from HPAI H5N1 is higher in birds with poorer underlying health status. This may be due to a range of factors, such as stress, nutritional status, exposure to pollutants (24), concurrent infection with other pathogens. Previous AI virus exposure may reduce susceptibility to infection and disease with HPAIV H5N1, which could reduce mortality but also increase the duration of viral shedding by partially immune birds (5).	Medium uncertainty – a range of wild bird species have been shown to be infected with HPAIV H5N1. High variability between wild bird species.	Carcass removal will not affect host susceptibility, but could be targeted to areas where particularly susceptible or important species are present. Stress due to disturbance from carcass removal has the potential to increase the birds' susceptibility to infection.	Without mitigation: High With mitigation: High
4a.2	Likelihood that virus strain is infective in wild birds.	Different strains of HPAIV H5Nx can have varying levels of infectivity and pathogenicity (25,26) and may result in varying likelihood of infection in wild birds, depending on the strain present within the population (5).	High	Carcass removal will not affect the virus strain present.	Without mitigation: Very high With mitigation: Very high
4a.3	Likelihood that exposure of live wild birds to infected carcasses results in infection in wild birds.	The likelihood of infection through direct transmission may increase with greater closeness and duration of contact with infected carcasses. Scavenging has been found to be an effective route for infection. In great skuas, scavenging of other bird species on migration (e.g., geese) is hypothesised to have been a route of infection which then led to further spread between great skuas within their breeding colonies (27). A higher viral load generally results in more effective transmission of viruses. This is the case for most viral disease across humans and animals, but no current evidence has been identified to quantify this for HPAIV H5N1 in wild birds. The viral load present in carcasses is likely to be influenced by the time since death, the viral load in the bird at the time of death, and environmental conditions such as temperature.	Medium uncertainty – there is good evidence for infection via scavenging but limited evidence for likelihood of infection from others forms of direct contact.	Carcass removal is likely to reduce the closeness and duration of contact between wild birds and carcasses, including scavenging. Carcass removal may reduce the total viral biomass associated with carcasses but may have limited impact on environmental contamination. Carcass removal is likely to have the greatest impact on reducing the viral load present in carcasses if carried out as soon as possible after death, when the levels of virus present in carcasses is highest.	Without mitigation: High With mitigation: High

Risk Pathway (Nodes)	Risk Factors	Available Evidence	Uncertainty/Variability	Potential Mitigating Factors or Control Measures	Likelihood estimate
4a.4	Likelihood that exposure of live wild birds to environmental contamination results in infection.	Indirect, waterborne transmission appears to be the primary driver of AI infection in aquatic birds rather than direct contact between live birds (14,15,28). The environmental contamination driving this route of infection is likely to come mainly from live birds rather than carcasses, although there is no data to quantify this at present. A higher viral load generally results in more effective transmission of viruses. This is the case for most viral disease across humans and animals, but no current evidence has been identified to quantify this for HPAIV H5N1 in wild birds. Viral load in the environment will be influenced by local conditions, such as time from contamination, temperature and salinity, as described in Node 2b.	High uncertainty due to lack of experimental data on infection of wild bird species via indirect exposure, and lack of evidence around proportion of environmental contamination originating from carcasses compared to live birds.	Carcass removal can only reduce the level of environmental contamination originating from carcasses. It will not reduce environmental contamination originating from other sources (mainly live birds), which is likely to be the source of the majority of the viral load in the environment, particularly in areas of high bird density. Carcass removal is therefore likely to result in the greatest proportional reduction in the overall viral load present in the environment originating from carcasses, and potentially the likelihood of infection, if carried out in areas with lower background levels of environmental contamination from live birds (most likely areas with lower bird density).	Without mitigation: High With mitigation: High
Node 3b: Likelihood that carnivorous mammalian wildlife species are exposed to HPAI H5N1 virus.					Without mitigation: **High** With mitigation: **Medium**
3b.1	Likelihood of direct contact between wildlife and infected carcasses.	Large numbers of carcasses are likely to be present within affected areas in the event of mass mortality due to HPAI. A higher number of carcasses in the vicinity of susceptible wildlife could potentially increase the likelihood of exposure occurring via direct contact between wildlife and carcasses. Closer proximity of carcasses to susceptible wildlife may	High uncertainty due to lack of data on interactions between wildlife and wild bird carcasses.	Carcass removal would reduce the number of carcasses present in the environment, particularly where carcasses are located in areas with high wildlife density, potentially reducing the risk of direct contact between wildlife and carcasses,	Without mitigation: High With mitigation: Medium

Risk Pathway (Nodes)	Risk Factors	Available Evidence	Uncertainty/Variability	Potential Mitigating Factors or Control Measures	Likelihood estimate
		increase the likelihood of direct or indirect exposure. Wild bird carcasses may remain at the location where death occurred or may move to other locations through natural process (e.g., currents, wind, tides). Natural movement of carcasses may reduce the likelihood of direct exposure of birds at the original location but could carry the virus to new locations, increasing the number of animals exposed. Limited evidence is available about natural movement of carcasses, although a study of carcass drift in the Gulf of Mexico found that carcasses of seabirds that die further offshore are less likely to reach the shore (20). Exposure of wildlife to HPAI H5N1 from wild bird carcasses may be more likely to occur in areas where there is a high concentration of wild animals (e.g., seal haul-outs) than in areas with lower numbers of wildlife. Both direct and indirect contact between wildlife and carcasses will be affected by the animals' natural behaviour (e.g., feeding, preferred habitat, social interaction). Scavenging of HPAI H5N1-infected carcasses by carnivorous wildlife may occur, resulting in exposure. Scavenging may reduce the likelihood of exposure of other animals through a reduction in carcass material but at increased risk to the scavenger (21).		particularly due to scavenging. Carcass removal may reduce exposure more effectively if targeted in areas with high wildlife density, but these may also be the areas with the greatest potential for disturbance of wildlife by human access. Even with carcass removal, the risk is not completely mitigated since removal is unlikely to be complete.	
3b.2	Likelihood of indirect contact between wildlife and contaminated environments.	Indirect exposure to HPAI H5N1 via environmental contamination may occur, but there is a paucity of evidence quantifying the contribution of carcasses to the overall viral load within the environment, where live birds, faecal contamination and other sources will also contribute. The evidence around exposure of wildlife to HPAI H5N1 via the environment is also very limited. Environmental contamination from carcasses may be more likely to occur in areas where high numbers of carcasses are present, and the likelihood of exposure may be higher when contaminated areas are closer to wildlife habitats. Indirect contact between wildlife and environments contaminated by carcasses will be affected by the wild animals' natural behaviour (e.g. feeding, social interaction). Any behaviour which brings more wild animals into highly contaminated environments has the potential to increase the likelihood of	High uncertainty due to lack of evidence on indirect routes of exposure for wildlife.	Carcass removal would reduce the number of carcasses present in the environment in proximity to susceptible wildlife, potentially reducing the risk of indirect contact from environmental contamination. However, the relative contribution of carcasses to levels of environmental contamination is unknown. The background level of contamination from live birds is likely to be the main source of exposure via indirect contact.	Without mitigation: Medium With mitigation: Medium

Risk Pathway (Nodes)	Risk Factors	Available Evidence	Uncertainty/Variability	Potential Mitigating Factors or Control Measures	Likelihood estimate
		exposure. The likelihood of contamination will also vary between different environments e.g. still vs. running water.			
Node 4b: Likelihood that carnivorous mammalian wildlife species are infected with HPAI H5N1 virus.					Without intervention: **Medium** With intervention: **Medium**
4b.1	Likelihood that host species is susceptible to infection.	Infection of mammalian species with HPAIV H5N1 has been reported in a range of wild species, including foxes (29,30), seals (31) and mustelids (32). The susceptibility to infection and resulting clinical signs appear to vary widely between mammalian species (33). The cases reported in wildlife have been identified due to clinical disease. No estimates of the overall prevalence of infection amongst wild mammals are available in Great Britain this season. In common with most infectious diseases, the likelihood of infection and poorer clinical outcomes from HPAI H5N1 is higher in animals with poorer underlying health, co-infections and poorer nutrition (33).	Medium uncertainty. Susceptibility of some species to HPAIV H5N1 is known, but not for all potential wildlife hosts.	Carcass removal will not affect host susceptibility. Not enough is known currently about the relative susceptibility of wildlife species to infection to target carcass removal to protect higher-risk species. Stress due to disturbance from carcass removal could increase the animals' susceptibility to infection, particularly in areas with a high density of wildlife.	Without intervention: Medium With intervention: Medium
4b.2	Likelihood that virus strain is infective in wildlife.	Different strains of HPAIV H5 can have varying levels of infectivity and pathogenicity (25,26) and may result in varying likelihood of infection in wildlife, depending on the strain present within the population (5).	High uncertainty due to lack of experimental data on infection of wildlife.	Carcass removal will not affect the virus strain present or its infectivity in wildlife.	Without intervention: Medium With intervention: Medium
4b.3	Likelihood that direct exposure of wildlife to carcasses results in infection.	The likelihood of infection through direct transmission may increase with greater closeness and duration of contact with infected carcasses. Scavenging has been found to be an effective route for infection. As virus concentration and survival varies between tissues in carcasses (see 2a.2 for details), preferential consumption of certain parts of carcasses may alter the risk of infection.	High uncertainty. Some evidence for infection via scavenging but limited evidence for likelihood of	Carcass removal is likely to reduce the closeness and duration of contact between wildlife and carcasses, including scavenging. Carcass removal is likely to have the greatest impact on reducing the viral load present in carcasses	Without mitigation: Medium With mitigation: Medium

Risk Pathway (Nodes)	Risk Factors	Available Evidence	Uncertainty/Variability	Potential Mitigating Factors or Control Measures	Likelihood estimate
		A higher viral load generally results in more effective transmission of viruses. This is the case for most viral disease across humans and animals, but no current evidence has been identified to quantify this for HPAI H5N1 in wild birds. The viral load present in carcasses is likely to be influenced by the time since death, the viral load in the bird at the time of death, and environmental conditions such as temperature. The likelihood of infection through direct transmission may increase with greater closeness and duration of contact with infected carcasses. Scavenging, involving prolonged, close contact with infected carcasses, appears to be an important route for transmission of HPAI virus to wild mammals. It has been demonstrated experimentally that carnivores can become infected with HPAI H5N1 through ingestion of infected bird carcasses (29). A higher viral load generally results in more effective transmission of viruses. This is the case for most viral disease across humans and animals, but no current evidence has been identified to quantify this for HPAI H5N1 transmission to wild animals. The viral load present in carcasses is likely to be influenced by factors including the time since death, the viral load in the bird at the time of death, and environmental conditions such as temperature (see node 2a).	infection from others forms of direct contact.	within the environment if carried out as soon as possible after death, when the levels of virus present in carcasses is highest.	
4b.4	Likelihood that exposure of wildlife to environmental contamination results in infection.	An outbreak of HPAI H5N8 at a wildlife rehabilitation centre showed transmission to foxes and seals in the absence of known direct contact, suggesting that indirect contact could transmit HPAI viruses to mammalian wildlife, although no experimental data are available (34). A higher viral load generally results in more effective transmission of viruses. This is the case for most viral disease across humans and animals, but no current evidence has been identified to quantify this for HPAI H5N1 in wild birds. Viral load in the environment will be influenced by local conditions, such as time from contamination, temperature and salinity, as described in node 2b.	High uncertainty due to minimal evidence around infection via environmental contamination.	Carcass removal is likely to have the greatest impact on reducing the viral load present in the environment, and hence the likelihood of infection, if carried out in areas with lower background levels of environmental contamination from live birds. Rapid removal of carcasses found on or near areas frequented by wild mammals is likely to reduce the level of local contamination and hence the likelihood of infection.	Without mitigation: Low With mitigation: Low

Risk Pathway (Nodes)	Risk Factors	Available Evidence	Uncertainty/Variability	Potential Mitigating Factors or Control Measures	Likelihood estimate
Node 3c: Likelihood that poultry and other captive birds are exposed to HPAI H5N1 virus.					Without intervention: **Low** With intervention: **Low**
3c.1	Likelihood of direct contact between carcasses and poultry/other captive birds.	For poultry and other captive birds, unlike wild birds and mammals, their location is clearly defined and the area where direct exposure may occur is small. Direct contact between wild bird carcasses and captive birds is unlikely unless moribund wild birds access the premises and die. If death of wild birds occurs within the premises, or in a location that creates ongoing environmental contamination (e.g., water sources), carcasses may represent an ongoing risk of exposure. A higher density of poultry or other captive bird premises in the vicinity of a mass mortality event due to HPAI H5N1 could increase the likelihood of direct exposure of the captive birds, particularly if there were free-ranging poultry, but the geographical overlap of poultry premises and areas of mass mortality is not likely to be common. While mass mortality is indicative of a severe HPAI H5N1 outbreak in wild birds in the local area, the main potential for exposure of domestic birds is likely to come from live birds rather than carcasses. Registered poultry holdings close to mass mortality events could be identified, but the presence of unregistered holdings (e.g., backyard poultry) would be unknown. Effective biosecurity measures should reduce the likelihood of direct exposure to HPAIV H5N1 by preventing entry of wild birds to the premises, although implementation may be variable.	High – there is limited evidence around the likelihood of wild bird carcasses being present on poultry or other captive bird premises if mass wild bird mortality occurs. High variability depending on implementation of biosecurity measures.	Removal of sporadic wild bird carcasses found on or close to captive bird premises should be routine aspects of biosecurity. Carcass removal would reduce or eliminate any carcasses on or close to captive bird premises in the event of mass mortality, but the feasibility and safety of removal of large numbers of birds would need to be considered.	Without intervention: **Very low** With intervention: **Very low**

Risk Pathway (Nodes)	Risk Factors	Available Evidence	Uncertainty/Variability	Potential Mitigating Factors or Control Measures	Likelihood estimate
3c.2	Likelihood of indirect contact between poultry/other captive birds and contaminated environments or fomites.	In a study from the Netherlands detailing access of wild birds and mammals to a farm in a high-risk area for avian influenza virus, no direct contact was observed between wild birds and poultry, suggesting that indirect contact with areas contaminated by wild birds is the main source of exposure for poultry (35). Environmental contamination in or around poultry or other captive bird holdings is more likely to originate from live birds than from carcasses, due to movement of and ongoing faecal contamination from live birds, which will not occur with carcasses. The likelihood of indirect exposure (e.g., via other wild birds acting as fomites, or environmental contamination in the vicinity of the premises) may increase with increasing proximity of wild bird carcasses to poultry or other captive bird premises, or areas with a high likelihood of fomite contamination (e.g., feed or bedding suppliers). Large numbers of carcasses are likely to be present within affected areas in the event of mass mortality due to HPAI. The number of carcasses in the vicinity of poultry or other captive birds may affect the likelihood indirect exposure via environmental or fomite contamination. Rodents and wild birds may also act as intermediaries, carrying HPAI H5N1 into captive bird premises from contact with carcasses. Effective biosecurity measures should reduce the likelihood of indirect exposure to HPAI H5N1 via fomites or the environment through cleansing and disinfection, although implementation may be variable. Free-ranging birds are more likely to come into contact with contaminated environments than housed birds.	High – there is limited evidence for the contribution of carcasses to overall environmental contamination.	Removal of any wild bird carcasses found on or close to captive bird premises should be routine aspects of biosecurity. Carcass removal would reduce or eliminate any carcasses on or close to captive bird premises in the event of mass mortality, but contamination of fomites or the environment is most likely to come from live birds. Removal of wild bird carcasses, rodent control, preventing wild bird access, and effective cleansing and disinfection, should be routine aspects of biosecurity. If personnel involved with mass carcass collection also have contact with poultry or other captive birds, it is possible that they may carry the infection on clothing or other equipment. This can be mitigated through good biosecurity.	Without intervention: **Low** With intervention: **Low**
Node 4c: Likelihood that poultry and other captive birds are infected with HPAI H5N1 virus.					Without intervention: **High** With intervention: **High**

Risk Pathway (Nodes)	Risk Factors	Available Evidence	Uncertainty/Variability	Potential Mitigating Factors or Control Measures	Likelihood estimate
4c.1	Likelihood that host species is susceptible to infection.	While the pathogenicity of HPAI H5N1 varies between domestic bird species, most common poultry species are susceptible to infection (36). The susceptibility of unusual captive bird species (e.g., in zoo collections) may not be known.	Medium – good evidence around susceptibility of poultry but not for all captive bird species.	Carcass removal will not change the susceptibility of poultry and other captive birds to HPAIV H5N1.	Without intervention: High With intervention: High
4c.2	Likelihood that virus strain is infective in poultry/captive birds.	HPAIV H5N1 is capable of infecting a range of poultry species, even though the clinical signs displayed may vary. (37)	Medium – good evidence around infectivity of HPAI H5N1 in poultry but not for all captive bird species.	Carcass removal will not change the infectivity of the virus strain.	Without intervention: High With intervention: High
4c.3	Likelihood that direct exposure of poultry or other captive birds to carcasses results in infection.	The likelihood of infection through direct transmission is likely to increase with increasing closeness and duration of contact with infected carcasses. Close direct contact with wild bird carcasses during a mass mortality event is most likely to occur on poultry or captive bird premises if wild birds are able to gain access and die on the premises in an area where the dead bird is accessible to captive birds.	Medium uncertainty - extensive evidence around experimental infection of birds, but minimal experimental data about infection via contact with wild bird carcasses.	Removal of carcasses on or in close proximity to captive bird premises could reduce the closeness and duration of direct exposure and reduce the likelihood of infection.	Without intervention: High With intervention: High
4c.4	Likelihood that exposure of poultry or other captive birds to environmental contamination from carcasses is sufficient to receive infective dose	As most HPAIV H5N1 infections in poultry appear to occur through indirect contact with live birds (35), the duration and type of contact with contaminated environments or fomites may influence the likelihood of infection.	Medium uncertainty due to limited experimental evidence around infection via environmental contamination.	Removal of carcasses on or in close proximity to captive bird premises could reduce the intensity and duration of indirect exposure and reduce the likelihood of infection.	Without intervention: Medium With intervention: Medium

Likelihood that other wild birds are infected with HPAI H5N1 virus due to a mass mortality event:	Without mitigation: **High (in high bird density areas)** **Medium (in low bird density areas)**

	With mitigation: **High (in high bird density areas)** **Low (in low bird density areas)**
Likelihood that carnivorous mammalian wildlife species are infected with HPAI H5N1 virus due to a mass mortality event:	Without intervention**: Medium** With intervention**: Medium**
Likelihood that poultry and other captive birds are infected with HPAI H5N1 virus due to a mass mortality event:	Without intervention**: Low** With intervention: **Low**

6.3 **Final risk estimation**

Summary

Table 1: summary table of likelihood estimates for each node in the risk pathway (see Figure 1).

Risk Pathway (Nodes)	Likelihood estimate
Node 1: Likelihood that mass wild bird mortality occurs from HPAI H5N1	**N/A (assumed to have occurred)**
Node 2a: Likelihood that viable HPAI H5N1 virus is present in carcasses that remain in the environment.	**High**
Node 2b: Likelihood that viable HPAI H5N1 virus is present in the environment/on fomites	**High**
Node 3a: Likelihood that wild birds are exposed to HPAI H5N1 virus	Without carcass removal: **High (in high bird density areas)** **Medium (in low bird density areas)** With carcass removal: **High (in high bird density areas)** **Low (in low bird density areas)**
Node 4a: Likelihood that exposed wild birds become infected with HPAI H5N1 virus.	Without carcass removal: **High** With carcass removal: **High**
Node 3b: Likelihood that carnivorous mammalian wildlife species are exposed to HPAI H5N1 virus.	Without carcass removal: **High** With carcass removal: **Medium**
Node 4b: Likelihood that exposed mammalian wildlife species are infected with HPAI H5N1 virus.	Without carcass removal: **Medium** With carcass removal: **Medium**
Node 3c: Likelihood that poultry and other captive birds are exposed to HPAI H5N1 virus.	With carcass removal: **Low** Without carcass removal: **Low**
Node 4c: Likelihood that exposed poultry and other captive birds are infected with HPAI H5N1 virus.	Without carcass removal: **High** With carcass removal: **High**

The nodes where the implementation of carcase removal resulted in a different likelihood are:

- Node 3a, the likelihood that wild birds are exposed to HPAI H5N1 virus, which is driven by the difference in the likelihood of contact of live birds with infected carcases, and the difference in the likelihood of contact of live birds with contaminated environment, but only in lower density areas.

- Node 3b, the likelihood that mammalian wildlife species are exposed to HPAI H5N1 virus, which is driven by the difference in the likelihood of direct contact between wildlife and infected carcases. However, this difference is not reflected in the overall likelihood level for wildlife.

In areas where birds congregate leading to high bird density (e.g., seabird nesting sites), carcass removal is likely to be least effective at reducing the overall viral load due to extensive environmental contamination which has already occurred from both live and dead birds. Indirect transmission due to environmental contamination appears to be the main driver of infection for wild birds. Human access to collect carcasses at high density locations is also most likely to result in disturbance of live wild birds, resulting in increased movement of birds, both at the original location and to other sites, with potential for greater spread of infection and increased susceptibility of birds due to stress, although this will vary by species and location. However, there is some preliminary evidence from Continental Europe that carcass removal may reduce the spread of infection where mitigation of the potential negative impacts is feasible (1). Carcass removal is likely to have the greatest impact on reducing the viral load present in carcasses if carried out as soon as possible after death, when the levels of virus present in carcasses is highest.

In areas of lower bird density (e.g., beaches), background levels of environmental contamination are likely to be lower, hence removal of carcasses may have more relative impact on the local viral load in carcasses and the environment, if it is feasible for it to be performed under good biosecurity conditions that does not cause wider viral dissemination. The likelihood of disturbance to birds and other wildlife species is also lower. However, carcass removal is unlikely to remove all dead birds due to ongoing mortality, natural movement of carcasses (e.g., with currents or tides), and practical difficulties of ensuring complete removal, reducing its effectiveness at preventing further transmission. Scavenging appears to be the main route where direct transmission from infected carcasses to susceptible birds and wildlife is likely to occur. Carcass removal may therefore help to reduce the likelihood of infection in wild birds and mammals which scavenge on wild bird carcasses to a greater extent than in the wild bird population as a whole, where the risk of transmission from live birds or the environment likely outweighs the risk from carcasses.

The likelihood of infection of poultry and other captive birds from wild bird carcasses is low in comparison to the likelihood of infection from live wild birds, whether carcasses are removed or not in locations where mass mortality has occurred. Removal of any wild bird carcasses found in or close to poultry or other captive bird premises is recommended as part of routine biosecurity measures, following guidance for disposal of wild bird carcasses.

The risk assessment cannot cover every scenario, but the information provided is intended to inform decision making about carcass removal in different situations. For example, carcase removal in the case of mass mortality among gathered migratory waterfowl in wetland areas during the winter months is likely to be of limited efficacy in preventing onward transmission to other waterfowl in the local area, as the environment will be heavily contaminated by live, infected birds and the virus will persist in freshwater for a prolonged period at low temperatures. Removal may however help to prevent transmission to scavenging birds and animals which would feed on the carcasses. In a different scenario where large numbers of freshly dead seabirds wash up on a beach with few live birds present during the summer months, removal of carcasses is likely to be more beneficial in preventing onward transmission via indirect contact.

Environmental contamination should be minimal if the carcasses are removed quickly, and any virus present in the environment will be inactivated rapidly if the ambient temperature is high. The carcasses themselves would be the main reservoir of infection in this scenario, and removal would have the greatest impact on the overall infection pressure within the local area.

This risk assessment has not considered the potential human health risks from HPAIV H5N1 (see https://www.gov.uk/government/collections/avian-influenza-guidance-data-and-analysis), the risks associated with transport and disposal of carcasses, the feasibility of performing carcass removal, the potential impact on bird welfare, or other risks to human and animal health from large numbers of wild bird carcasses remaining and decomposing in the environment. These considerations must be factored into local decisions about whether to proceed with carcass removal.

Consequences of onward transmission of HPAI H5N1 from carcasses

The consequences and impact of further spread of HPAIV H5N1 from wild bird carcasses will vary between the target populations considered in this risk assessment.

For wild birds, HPAI is already a major concern in a number of species, including in species of conservation concern. For rare species (e.g., raptors such as sea eagles or osprey), the conservation impact of even a small number of deaths due to HPAI H5N1 could be considerable. Infection in more common species (e.g., gulls) may have a lower impact for conservation, but would still enable the virus to persist in the population, potentially resulting in further mass mortality.

The current strain of HPAIV H5N1 is poorly adapted to infect mammalian hosts, although it is possible that the virus could adapt to infect mammals more effectively. While infection in mammalian wildlife does occur and can result in severe disease and death, there is no evidence that it is occurring frequently in GB at present.

Most HPAIV H5N1 infections in poultry and other captive birds are thought to originate from direct or indirect transmission from live wild birds rather than carcasses. When infection occurs, the consequences for the poultry sector are severe, due to losses from the disease and the implementation of control measures. Infection in rare or valuable captive bird species (e.g., in zoo collections) could have major financial, emotional and conservation impacts. Information about confirmed findings of influenza of avian origin in non-avian wildlife as available online.

Summary of key uncertainties

The overall uncertainty around the conclusions of this risk assessment is HIGH. The key uncertainties driving this are:

- Limited evidence around the comparative likelihood of transmission arising from direct contact with carcasses (which is likely to be reduced by carcass removal) in comparison to the likelihood of transmission via environmental contamination (where carcass removal would result in an unknown but smaller reduction).
- Limited evidence for the likelihood and routes of infection through direct contact with wild bird carcasses.
- Limited evidence for the proportional contribution of carcasses and live birds to environmental contamination, and to the overall risk of onward indirect transmission of HPAIV H5N1.

The evidence base for transmission of HPAIV H5N1 from wild bird carcasses is very limited at present. Further scientific work is required to address some of the fundamental questions arising from this risk assessment, particularly quantification of virus in carcasses and the environment. As a result of the limited data available, a more detailed, quantitative risk assessment cannot be conducted with the evidence currently available.

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