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ANIMAL HEALTH **RISK ANALYSIS** ASSESSMENT No. **3**

CHINESE-ORIGIN H7N9 HIGHLY PATHOGENIC AVIAN INFLUENZA

Spread in poultry and human exposure

SUMMARY

- The likelihood of the Chinese-origin H7N9 HPAI virus spreading from known affected areas to currently **unaffected areas of China** during the period May to September 2017 through:
  - Formal or informal **live bird trade** can be considered as **moderate, with low uncertainty,** for juvenile and adult chickens, **low** for day-old chicks and other poultry (ducks, geese, quail…), **with low and medium uncertainties respectively**.
  - Formal or informal **trade of poultry products** can be considered as **low** for frozen chicken carcasses or meat and feathers, **with low uncertainty,** and **negligible** for eggs, **with medium uncertainty**.
  - **Fomites** can currently be considered as **moderate, with medium uncertainty**, depending on the awareness of farm visitors and travellers and the level of cleaning and disinfection, as well as the biosecurity measures implemented.
  - **Movements of wild birds (migratory or nomadic*)** can be considered as **negligible, with medium uncertainty**.
- The likelihood of the Chinese-origin H7N9 HPAI virus spreading from known affected areas of China to unaffected countries in the **South and Southeast Asia regions** during the period May to September 2017 through:
  - **Live bird trade** can be considered as:
    - **Moderate, with medium uncertainty,** for Lao PDR through informal or formal trade, depending on measures in place.
    - **Moderate, with low uncertainty,** through informal trade in Viet Nam and Myanmar, but **negligible** through formal trade (provided appropriate measures are enforced).
    - **Negligible, with low uncertainty,** through formal or informal trade for other countries of the South (e.g. Nepal, India) and Southeast Asia regions (e.g. Cambodia).
  - **Poultry products trade** can be considered as **low, with medium uncertainty**, regardless of virus survival in those products.
  - **Fomites** can be considered as:
    - **Low, with medium uncertainty,** for Viet Nam, Lao PDR and Myanmar due to informal commerce with China.
    - **Negligible, with medium uncertainty,** for other Southeast Asian countries.
  - **Movements of wild bird (migratory or nomadic)** during the period May to September 2017 can be considered as **negligible, with low uncertainty**.
- The likelihood of the Chinese-origin H7N9 HPAI virus spreading from known affected areas of China to unaffected countries **beyond the Southeast Asia region** during the period May to September 2017 through:
  - **Global trade and travel** can be considered as **negligible, with low uncertainty**.
  - **Migratory wild bird movements** can be considered as **negligible, with medium uncertainty,** for the Russian Federation, Mongolia, Japan and the Republic of Korea, and **negligible, with low uncertainty,** for other countries.
- The likelihood of human exposure to the Chinese-origin influenza A(H7N9) virus (with high pathogenicity in chickens) through contact with infected birds, live bird market (LBM) visits or upon consumption of poultry meat or poultry-related products within affected areas of China during the period May to September 2017 is currently considered as low to moderate, with low uncertainty, and moderate for occupational exposure. The likelihood of human exposure depends, among other factors, on the extent of infection in farms and whether infected birds are sent to market.

* Nomadic birds: bird species holding no fixed territory and moving according to weather and food availability.

BACKGROUND

Epidemiological situation

In February 2017 China reported the detection of a highly pathogenic avian influenza virus of the H7N9 subtype derived from the low pathogenicity virus that has been circulating in poultry in China since early 2013 (WHO, 2017a; FAO, 2017a). It has been ascertained that a virus with changes at the cleavage site has been present at least since early November 2016 (Global Initiative on Sharing All Influenza Data [GSAID], 2017), and, considering knowledge of H7N9 distribution relies on report and detection in animals and humans, the virus may be more widespread than is currently known. Between February and 16 May 2017, H7N9 HPAI has been detected in 43 samples (32 chickens, one duck and ten environmental samples) collected from live bird markets and four chicken farms in Fujian, Guangdong, Guangxi and Hunan provinces. H7N9 HPAI virus isolates from human cases were further reported from Hebei and Henan (OIE, 2017; FAO, 2017a; see map 1). In contrast to its low pathogenic ancestor virus, the HPAI strain can causes disease and mortality in poultry although most cases so far have been detected through active surveillance, which suggests considerable underestimation of circulation. Only four outbreaks of the disease have been reported – from Guangxi Province, a poultry farm and backyard in Hunan Province, a chicken layer farm in Hebei and, most recently, a chicken layer farm in Henan. The ability of the H7N9 HPAI virus to infect both humans and poultry raises concern about a possible influenza pandemic (there is no evidence so far of sustained human-to-human transmission for either HPAI or LPAI strains) and international spread either due to poultry trade (lower infectious dose for chickens; other, multiple poultry species affected) or through wild birds (in case the virus adapts to wild *Anatidae*, as seen for other HPAI viruses in the past, e.g. Goose/Guangdong-lineage H5 HPAI viruses). FAO has conducted a qualitative risk assessment addressing the potential spread of H7N9 HPAI to unaffected provinces of China and other countries in Southeast Asia and beyond during the period May to September 2017, as well as human exposure in affected areas of China where H7N9 HPAI has been reported. Several pathways of virus incursion were considered, such as movements of live poultry, poultry products via trade (formal and informal) and movements of wild birds (migratory and nomadic).

Risk pathways

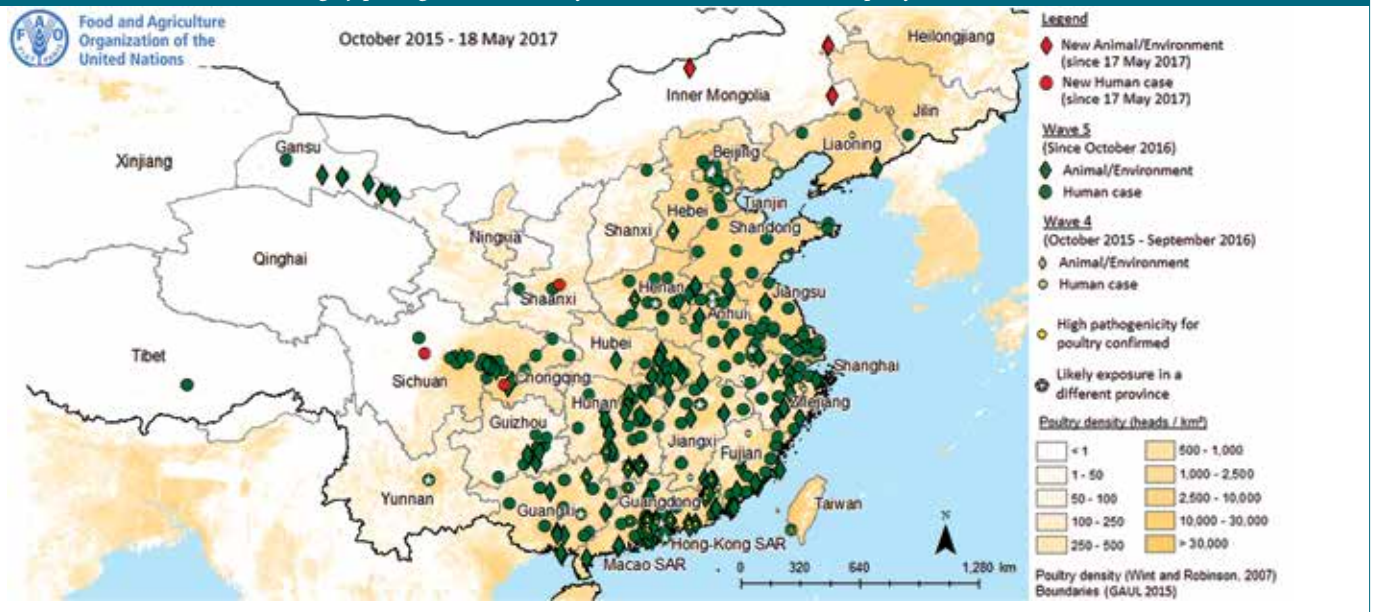
Animal and/or human cases of H7N9 HPAI occurring in six provinces of China (Guangdong, Guangxi, Fujian, Hebei, Henan and Hunan) raise concerns about other provinces of China and countries in Asia and beyond being at risk of introduction and spread of H7N9 HPAI through multiple risk pathways. To date, little is known about the relationship between these HPAI isolates, namely if they share a common ancestor or evolved independently of each other. At the time of this assessment (May 2017), vaccination against H7 was prohibited in China.

The qualitative risk assessment was conducted following the World Organisation for Animal Health (OIE) framework (Dufour *et al.*, 2011). To assess the risk of entry and exposure, several risk pathways were considered:

- trade in live poultry (both formal and informal);
- trade in poultry-related products (both formal and informal);
- fomites, including transport, visitors, faeces, feathers;
- wild bird migration or nomadic movements.

Tables 1–4 depict the considerations used to assess probabilities of entry, exposure and occurrence, including associated uncertainties (Low [L], Medium [M] and High [H]).

FIGURE 1. *H7N9 low and highly pathogenic viruses confirmed in human cases or samples from birds or live bird market environments.*



Note: Human cases are depicted in the geographic location where they were reported, recognising that exposure may have occurred in a different geographic location. Yellow circles inside the symbols depict isolates for which high pathogenicity (for poultry) has been identified.

TABLE OF PROBABILITIES 1

What is the likelihood of the Chinese-origin H7N9 HPAI virus spreading from affected areas to currently unaffected areas of China through trade in poultry and poultry-related products, fomites or wild birds during the period May to September 2017?

Vehicles	Evidence for P (entry) with uncertainty level[A]	P (entry)[B]	Evidence for P(exposure) with uncertainty level	P (exposure)[C]	P(occurrence) = P(entry) x P(exposure) with uncertainty level
LIVE BIRD TRADE					
Juvenile and adult chickens	• Ongoing H7N9 (both LPAI and HPAI) epidemic in China with HPAI outbreaks in chickens (L) • Informal movements between provinces (L) • An infected flock passing checkpoints (L) • Detection of sick or dead birds (L) • High number and volume of poultry movements, but less activity expected in the coming months (L)	Moderate for chickens	• Chickens are the main host of H7N9 (L) • HPAI may broaden its host range (H) • High density of chickens and other poultry in LBMs (L) • High number of live bird trading places (L) • Presence of defeathering devices in LBMs increasing airborne transmission (L)	High for chickens	Moderate for chickens with low uncertainty
Other poultry (Ducks, geese, quail, day-old chicks [D] (DOCs))	• Market closures changing live bird flows (L) • Testing and certification at provincial borders (L) • Timeline of mitigation measures varies between provinces after outbreak occurs (M) • DOCs do not represent a risk for H7N9 HPAI infection but infection can occur later through fomites during transport (L)	Low for other poultry and DOCs	• H7N9 HPAI not well adapted to ducks (M) • Several duck farms tested positive in H7 serology, but N9 has not been tested (M) • Few PCR positive results in ducks during surveillance (L) • No positive samples or data available in other poultry species for H7N9 HPAI (L)	Low for other poultry and DOCs	Low for other poultry and DOCs with medium and low uncertainty respectively
POULTRY PRODUCTS					
Chicken meat and carcasses, feathers	• Informal movements and infected products passing provincial boundaries (L) • H7N9 outbreaks in China in at least five provinces (L) • High flow of poultry-related products between provinces (L) • Survival of virus in frozen meat (L) • Systemic infection leading to H7N9 HPAI virus presence in organs, feathers, blood (L) • Feathers processed/disinfected only if imported as a valued product (mostly ducks and geese) and not a by-product (chicken feathers) (M) • Cooking inactivates the virus (L)	Low for frozen meat and carcasses, feathers	• Many susceptible sites in China (wet markets, retail markets, etc.) (L) • Limited exposure for chickens and other poultry from these products (M) • Meat goes to consumers and restaurants without any amplifier in between; meat is cooked (M) • Imported feathers are processed (M) • Cleaning and disinfection of LBMs strengthened in most provinces (M)	Low for frozen chicken meat and carcasses, feathers	Low for frozen chicken meat and carcasses, feathers, with low uncertainty
Eggs	• Potential vertical transmission but eggs are not viable (M)	Negligible for eggs as a product		Negligible for eggs as a product	Negligible for eggs as a product with medium uncertainty
FOMITES					
(see page 10)	• No or deficient cleaning and disinfection in LBMs and farms (L) • Preventing poultry from going back to farms after being in LBMs (H) • Market closures following human case reports (L) • Informal trade movements (L) • Visitors of poultry premises crossing provincial borders (L) • Inappropriate cleaning of imported eggs (L) • Contaminated feed (M) • Visitors consecutively going to different farms (vets, technicians, company representatives, etc.) with contaminated equipment (L) • Sharing of potentially contaminated equipment between farms (M) • Travellers potentially exposed to H7N9 HPAI in affected provinces and going to unaffected provinces (H) • Faeces used as a fertilizer and sold as a valuable resource from one farm to another (M) • Rodents carrying the virus mechanically (M)	Moderate	• More than 50% of poultry birds are raised in small-scale farms with limited biosecurity (L) • Strict biosecurity measures as advised by the government implemented in LBMs (M)	Moderate	Moderate, with medium uncertainty
WILD BIRDS					
	• No evidence of H7N9 HPAI in wild birds (M) • Experimental infection in ducks showing no clinical signs and low level of replication – virus poorly adapted to ducks (M) • Several duck farms tested positive in H7 serology, but N9 has not been tested (M) • Few PCR positive results in ducks during surveillance (L)	Low	• High density of poultry and backyard farms (>50% of raised poultry), free-grazing duck farms exposed to wild birds in the eastern flyway (L) • H7N9 HPAI has a lower infectious dose for chickens (L)	High	Negligible, with medium uncertainty

[A] *Three levels of uncertainty were used to assess the uncertainty of each evidence: Low (L), Medium (M) and High (H).*

[B] *Likelihood of **introduction** (or reintroduction) of the pathogen into an area (or country). Any factors that would permit entry of the pathogen into the previously unaffected zone have to be listed in this part.*

[C] *Likelihood of pathogen encountering susceptible hosts in the production system of a zone (or country). Any factors that would enable pathogen spread in the zone, once introduced, has to be considered in this part.*

[D] *Day-Old Chick: A "day-old chick" (DOC) is a newly-hatched chick (Gallus gallus). We consider that the term DOC refers to unfed chicks less than 72 hours old.*

TABLE OF PROBABILITIES 2 *What is the likelihood of the Chinese-origin H7N9 HPAI virus spreading from a known affected area of China to unaffected countries in the South and Southeast Asia regions through trade in live poultry and poultry-related products, fomites or wild birds during the period May to September 2017?*

Vehicles	Evidence for P (entry) with uncertainty level	P (entry)	Evidence for P(exposure) with uncertainty level	P (exposure)	P(occurrence) = P(entry) x P(exposure) with uncertainty level
LIVE BIRD TRADE					
General evidence for Southeast Asia region	• Evidence listed under 1.1. (L) • H7N9 HPAI virus has been isolated from human cases in Guangxi Province (bordering Viet Nam) reporting local exposure (L) • Spent hens, young chicks, day-old chicks, ducks and eggs are the main informal importations (L) • Existence of frequent informal movements (L)				
Lao PDR	• Lao PDR continues to formally import live birds (spent hens, layer chickens, hybrid chickens) from China and the other neighbouring countries. No information concerning informal live bird movements in Lao PDR was available (M)	Moderate	• H7N9 HPAI has a lower infectious dose (L) • Poultry premises situated in areas near the border with China (L) • H7N9 HPAI may broaden its host range (H) • Chickens are the main host (L)	High	Moderate with medium uncertainty
Viet Nam and Myanmar	• Informal movements across borders and porous borders, particularly in Viet Nam, due to LBM closures in China and subsequent change in trading patterns (L) • High season for trade between March and June (L) • Ban of formal importations of live poultry in Myanmar and Viet Nam (L)	Moderate	• H7N9 HPAI has a lower infectious dose for chickens (L) • Poultry premises situated in areas near the border with China (L) • H7N9 HPAI may broaden its host range (H) • Chickens are the main host (L)	High	Moderate through informal trade in Viet Nam and Myanmar; negligible through formal trade (provided appropriate measures are enforced) with low uncertainty for both
Other countries (e.g. Cambodia, Nepal, India)	• In Cambodia, there is no known import or export with China and poultry trade with Viet Nam has been restricted, with increased monitoring of movements at the borders with Viet Nam. In addition, no informal trade seems to occur with China (L) • In India, formal trade in live poultry or poultry-related products is strictly regulated and does not occur through the border with Tibet Autonomous Region. Informal trade is unlikely to happen due to the difficult terrain (L) • Very low volumes of live poultry and poultry products (either formally or informally) are reported crossing the border between Nepal and Tibet Autonomous Region (L)	Negligible	• H7N9 HPAI has a lower infectious dose for chickens (L) • Poultry premises situated in areas near the border with China (L) • H7N9 HPAI may broaden its host range (H) • Chickens are the main host (L)	High	Negligible with low uncertainty through both formal and informal trade
POULTRY PRODUCTS					
Frozen chicken meat and carcasses, Eggs, Feathers	• Evidence presented under 1.2. • In Viet Nam and Myanmar, eggs and also frozen chicken carcasses or parts (wings, feet) are traded with China via informal movements while in Lao PDR only eggs, frozen bird carcasses or by-products are traded informally and to a lesser extent (M) • Formal imports of poultry products from China are banned in Myanmar and Viet Nam while Lao PDR is still letting in official imports of poultry products from China (L) • Little to no poultry products are traded between China and Cambodia or Nepal, either formally or informally (L)	Low	• Low exposure risk for poultry from these products (M) • Meat goes to consumers and restaurants without potential amplifiers in between; meat is cooked (M)	Low	Low with medium uncertainty
FOMITES					
(see page 13)	• Evidence already presented under 1.3., 2.1., 2.3. • People crossing borders with contaminated equipment, clothes or vehicles (M) • Little or no live bird or poultry product movements from China are occurring in other countries of Southeast Asia (e.g. Cambodia) (M)	Low for Viet Nam, Lao PDR and Myanmar Negligible for other Southeast Asian countries	• Biosecurity measures implemented in the different premises (M) • Number and density of LBMs and poultry premises lower than in China (L)	Moderate	Low with medium uncertainty for Viet Nam, Lao PDR and Myanmar due to informal commerce with China. Negligible with medium uncertainty for other Southeast Asian countries
Wild birds	• Several stopover and breeding sites migrations from China to South Asia not likely to happen in summer (northward migrations) (L) • No evidence of H7N9 HPAI in wild birds (M)	Negligible	• Poultry and backyard farms, free-grazing duck farms exposed to wild birds but their density is less than in China (L) • H7N9 HPAI has a lower infectious dose for chickens (L)	High	Negligible with low uncertainty

TABLE OF PROBABILITIES 3

What is the likelihood of the Chinese-origin H7N9 HPAI virus spreading from a known affected area of China to an unaffected area beyond Southeast Asia through global trade in poultry and poultry-related products or wild birds during the period May to September 2017?

Vehicles	Evidence for P (entry) with uncertainty level	P (entry)	Evidence for P(exposure) with uncertainty level	P (exposure)	P(occurrence) = P(entry) x P(exposure) with uncertainty level
GLOBAL TRADE AND TRAVEL					
	• Evidence presented under 1.1., 1.2., 1.3. and 2.2. • Informal trade movements across borders beyond Southeast Asia are unlikely (M) • Strict regulations on other continents (Europe, America, Oceania, etc.) (L) • Travellers infected in China and travelling back to Europe, Africa, America etc. (H) • Infected travellers being detected during travel or on arrival if symptoms develop (WHO) (H) • The majority of Chinese chicken exports are directed to Hong Kong SAR, Malaysia and Japan (L)	Negligible	• H7N9 has a lower infectious dose for chickens (L) • H7N9 HPAI may broaden its host range (H) • Chickens are the main host (L) • Infected birds are unlikely to enter the poultry market chain of these countries (L) • Infected products will be unlikely sources of exposure for local birds. (L)	Low	• Negligible with low uncertainty
WILD BIRDS					
	• Evidence listed in 1.4, 2.4. • Different flyways connecting China with other continents (L) • H7N9 HPAI outbreaks in chickens in China (L) • Summer migration for the period considered (birds head northward to Russian Federation, Mongolia, Republic of Korea, Japan) (M) • No evidence of H7N9 HPAI in wild birds (M) • Other HPAI viruses managed to spread from China to the Middle East, Europe and Africa (e.g. H5N1) (L) • Mitigation measures and contingency plans vary in countries of other continents (M)	Negligible	• Poultry and backyard farms, free-grazing duck farms exposed to wild birds along the flyway (L) • H7N9 HPAI has a lower infectious dose for chickens (L)	Moderate to High	Negligible with medium uncertainty for Russia, Mongolia, Republic of Korea and Japan Negligible with low uncertainty for other countries

TABLE OF PROBABILITIES 4

What is the likelihood of a human becoming exposed to the Chinese-origin influenza A(H7N9) virus (with high pathogenicity in chickens) through contact with infected live birds, during LBM visits or upon consumption of poultry meat or poultry-related products within affected areas of China during the period May to September 2017?

Vehicles	Evidence for P (entry) with uncertainty level	P (entry)	Evidence for P(exposure) with uncertainty level[E]	P (exposure)	P(occurrence) = P(entry) x P(exposure) with uncertainty level
Live birds *Poultry products* *LBM visits* *Consumption of chicken meat and related products*	• Poultry may show clinical signs with H7N9 HPAI but not consistently (M) • Several H7N9 HPAI outbreaks in chickens occurred since February in Hunan, Guangdong (L) • Due to systemic infection, H7N9 HPAI is present in organs, blood, meat (L)	Moderate	• Human cases appear to be associated with direct or indirect contact with live bird species, especially poultry (at LBMs, during transport, at slaughterhouses) (L) • No human-to-human transmission demonstrated (M) • People's awareness varies about appropriate personal protection when dealing with live poultry (M) • High number of people involved in poultry value chains (L) • Slaughtering chickens at home (L) • H7N9 HPAI isolated from human cases in Guangxi, Guangdong provinces (L) • H7N9 HPAI detected in five provinces in the south and centre of China (L) • Virus may not be inactivated in insufficiently cooked meat (M)	Low to moderate, with moderate for occupational exposure	Low to moderate, with moderate for occupational exposure, and low uncertainty

[E] *It is the likelihood of a human being exposed to any H7N9 HPAI vehicle (live poultry, poultry products, fomites) due to profession, way of life, consumption habit and awareness about the hazard in an affected area (or country).*

ASSESSMENT

Main risk questions

The current risk assessment was performed on the recently emerged highly pathogenic form (for chickens) of the H7N9 virus in China and considered the period May to September 2017.

The risk questions guiding this assessment are:

1. What is the likelihood of the Chinese-origin H7N9 HPAI virus spreading[1] from known affected areas of China to currently unaffected areas of China during the period May to September 2017 through trade (formal or informal) in poultry or their products, fomites or wild birds?
2. What is the likelihood of the Chinese-origin H7N9 HPAI virus spreading from a known affected area of China to unaffected countries in the South and Southeast Asia regions during the period May to September 2017 through trade (formal or informal) of poultry or their products, fomites or wild birds?
3. What is the likelihood of the Chinese-origin H7N9 HPAI virus spreading from a known affected area of China to an unaffected area beyond South and Southeast Asia during the period May to September 2017 through global trade in poultry and related products, travellers or wild birds?
4. What is the likelihood of a human becoming exposed[2] to the Chinese-origin influenza A(H7N9) virus (with high pathogenicity in chickens) through contact with infected live birds, during LBM visits and on consumption of poultry meat or poultry-related products within affected areas of China during the period May to September 2017?

Methodology for qualitative risk assessment and uncertainties

Levels of likelihood for the probabilities of entry and exposure of at least one animal (or human) were defined as follows (from highest to lowest levels): **high** (highly likely to occur), **moderate** (potentially occurring), **low** (unlikely to occur) and **negligible** (extremely unlikely to occur). All pieces of evidence used to answer each question of the risk assessment can be found in Annexes 1–4.

The probability of occurrence was determined using a matrix for combination of qualitative assessments for independent events (Figure 2).

Given the lack of data and studies on H7N9 HPAI at the time of the assessment, some considerations are based on assumptions derived from previous work conducted on other HPAI viruses. Levels of uncertainty (low, medium and high) were added to reflect this:

FIGURE 2. *Matrix for combination of qualitative assessments for independent events*

	Probability 2			
Probability 1	**Negligible**	**Low**	**Moderate**	**High**
Negligible	Negligible	Negligible	Negligible	Negligible
Low	Negligible	Negligible	Low	Low
Moderate	Negligible	Low	Low	Moderate
High	Negligible	Low	Moderate	High

Note: Probability 1 = Probability of entry. Probability 2 = Probability of exposure.
Source: adapted from Dufour *et al.*, 2011.

- High uncertainty (H): lack of data, limited data, or lack of conclusive data; weak correlation or crude speculation;
- Medium uncertainty (M): small sample, fair correlation/ good fit; reliable method;
- Low uncertainty (L): large sample set; known fact, event known to occur, or exact measure.

Consequences assessment

The risk of H7N9 HPAI introduction into previously unaffected areas of China or other countries through trade in poultry or poultry products and fomites represents a major threat to public and animal health as well as food security.

If poultry flocks (especially chicken flocks) are exposed to the virus in currently unaffected areas, the likelihood of infection is very high, with an even lower dose needed for HPAI viruses to infect their hosts as compared with LPAI viruses and considering how fast the infection with HPAI viruses spreads within flocks and, depending on the level of biosecurity, between flocks.

Likewise, the economic impact of H7N9 HPAI is considered to be very high. Not only does H7N9 cause clinical signs and mortality in poultry and therefore lead to losses in production and market shares. Control or elimination of the H7N9 HPAI virus is also costly because of measures implemented like stamping out, quarantine, movement control, market closures and compensation of farmers. On the one hand, if control measures are not implemented in time, H7N9 HPAI can spread quickly along poultry value chains. In addition, if no or insufficient compensation is granted, fear of losses caused by control measures may drive producers to quickly sell their poultry as soon as they notice clinical signs. Also, market closures may lead to commerce being executed elsewhere, potentially in an informal and less controllable manner. Should H7N9 HPAI remain endemic, ongoing costs associated with prevention and early detection, along with import bans imposed by other countries, are considered to be high.

China has put in place different measures to control H7N9 HPAI, such as culling of entire flocks on infected premises, cleaning, disinfection and fallowing. In addition, active surveillance in LBMs, quarantine and certification of poultry

[1] Spread is the directional movement of H7N9 HPAI virus from affected areas to currently unaffected areas.

[2] The likelihood of a human being exposed to any H7N9 HPAI vehicle (live poultry, poultry products, fomites) due to profession, way of life, consumption habit and awareness about the hazard in an affected area (or country).

CONTRIBUTING EXPERTS

All questions were assessed with publications, reports and data made available by experts:

- Adlhoch, Cornelia (*European Centre for Disease Prevention and Control*)
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movements, closing of live bird trading areas and strengthened biosecurity measures are in place in an attempt to limit further spread of both H7N9 HPAI and LPAI to currently unaffected areas. However, the presence of the HPAI virus in six provinces, including one in northern China (Hebei), demonstrates that the virus is already widespread.

Just as the LPAI strain, H7N9 HPAI could infect humans and cause fatalities and thus is of high public health interest. Humans become infected during LBM visits or upon close contact with poultry or poultry- slaughtering activities, and may develop severe respiratory disease, potentially leading to death. If a human is exposed to infected live poultry or poultry products, or to contaminated environment or materials, the likelihood of infection remains just as high as for the H7N9 LPAI strain. However, as opposed to the LPAI virus which does not cause clinical signs in poultry, passive surveillance can be used to identify flocks infected with HPAI, which may decrease the chances of human exposures.

Knowledge gaps

Given the very recent emergence of H7N9 HPAI virus, few studies are available so far. Assumptions had to be made concerning its likely behaviour based on other HPAI viruses (e.g. H5N1 or the H7N9 virus recently detected in the United States).

Additional information will be needed to conduct a more comprehensive assessment of H7N9 HPAI virus at national, regional and international levels. The important data gaps are:

- information from outbreak investigations in poultry and analysis of genetic characterization(s) of isolates to determine the potential source of virus;
- H7N9 surveillance results in poultry by species, breed, age and production type from China and bordering countries;
- H7N9 surveillance results in wild birds[3] and additional knowledge about wild bird susceptibility and H7N9 transmissibility in wild birds (note: domestic ducks can be used as a proxy);
- trade relationships and data on movements and commerce (formal and informal) between the different provinces within China (frequency, volume, products, seasonal activity, etc.) and from China to other countries (Asia and beyond);
- economic impact, including measures such as culling of infected flocks, movement bans or LBM closures, and how this may influence spread of H7N9 HPAI along poultry value chains;
- additional information on H7N9 HPAI virus characteristics (infectious dose, species range, survival in environment, etc.).

Mitigation measures

The strengthened risk management measures applied by Chinese authorities since the report of the first H7N9 HPAI human cases will to some extent mitigate the risk of human and poultry exposure to the H7N9 virus in LBMs and the spread of this virus through trading activities, but elimination is highly unlikely without a specific, well-designed elimination programme. Thorough epidemiological investigations need to continue in order to identify in which settings the virus is circulating other than LBMs, as well as to understand why human infections with the virus are still occurring despite the measures taken in markets to reduce this risk. Increased surveillance at farm level will be necessary to ensure that poultry going to markets are not coming from infected farms but there is unlikely to be sufficient capacity to test all flocks prior to sale (it is not done for H5 HPAI viruses either). China will need to implement a suite of measures to contain infection with this virus and then to move towards virus elimination. Neighbouring countries should follow OIE Terrestrial Code recommendations for trade and should continue to address the issue of informal trade, which requires an understanding of the drivers of trade.

Recommended mitigation measures reducing likelihood of H7N9 virus spreading within affected areas, or from an affected

[3] It is important to include H7N9 as part of the testing requirement for routine surveillance in wild birds.

area to an unaffected area, and reducing the likelihood of human infection with influenza A(H7N9) can be found in the previous assessment addressing H7N9 LPAI (pp. 4-5): http://www.fao.org/3/a-i3813e.pdf

A biosecurity guide for live poultry markets describing good practices is also available: http://www.fao.org/3/a-i5029e.pdf

Concerning human exposure, additional information, advice and recommendations provided by WHO to reduce exposure to avian influenza virus A(H7N9) can be found at: http://www.who.int/influenza/human_animal_interface/faq_H7N9/en/

Annex 1
INFORMATION USED TO ASSESS RISK QUESTION 1

What is the likelihood of the Chinese-origin H7N9 HPAI virus spreading from known affected areas of China to currently unaffected areas of China during the period May to September 2017 through:

Live poultry trade

Considering:

- Our knowledge on H7N9 distribution relies on detection and reporting of human cases and animal/environmental findings, the real extent of H7N9 spread may be underestimated. This is supported by the reporting of only two outbreaks in poultry despite the circulation of this HPAI virus for at least five months.
- H7N9 HPAI has so far been detected in yellow chickens/broiler type, layers, in one duck, environmental samples of live bird markets (LBMs) and four farms in Guangxi, Hebei, Henan and Hunan. No information on the precise location where H7N9 HPAI virus first emerged is available, although the first evidence of changes to the cleavage site typical of an HPAI virus was detected in samples from markets in Guangdong in late 2016. In addition, little is known about the relationship between the H7N9 HPAI isolates, and whether they share a common ancestor or evolved separately. The H7N9 LPAI virus has so far been detected in poultry in 29 different provinces, municipalities and special administrative regions of southern and eastern China (FAO, 2017a).
- Whenever HPAI occurs, there is always the possibility of emergency sale of flocks by owners once the first signs of disease are detected.
- Action will be taken upon reporting of disease, especially in the case of HPAI, to prevent onward transmission through culling of the affected flock.
- Several HPAI viruses (e.g. H5N1 and H5N8) have been shown to broaden their host range (Kaplan, 2013; Schrauwen, 2014) and as H7N9 HPAI seems adapted to both humans and chickens according to genetic analysis (Li, 2017; Millman *et al.*, 2015), it may be able to infect more species (e.g. ducks, quail, pigs) and affect additional value chains. In experimental infections conducted in China, ducks showed no clinical signs and H7N9 HPAI virus replication was limited (OFFLU, 2017a). However, one domestic duck sample tested positive by polymerase chain reaction (PCR) during active surveillance in China (FAO, 2017a). However, no results from studies on susceptibility of other poultry species or pigs for H7N9 HPAI are available yet.
- For H7N9 HPAI, a lower dose may be sufficient to infect birds, potentially leading to increased transmissibility among poultry by close contact and airborne transmission when compared to H7N9 LPAI, extrapolating from previous work done on other LP/HP viruses (OFFLU, 2017a; Nickbakhsh *et al.*, 2016; Pantin-Jackwood *et al.*, 2017).
- Extrapolating from other HPAI viruses (e.g. H5N1) (FAO, 2016), commercially produced day-old chicks, when they leave the incubator, represent a very low-level risk for H7N9 HPAI infection: if the eggs were infected, the chicks would not hatch; if the parent flock was infected the eggs would be thin-shelled and rejected as such. However, infection can occur later through contact with contaminated surfaces and fomites during transport (Sims and Swayne, 2016).
- On 19 March 2017, an outbreak of H7N9 HPAI in Hunan Province caused high morbidity and mortality: out of a population of 189 676 susceptible birds, 29 760 layer chickens were found sick, of which 18 497 died. An H7N9 HPAI outbreak also occurred on 28 April in Hebei Province, where 8 500 layer chickens were found sick, of which some 5 000 died. On 3 May, another H7N9 HPAI outbreak was reported in a chicken layer farm in Henan Province, where 7 500 layer chickens showed clinical signs and some 5 000 died (FAO, 2017a).
- H7N9 HPAI can be detected through active and passive surveillance with the presence of sick or dead birds along the market chain. H7N9 LPAI, on the other hand, which causes little to no clinical signs in birds, can only be detected through active surveillance along the market chain. So far, more cases have been detected through active than passive surveillance (FAO, 2017b).
- Though active surveillance has been set up to detect both H7N9 LPAI and HPAI, there is limited data available on the level of infection of farms in areas affected by H7N9 strains (MoA, 2017b).
- In most Chinese provinces, all birds present on premises (farms, LBMs, etc.) where virological or serological (for breeding poultry only) samples test positive for H7N9 are

Commercially produced day-old chicks when they leave the incubator represent a very low-level risk for HPAI infection.

stamped out under the supervision of the government veterinary services (MoA, 2014). Following such measures, temporary closure, cleaning, and disinfection in these premises are performed, but few such outbreaks or cases have been detected to date and it is unclear whether cleaning and disinfection is properly implemented in all instances. It is believed that there is a high level of resistance against such measures at provincial level.

- Media reports suggest that, owing to the administrative structures in China (city, county, district), during the time needed for confirmation of H7N9 (LPAI or HPAI) isolates by the national reference laboratory and full implementation of mitigation measures, the virus can continue spreading (http://jryaw.com/Article.asp?ID=67801).
- Strengthened measures in China, including testing and certification prior to movement and trade in live birds or carcasses across provincial boundaries, as well as temporary closure of LBMs, may have increased the likelihood for H7N9 HPAI and LPAI to spread through informal movements and modified the pattern of LBM connections (e.g. by supply from a closed market partially being transferred to other markets) (MoA, 2017b).
- The highest likelihood of virus spread within affected or unaffected areas is associated with the risk pathways that involve LBMs, trade in live birds, illicit movement of live birds, and fomites, including contaminated feed and bedding (Swayne *et al.*, 2013) but other pathways such as faeces used as fertilizer need to be considered. Local transmission by passerine birds acting as bridging species, though a possibility, may not be important in long-distance spread. (Jones *et al.*, 2014).
- Like H7N9 LPAI, H7N9 HPAI is expected to follow a seasonal pattern: circulation of seasonal influenza viruses may decrease at the end of May 2017 as temperatures rise and humidity decreases (especially in China's southeastern provinces), and will remain low until October 2017 (Tamerius *et al.*, 2011; ChinaMaps.org). However, a study shows a slight increase in the detection of H7N9 virus in environmental samples collected during summer of 2016 (Huo, X. *et al.*, 2017).

Therefore, the likelihood of the Chinese-origin H7N9 HPAI virus spreading from known affected areas to currently **unaffected areas of China** through formal or informal **live bird trade** during the period May to September 2017 can be considered as **moderate, with low uncertainty, for** juvenile and adult chickens, **low** for day-old chicks and other poultry (ducks, geese, quail, etc.), **with low and medium uncertainties respectively** (see Annex 1).

It is unlikely that HPAI-infected eggs will end up in the market chain.

Poultry products

Considering:

- Eggs from infected hens can harbour HPAI virus (as was shown for H5N1 HPAI), but no studies have been carried out on H7N9 HPAI virus so far. Experimental studies with other HPAI viruses detected HPAI virus in the albumen and yolk of the last few eggs laid by hens before death (Swayne *et al.*, 2012). However, considering potential malformation of infected eggs, the thinning of egg shells, and the fact that HPAI-infected hens may be either too sick to produce eggs or die quickly, it is unlikely that many infected eggs will be found in the market chain (FSIS, 2010; Sims and Narrod, 2007).
- HPAI viruses cause systemic infection in poultry and are therefore found throughout poultry carcasses, including organs, meat and feathers (in contrast, LPAI viruses are generally not found in meat or organs, or feathers and therefore these products do not present the same risk in LPAI exposure).
- Frozen chickens, chicken meat and feathers are usually destined for human consumption or industrial processing without any amplifiers in between.
- Frozen or chilled poultry products are mainly broiler meat and eggs for human consumption, in which influenza viruses can survive (FAO, 2017c). Influenza viruses could not survive in properly cooked meat or eggs.

Therefore, the likelihood of the Chinese-origin H7N9 HPAI virus spreading from known affected areas to currently **unaffected areas of China** through formal or informal **trade in poultry products** during the period May to September 2017 can be considered as **low** for frozen chicken carcasses or meat and feathers, **with low uncertainty,** and **negligible** for eggs, **with medium uncertainty**.

Fomites

Considering:

- H7N9 LPAI virus can survive for months in the environment, depending on weather conditions (Gautret, 2014), leading to further spread unless cleaning and disinfection of any material (crates, cages, etc.) coming in contact with poultry is performed well and follows the recommended contact time for approved disinfecting agents (De Benedictis, 2007).
- In China, more than 50 percent of poultry birds are raised on small-scale farms with limited biosecurity (OFFLU, 2017b).
- Visitors, shared farm equipment (trucks, motorcycles) and feed movements represent the most likely fomite source of infection between farms (FAO, 2014).
- Visitors to poultry premises, especially those visiting several farms consecutively (e.g. traders, veterinarians, company representatives), can spread the virus from one farm to another via clothes and equipment if no changing or cleaning and disinfection is carried out before and after their visits (Desvaux *et al.*, 2011).
- There is a possibility of spreading the virus back to farms and other LBMs through vehicles (crates, trucks, motorcycles, etc.) when biosecurity measures are not applied during trade operations (both formal and informal).
- Travellers potentially exposed to H7N9 HPAI may move from affected provinces in China to unaffected areas. However, travellers are unlikely to have contact with family or commercial poultry operations upon arrival at their destination, particularly if they feel sick. Nevertheless, FAO recommends avoiding poultry farms during 10-12 days after returning from affected areas to prevent any further spread.

- Feathers can either be contaminated due to systemic infection or mechanically, by carrying virus particles from contaminated dust or water droplets (Beato *et al.*, 2009).
- Airborne transmission of H7N9 HPAI may occur over short distances between farms when large quantities of virus are produced, as was suspected for several farms in an H5N2 HPAI outbreak in Canada (Xu, W., 2016).
- Viral genome and infectious avian influenza A viruses of H5N6 HPAI, H7N9 LPAI, and H9N2 LPAI subtypes were detected in air sampled at LBMs in Guangzhou. The use of defeathering devices increased the quantity of virus-laden airborne particles, in particular for the feathers of infected birds contaminated by H7N9 LPAI (Zhou, J., 2016).
- During closures of LBMs, changes in live poultry movements may occur and live poultry may be taken for sale elsewhere.
- Closure of LBMs, regular cleaning and disinfection, market rest days and rapid turnover of poultry conducted in affected areas reduce both H7N9 LPAI and HPAI environmental accumulation in such premises (FAO, 2015).
- H7N9 HPAI virus, like other influenza viruses (e.g. H5N1), is also present in faeces potentially sold as a valuable resource to other farms or used as fertilizer on crops (CFSPH, 2015).
- Rodents are present in high number in rural and urban areas and may spread H7N9 HPAI mechanically in affected areas (e.g. between farms) (Velkers, FC. *et al.*, 2017).

Therefore, the likelihood of the Chinese-origin H7N9 HPAI virus spreading from known affected areas to currently **unaffected areas of China through fomites** during the period May to September 2017 can currently be considered as **moderate, with medium uncertainty**, depending on the awareness of farm visitors and travellers, cleaning and disinfection levels as well as biosecurity measures implemented.

Wild birds

Considering:

- To date, the H7N9 LPAI has only been detected in one tracheal sample from a healthy tree sparrow out of 2 198 collected from wild birds in Shanghai in the spring of 2013 (Zhao *et al.*, 2014). There is no evidence of H7N9 HPAI virus circulating in local wild bird populations despite regular testing on droppings collected in the Poyang Lake area, a wild bird congregation point (OFFLU, 2017c).
- A lower infectious dose for the HPAI strain, as compared to the LPAI strain of the same virus, is observed in domestic and wild birds for other influenza viruses (e.g. H1N1, H5N1). However, no studies on H7N9 HPAI infectious dose in wild bird species are available (OFFLU, 2017d).
- In experimental infections conducted in China, domestic ducks (the same species as mallard [*Anas platyrhynchos*], the major migratory waterbird species) showed no clinical signs and H7N9 HPAI virus replication was limited (OFFLU, 2017c). However, one domestic duck sample tested positive in PCR during active surveillance in China (FAO, 2017a). More experimental and surveillance data is needed to assess the risk of transmission and/or geographic spread through wild birds.
- H7N9 HPAI seems poorly adapted to domestic ducks, which have more opportunity to transmit the virus to wild *Anatidae* (FAO, 2017a; OFFLU, 2017a). Other HPAI viruses have shown little adaptation to ducks (e.g. 1997 H5N1 virus from Hong Kong SAR) (Perkins and Swayne, 2002), and the H7N9 LPAI viruses from 2013 were poorly adapted to domestic ducks and mallards (Pantin-Jackwood *et al.*, 2014).
- There is currently no epidemiological evidence indicating that migratory wild birds play a role in the spread of H7N9 HPAI, but it cannot be ruled out given that movements of wild birds have been associated in the past with short- and long-distance spread of other HPAI viruses (e.g. H5N1 and H5N8) (Sims *et al.*, 2017).
- It is not known if wild birds infected with H7N9 HPAI will die, which could be detected through passive surveillance. There are highly pathogenic viruses that produce clinical signs in some wild bird species, e.g. H5N1 clade 2.2 and H5N8 clade 2.3.4.4, but others do not systematically do so, e.g. H5N6 clade 2.3.4.4 in Asia (Sims *et al.*, 2017; Jeong *et al.*, 2017).

Therefore, the likelihood of the Chinese-origin H7N9 HPAI virus spreading from known affected areas to currently **unaffected areas of China through movements of wild birds (migratory or nomadic[4])** during the period May to September 2017 can be considered as **negligible, with medium uncertainty**.

Annex 2
INFORMATION USED TO ASSESS RISK QUESTION 2

What is the likelihood of the Chinese-origin H7N9 HPAI virus spreading from a known affected area of China in unaffected countries in the South and Southeast Asia5 regions during the period of May to September 2017 through:

[4] Nomadic birds: bird species holding no fixed territory and moving according to weather and food availability.

[5] Mainland Southeast Asia, comprising Viet Nam, Laos, Cambodia, Thailand, Myanmar, and West Malaysia. Maritime Southeast Asia, comprising Indonesia, East Malaysia, Singapore, Philippines, East Timor, Brunei, Cocos (Keeling) Islands, and Christmas Island.

Live poultry trade

Considering:

- Evidence presented under 1.1.
- In Guangxi Province, one chicken farm tested positive for H7N9 HPAI virus (FAO, 2017a). Guangxi Province borders Viet Nam.
- Regulatory officials in countries in Southeast Asia are aware of hazards from avian influenza and strict regulatory frameworks are in place at borders, including banned importation of live poultry and/or strictly regulated movements (FAO China [FAOCN], 2017; FAO Cambodia [FAOKH], 2017; FAO Lao PDR [FAOLA], 2017; FAO Myanmar [FAOMM], 2017; FAO Viet Nam [FAOVN], 2017 – personal communications; Viet Nam Government, 2017).
- Lao PDR imports live bird (spent hens, layer chickens, hybrid chickens, etc.) from China and other neighbouring countries and implements measures such as checking of flock documents, observation for clinical signs and sampling at the Chinese border (FAOLA, 2017 – personal communication).
- Due to previous outbreaks of avian influenza, there is no official poultry movement at the borders of China and Viet Nam, or China and Myanmar. Even though exports and imports of live poultry between these countries are officially banned, informal movements still occur (FAO MM, 2017; Regional Office for Asia and the Pacific (FAORAP), 2017; FAOVN, 2017 – personal communications; Viet Nam Government, 2017).
- In Tibet Autonomous Region, three A(H7N9) human cases were reported in May 2017 after local exposure at the same farmers' market but the virus was not detected in poultry (FAO, 2017a). Movements of people and goods are expected to increase during the summer after snow melts and routes connecting Tibet to Nepal become accessible. However, very low volumes of live poultry and poultry products (either formally or informally) are reported crossing the border between Nepal and Tibet (Social Marketing and Distribution (SMD) of Nepal, 2014).
- In India, formal trade with live poultry or poultry-related products is strictly regulated and does not occur through border mountain passes between India and Tibet Autonomous Region. Considering the high-altitude, remote paths between India and Tibet, informal trade in live poultry and poultry products is unlikely to occur (FAO Nepal (FAONP), 2017 – personal communication).
- In Cambodia, there are no known poultry imports or exports with China and poultry trade with Viet Nam has been restricted, with increased monitoring of the movements at the borders with Viet Nam. (FAOKH, 2017 – personal communication).
- Strengthened measures in China, including testing and certification prior to movements of live birds or carcasses, closure of Chinese LBMs and bans on live poultry trade over different national boundaries, may have increased the likelihood of H7N9 HPAI and LPAI spreading through informal movements from China to Southeast Asian countries.
- Porous borders facilitate the uncontrolled movement of people and animals, including informal trade in poultry or poultry products, especially in Viet Nam from Guangxi Province, but also in northwestern Myanmar from Yunnan Province (FAOMM, 2017; FAORAP, 2017; FAOVN, 2017 – personal communications).
- Informal movements of live birds (spent hens, DOCs, young chicks and 3-21-day-old ducks) concern mainly Viet Nam and Myanmar. No information on informal live bird movements in Lao PDR was available (FAOMM, 2017; FAORAP, 2017; FAOVN, 2017 – personal communications). Cambodia, which does not share common boundaries with China, has little or no informal trade with China (FAOKH, 2017 – personal communication).
- For countries in the region (Viet Nam, Myanmar, Lao PDR, Cambodia, Indonesia), FAO is assisting the risk areas bordering and/or trading with China in implementing risk-based surveillance with focus on chicken value chains (Belot *et al.*, 2014). Additional active surveillance is carried out in Cambodia and Viet Nam (FAOKH, 2017; FAOVN 2017 – personal communications). No H7N9 virus has been detected to date.

Therefore, the likelihood of the Chinese-origin H7N9 HPAI virus spreading from known affected areas of China to unaffected countries in the **South and Southeast Asia regions** through **live bird trade** during the period May to September 2017 can be considered as:

- **Moderate, with medium uncertainty,** for Lao PDR through informal or formal trade, depending on measures in place.
- **Moderate, with low uncertainty,** through informal trade in Viet Nam and Myanmar, but negligible through formal trade (provided appropriate measures are enforced).
- **Negligible, with low uncertainty,** through formal or informal trade for other countries of the South (e.g. Nepal, India) and Southeast Asia regions (e.g. Cambodia).

Poultry Products

Considering:

- Evidence presented under 1.2.
- Formal imports of poultry products from China are banned in Myanmar and Viet Nam while Lao PDR allows official imports of poultry products from China (FAOVN, 2017; FAOLA, 2017; FAOMM, 2017; FAORAP, 2017 – personal communications).
- In Viet Nam and Myanmar, eggs and frozen chicken carcasses or parts (wings, feet, etc.) are traded with China

via informal movements while in Lao PDR only eggs, frozen bird carcasses or by-products are traded informally, and to a lesser extent (Nguyen, T.T.T. *et al.*, 2015; FAOMM, 2017; FAORAP, 2017; FAOVN, 2017 – personal communications). Virus can survive in fresh or frozen meat and carcasses (OIE, 2009).

- Few or no poultry products are traded between China and Cambodia either formally or informally (FAOKH, 2017 – personal communication).

Therefore, the likelihood of the Chinese-origin H7N9 HPAI virus spreading from known affected areas of China to unaffected countries in the **South and Southeast Asia region** through **poultry products trade** during the period May to September 2017 can be considered as **low, with medium uncertainty,** regardless of virus survival in those products.

Fomites

Considering:

- Evidence presented under 1.3., 2.1. and 2.3.
- Travellers who visited poultry premises in China and then crossed borders could potentially introduce the virus into neighbouring countries (Viet Nam, Lao PDR and Myanmar) via clothes, boots, on vehicles (trucks, motorcycles, etc.) and equipment (backpacks, crates and cages, syringes) unless changing or cleaning and disinfection are carried out before and after visits (Nguyen, T.T.T. *et al.*, 2015; FAOMM, 2017; FAOLA, 2017 – personal communications).
- Few or no live bird or poultry products movements from China are occurring in other countries of Southeast Asia (e.g. Cambodia) (FAOKH, 2017 – personal communication).

Therefore, the likelihood of the Chinese-origin H7N9 HPAI virus spreading from known affected areas of China to unaffected countries in the **South and Southeast Asia regions through fomites** during the period May to September 2017 can be considered as:

- **Low, with medium uncertainty,** for Viet Nam, Lao PDR and Myanmar due to informal commerce with China.
- **Negligible, with medium uncertainty,** for other Southeast Asian countries.

Wild birds

Considering:

- Evidence already presented under 1.4.
- In spring, wild birds that spent the winter months in southern Asia head back north and northeastward, e.g. to the Russian Federation, Mongolia or the Republic of Korea, to reach summer breeding sites. Southeast Asia is crossed by two major migratory flyways: the Central and the East Asian Flyway.

Therefore, the likelihood of the Chinese-origin H7N9 HPAI virus spreading from known affected areas of China to unaffected countries in the **South and Southeast Asia regions through movements of wild birds (migratory or nomadic)** during the period May to September 2017 can be considered as **negligible, with low uncertainty**.

Annex 3
INFORMATION USED TO ASSESS RISK QUESTION 3

What is the likelihood of the Chinese-origin H7N9 HPAI virus spreading from a known affected area of China to an unaffected area beyond South and Southeast Asia during the period May to September 2017 through:

Global trade and travel

Considering:

- Evidence presented under 1.1., 1.2., 1.3 and 2.2.
- Regulatory officials and poultry producers in countries beyond Southeast Asia are aware of avian influenza hazards, especially since the recent global spread of H5N8 HPAI in late 2016/early 2017, which emerged in China (Sims *et al.*, 2017). Strict regulatory frameworks concerning trade and border crossing are in place to prevent any infected bird or related product from entering these countries (e.g. in E.U., Japan, and USA). South America (especially Brazil, Argentina and Chile) is a main exporter of poultry and related products to China. Africa and the Middle East represent a very small market share for Chinese poultry product exports (GAIN, 2017). Thus, poultry or related products from potentially infected Chinese flocks are unlikely to enter the poultry market chain in these regions.
- Animal products from China exported to other parts of the world are mainly industrially produced broiler meat for human consumption (frozen or cooked) and whereas virus is unlikely to persist in cooked meat, it can survive in fresh or frozen meat (GAIN, 2017; OIE, 2009). However, fresh or frozen poultry meat products are unlikely sources of exposure for local poultry populations.
- Informal trade in poultry between China and countries beyond Southeast Asia is unlikely, considering the distances between them and the different borders to be crossed.
- A large number of tourists potentially exposed to H7N9 HPAI travel from China to other continents (especially Europe and North America). But these travellers are unlikely to act as fomites and infect commercial poultry upon arrival at their destination.

Therefore, the likelihood of the Chinese-origin H7N9 HPAI virus spreading from known affected areas of China to unaffected

countries **beyond the Southeast Asia region through global trade and travel** during the period May to September 2017 can be considered as **negligible, with low uncertainty**.

Wild Birds

Considering:

- Evidence presented under 1.4. and 2.4.
- China has seasonal migration stopover and breeding sites of wild bird species known to be the main natural reservoir of LPAI viruses, but also known to spread HPAI viruses (e.g. H5N1, H5N8) on short and long distances (during autumn migration, westward to the Middle East, Europe and Africa; in summer, northward to the Russian Federation and Mongolia) (Peng, C. *et al.*, 2011; Tian, H. *et al.*, 2015). In the period covered by the risk assessment (May to September 2017), spring and summer migration patterns are of interest. However, spread will only occur if the virus is able to survive in one or more species during long-distance migration.

Therefore, the likelihood of the Chinese-origin H7N9 HPAI virus spreading from known affected areas of China to unaffected countries **beyond the Southeast Asia region through migratory wild bird movements** during the period May to September 2017 can be considered as **negligible, with medium uncertainty,** for the Russian Federation, Mongolia, Japan and the Republic of Korea and **negligible, with low uncertainty,** for other countries.

Annex 4
INFORMATION USED TO ASSESS RISK QUESTION 4

Considering:

- Epidemiological investigations indicate that human infection with, or cases of, influenza A(H7N9) appear to be associated with direct or indirect contact with live bird species, especially in LBMs or in relation to poultry transport, handling and/or slaughtering activities (FAO, 2014).
- To date there have been more human cases of influenza A(H7N9) reported since 2013 than human cases of all other avian influenzas together since 2004 (H5N1, H5N6, H7N7, H9N2, H10N8) (EMPRES-i, 2017; WHO, 2017b; WHO, 2017c).
- Limited data is available about the prevalence of H7N9 HPAI in different domestic bird species in China. As of 16 May, H7N9 HPAI was reported in particular yellow chickens/broiler layers, in one duck, in environmental samples from markets and in four farms (Guangxi, Guangdong, Fujian, Hebei and Hunan provinces) (FAO, 2017a). H7N9 HPAI virus has dual receptor binding (human-like and avian-like) according to biological characterization and genetic analysis (Li, 2017; Zhu, *et al.*, 2017; Millman *et al.*, 2015).
- H7N9 HPAI virus has so far been isolated only from human cases exposed in Guangdong Province in December 2016 and January 2017, but human cases may be present in other provinces (WHO, 2017a; Yang, J-R. and Liu, M-T., 2017).
- Poultry infected with H7N9 HPAI show clinical signs leading to a higher likelihood of detection of sick or dead poultry. Therefore, awareness provided, people may avoid contact with infected animals. However, there is a short period in which poultry may shed virus without showing clinical signs (OFFLU, 2017a).
- In contrast to LPAI viruses, H7N9 HPAI will cause systemic infection in birds due to an increased range of proteases that can cleave the haemagglutinin (HA), so that the virus can be found in organs and other body parts (e.g. feathers) (Swayne and Suarez, 2000). Exposure of humans to virus during slaughtering activities is likely increased when compared to H7N9 LPAI, as the level of virus in meat and other products is higher.
- An experiment conducted in Hong Kong SAR showed that H7N9 HPAI virus isolated from humans was transmitted between ferrets[6] by contact, and two out of three human isolates tested could be effectively airborne-transmitted; some ferrets died. However, H7N9 HPAI virus isolated from chickens did not transmit between ferrets (neither contact nor airborne transmission) and there was low seroconversion. Both the human and chicken isolates had trypsin independent replication in cell culture, indicative of HPAI. (Zhu, W., 2017; OFFLU, 2017a).
- In Southeast Asia, people who consume prepared/cooked yellow chicken broiler meat can be exposed to the virus if the meat is not cooked thoroughly. However, high temperatures during cooking inactivates the virus (FAO, 2017c). During preparation of meat from infected birds, humans could be exposed to virus. However, quantities of virus may vary and not be sufficient to cause human infection.
- In some parts of Asia, raw blood of freshly slaughtered chicken is traditionally consumed and may expose people to H7N9 HPAI virus. However, this route of transmission has not been reported for H7N9 in China.
- Closure, cleaning and disinfection of markets where human cases were infected, as well as disease control measures imposed by the Chinese Government in the different affected provinces, such as enhanced active surveillance, trade regulations and culling of infected birds, reduce potential exposure of humans to both H7N9 HPAI and LPAI, although these biosecurity measures are not applied uniformly.

[6] Ferrets are usually used as a human model in laboratory experiments to study influenza viruses.

High temperatures during cooking inactivate avian influenza viruses.

- At present, there have been no reports of H7N9 (HPAI or LPAI) infections in pigs in China. One serological survey reported little or no evidence of exposure to H7 virus in this species (LPAI) (Zhao *et al.* 2014).

Therefore, the likelihood of **human exposure** to the Chinese-origin influenza A(H7N9) virus (with high pathogenicity in chickens) through contact with infected birds, LBM visits or upon consumption of poultry meat or poultry-related products within affected areas of China during the period May to September 2017 is currently considered as **low to moderate, with low uncertainty**, with **moderate** for **occupational** exposure. The likelihood of human exposure depends, among other factors, on the extent of infection in farms and whether infected birds are sent to market.

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RISK ANALYSIS IN ANIMAL HEALTH

Risk analysis is a procedure, which we all do intuitively in our everyday life as we also do in our professional work to assess the risk of any hazard or threat. In animal health, risk analysis has been most widely used as a decision tool about the most appropriate health interventions to support disease control strategies, guide disease surveillance and support of disease control or eradication strategies.

It should be remembered that risk is not equal to zero and never stays static. Risks changes as drivers or factors of disease emergence, spread or persistence change such as intensification of livestock production, climate change, civil unrest and changes in international trading patterns. Risk analysis should therefore not be seen as a "one off" activity and it should be seen as a good practice of animal health systems to conduct their regular activities. Therefore, risk analysis process should be repeated and updated regularly.

Risk analysis comprises the following components:

Hazard identification: the main threats are identified and described.

Risk Assessment: risks of an event occurring and developing in particular ways are first identified and described. The likelihood of those risks occurring is then estimated. The potential consequences or impact of the risks if they occur are also evaluated and are used to complete the assessment of the risk.

Risk Management: involves identifying and implementing measures to reduce identified risks and their consequences. Risk never can be completely eliminated but can be effectively mitigated. The aim is to adopt procedures that will reduce the level of risk to what is deemed to be an acceptable level.

Risk Communication: an integrated processes that involves and informs all stakeholders within the risk analysis process and allows for interactive exchange of information and opinions concerning risk. It assists in the development of a transparent and credible decision-making processes and can instil confidence in risk management decisions.

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