



**Image 1:** A live animal market in Cambodia.  
Source: Maria Van Kerkhove.

## CASE STUDY 9: Mathematical Models for Cambodia to Reduce the Risk of H5N1 Flu Outbreaks in Poultry

### The problem

Highly pathogenic avian influenza, subtype H5N1 (HPAI/H5N1), first crossed the species barrier into humans in 1997, when an outbreak of 18 human cases was identified in Hong Kong. This outbreak resulted in 6 deaths. In late 2003, H5N1 crossed the species barrier a second time, infecting a family from Hong Kong that had recently travelled to Fujian Province in China.

Since 2003, H5N1 has been confirmed in domestic poultry and/or wild birds in 61 countries throughout Asia, Africa and Europe. During this period, 620 humans have become infected with the virus, 367 of whom have died (Figure 1). Many of these people have reported exposure to ill or dead poultry prior to illness.

The movement of poultry through live-bird markets (LBM), which are common in Asian countries because of a cultural preference to consume freshly slaughtered meat, has been shown to be an important factor in the circulation of HPAI/H5N1 in Vietnam and Hong Kong<sup>1,2</sup>.

The dense concentration and high turn-over rate of live birds in LBM provide ample conditions for virus

- 1 Kung NY, Guan Y, Perkins NR, Bissett L, Ellis T, Sims L, Morris RS, Shortridge KF, Peiris JS. The impact of a monthly rest day on avian influenza virus isolation rates in retail live poultry markets in Hong Kong. *Avian Disease*. 2003; 47:1037.
- 2 Sims LD, Ellis TM, Liu KK, Dyrting K, Wong H, Peiris M, Guan Y, Shortridge KF. Avian influenza in Hong Kong 1997-2002. *Avian Disease*. 2003; 47:832-838.

amplification<sup>3</sup> and therefore LBM may be an important reservoir for HPAI or act as a “hub” of circulation<sup>4</sup>. HPAI surveillance programs in several countries including Vietnam, Thailand, Cambodia, China and Hong Kong have demonstrated that HPAI/H5N1 is circulating in LBM.

### The science

The degree of connectedness of animal networks, that is the frequency with which links between premises and LBMs are made via people, animal movement and/or sharing of equipment, has been shown to influence the potential for widespread epidemics of disease<sup>5</sup>.

Using data collected from LBM and other sources, models have been developed to describe animal movement practices and their contact structures. These can then be used in designing targeted animal and human health surveillance, disease prevention and control activities<sup>6</sup>. This is particularly important in resource-limited settings where such activities may be limited<sup>7</sup>. However, little has been understood about poultry market chains in countries where HPAI/H5N1 is endemic or recurrent.

### The application to policy and practice

A comprehensive study was conducted to describe the current movements of live poultry throughout Southern Cambodia in order to understand how these movements could influence the potential spread of HPAI at local, regional and national levels<sup>8,9</sup>.

The results have demonstrated that live poultry movement in Southern Cambodia is one-directional, highly connected and highly centralized. It was found that:

- Approximately 83,000 live chickens and 35,000 live ducks were traded across the networks each week;
- Most poultry movement occurs via middlemen and market sellers on trucks and motorbikes into markets, semi-commercial farms and stock houses located in Phnom Penh, Cambodia;

- 3 Webster RG. Wet markets: a continuing source of severe acute respiratory syndrome and influenza? *Lancet*. 2004; 363:234-36.
- 4 Senne D, Pearson J, Panigrahy B. Live poultry markets: a missing link in the epidemiology of avian influenza. In: Beard C, Easterday B (Eds). *Proceedings of Third International Symposium on Avian Influenza*. Richmond: United States Animal Health Association, 1992, pp.50-58.
- 5 Kao RR, Green DM, Johnson J, Kiss IZ. Disease dynamics over very different time-scales: foot-and-mouth disease and scrapie on the network of livestock movements in the UK. *Journal of the Royal Society Interface*. 2007; 4(16):907-916.
- 6 Dent J, Kao R, Kiss I, Hyder K, Arnold M. Contact structures in the poultry industry in Great Britain: Exploring transmission routes for a potential avian influenza virus epidemic. *BMC Veterinary Research*. 2008; 4:27.
- 7 Stark K, Regula G, Hernandez J, Knopf L, Fuchs K, Morris R, Davies P. Concepts for risk-based surveillance in the field of veterinary medicine and veterinary public health: Review of current approaches. *BMC Health Services Research*. 2006; 6(1):20-27.
- 8 Kung NY, Guan Y, Perkins NR, Bissett L, Ellis T, Sims L, Morris RS, Shortridge KF, Peiris JS. The impact of a monthly rest day on avian influenza virus isolation rates in retail live poultry markets in Hong Kong. *Avian Disease*. 2003; 47:1037.
- 9 Sims LD, Ellis TM, Liu KK, Dyrting K, Wong H, Peiris M, Guan Y, Shortridge KF. Avian influenza in Hong Kong 1997-2002. *Avian Disease*. 2003; 47:832-838.

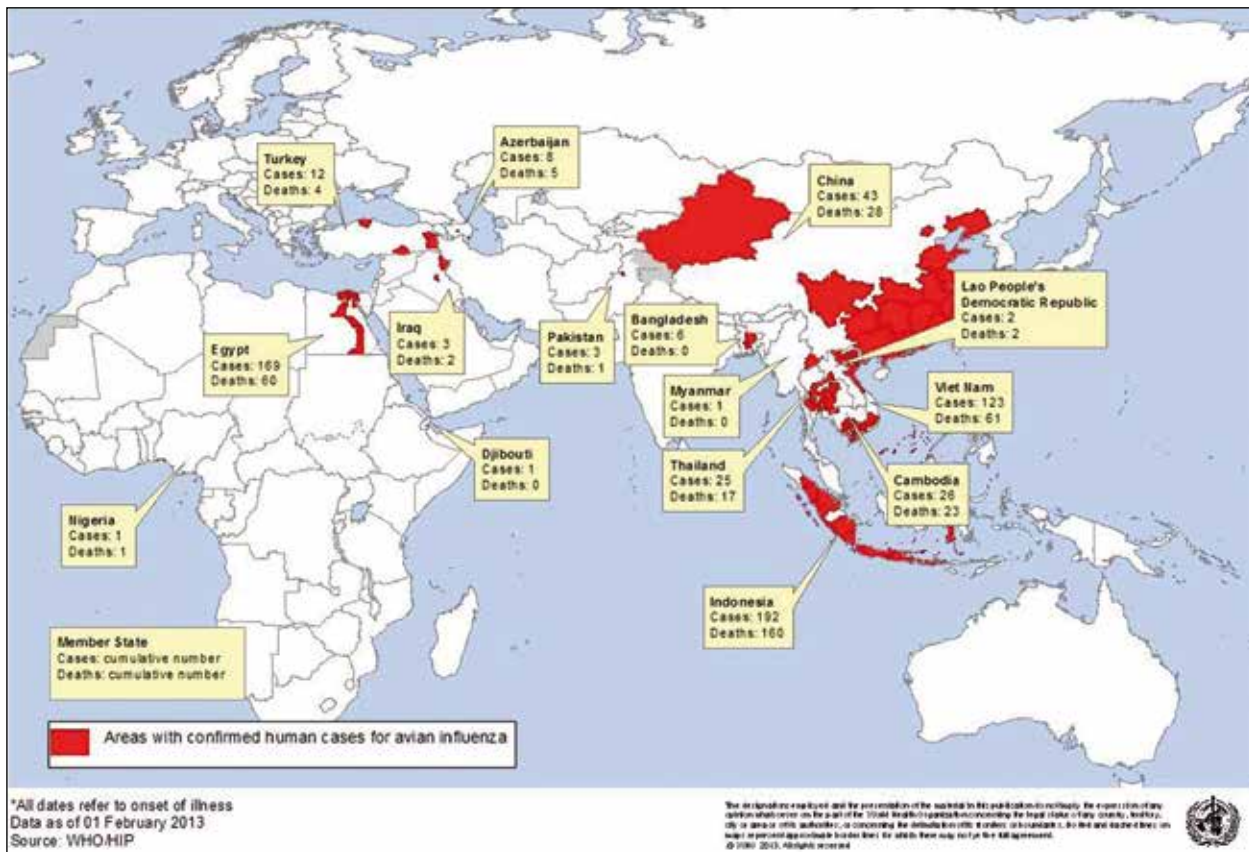


Figure 1: Countries with confirmed H5N1 influenza reported in human populations between 2003 and 2013.

Source: World Health Organization, 2013<sup>10</sup>.

- Approximately 85% of middlemen trade live birds >10 km from where they purchased the birds; and
- Live poultry originating in 11 of Cambodia's 24 provinces and from regions in Southern Vietnam were sold directly to the three main LBM in Phnom Penh.

The investigators found that the unidirectional movement of poultry into Phnom Penh made LBM in Phnom Penh a potential hub for the spread of H5N1, making them ideal locations for surveillance and control<sup>11, 12</sup>.

## Did it make a difference?

These studies have been able to identify critical points for active HPAI surveillance and have informed Cambodia's HPAI subsequent surveillance activities. Although this does not replace the need for routine and regular

surveillance, the identification of critical points for targeted intervention favours the prudent use and conservation of resources.

Given the rapid global spread of HPAI/H5N1 in recent years, surveillance of poultry populations and LBM will remain a high priority for monitoring and control efforts against HPAI in Cambodia and elsewhere. Understanding poultry movement is essential for the development of appropriate and targeted recommendations for active HPAI/H5N1 surveillance programs. The results of this and similar studies can therefore be used to inform the selection of markets that best suit particular objectives of a surveillance system, in particular whether the objective is monitoring of the HPAI status of poultry populations in rural areas or early detection of incursion in markets with high potential for spread.

<sup>10</sup> World Health Organization (WHO). Areas with confirmed human cases for avian influenza A (H5N1) reported to WHO, 2003-2013. Geneva, 2013. Available at: [http://gamapserver.who.int/mapLibrary/Files/Maps/2003\\_AvianInfluenza\\_GlobalMap\\_01Feb13.png](http://gamapserver.who.int/mapLibrary/Files/Maps/2003_AvianInfluenza_GlobalMap_01Feb13.png) [accessed 29 April 2013].

<sup>11</sup> Kung NY, Guan Y, Perkins NR, Bissett L, Ellis T, Sims L, Morris RS, Shortridge KF, Peiris JS. The impact of a monthly rest day on avian influenza virus isolation rates in retail live poultry markets in Hong Kong. *Avian Disease*. 2003; 47:1037.

<sup>12</sup> Sims LD, Ellis TM, Liu KK, Dyrting K, Wong H, Peiris M, Guan Y, Shortridge KF. Avian influenza in Hong Kong 1997-2002. *Avian Disease*. 2003; 47:832-838.